Draft Water Resources Management Plan 2019

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Exclusions on the Grounds of National Security

Northumbrian Water Limited has not excluded any information from this plan on the grounds that the information would be contrary to the interests of national security.

Under Section 37B(10)(b) of the Water Industry Act 1991, as amended by the Water Act 2003 ("the Act"), the Secretary of State can direct the Company to exclude any information from the published Plan on the grounds that it appears to him that its publication would be contrary to the interests of national security.

Northumbrian Water is a trading division of Northumbrian Water Limited which is a group Company of Northumbrian Water Group

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Non-Technical Summary

Introduction

Water Resources Management Plan Purpose

This document is Essex & Suffolk Water's (ESW) draft Water Resources Management Plan (WRMP). It demonstrate that ESW has an efficient, sustainable secure supply of water over the Company's chosen planning period. For this WRMP, the Company has prepared water demand and supply forecasts for a 40 year planning period from 1 April 2020 to 31 March 2060.

The WRMP covers the entire ESW customer supply area (see Figure 1 in Appendix 1). For the purposes of the Company's demand forecasts and supply demand balance calculations, the supply area has been split into the following Water Resource Zones (WRZ) (see Figures 2 and 3 in Appendix 1):

Table 0.1: ESW Water Resource Zones

Supply Area	Water Resource Zone
Essex	Essex WRZ
Suffolk	Blyth WRZ
	Hartismere WRZ
	Northern Central WRZ

The WRMP has been prepared following the Water Resources Management Plan (England) Direction 2017 (Defra, 2017), Defra's Guiding Principles for Water Resources Planning (Defra, 2016) and the Environment Agency's (the Agency) Water Resources Planning Guideline (the WRPG) (Environment Agency, 2017).

Water Resources Background

The Essex and Suffolk supply areas are located within some of the driest areas of the country and as such face particular challenges including growing demand, uncertainty from climate change and a general lack of new intrinsic water resources. ESW has always fully embrace the concept of the 'twin track approach' to maintaining water supplies through a combination of demand management and water supply schemes and initiatives.

ESW prides itself on its track record of demand management and in delivering innovative water supply solutions such as the "Langford Effluent Recycling Scheme" and the "Abberton Scheme", both of which are described within this Plan. The Company has amongst the lowest levels of leakage in the UK and is an acknowledged industry leader in water efficiency and water conservation. Additionally ESW is fully committed to achieving the maximum possible level of domestic meter penetration within an appropriate timescale and with the Company's customers' support.

Despite all the rigorous work on demand management, ESW's PR09 WRMP recognised that a major water resource scheme was required in the Essex WRZ to meet the growing demand for water. The Abberton Scheme was identified as being the appropriate option for ESW to pursue during AMP5. The Abberton Scheme comprised three major elements, namely:

i. The upgrade of the Ely Ouse to Essex Transfer Scheme (EOETS) by way of two new pipelines and an upgrade to the pumping facilities;
ii. A variation to the abstraction licence at Denver in Norfolk from where water is transferred by the EOETS; and
iii. The enlargement of Abberton Reservoir.

All works were completed in 2012 providing the Essex WRZ with a PR14 supply surplus throughout the planning period.

PR19 Supply and Demand Forecasts

In this draft WRMP, all components of the supply and demand forecasts have been reviewed using the appropriate methods recommended in the Agency's WRPG (Environment Agency, 2017), hereafter 'the WRPG'.

The chosen planning scenario remains the Dry Year Annual Average (DYAA) as no WRZ demonstrates a critical period where peak demands are driving investment within the WRZ.

Water Supply Forecasts

Future water supplies are forecast by calculating Water Available for Use (WAFU). WAFU is calculated by quantifying the Deployable Output (DO) of the Company's raw water sources and treatment works within each water resource zone. Outage (for example when a treatment works is out of supply due to planned maintenance), process losses (for example the water used to back wash treatment works filters) and sustainability reductions (for example where the Company's abstraction licence has been reduced to ensure they are sustainable) are then subtracted from DO to give WAFU.

The Suffolk WRZ WAFU remains similar to PR14 but the Essex WRZ DO is increased by more than 65Ml/d since PR09 as a result of the completion of the Abberton scheme.

The Essex WRZ WAFU has marginally increased reflecting a recent reassessment of river flows from 1915 to 2015.

Effect of Climate Change on Future Water Supplies

Climate change was assessed in ESW's PR14 WRMP using the CP09 Climate Projections. As these remain the latest projections, ESW's PR14 groundwater climate change assessment remains valid. It concluded that climate change has a low impact in the Suffolk groundwater dominated WRZs.

ESW has reassessed the effect of climate change on the DO of its river abstractions using the latest method. ESW's abstraction from the River Waveney is most affected by climate change as summer river flows decline over time and there is no winter raw water storage to take advantage of potential higher winter flows. However, the Waveney abstraction can be supported by the Waveney Augmentation Groundwater Scheme (WAGS), which offsets some of the effect of climate change.

In the Essex WRZ there is a slight positive enhancement to supplies in the pumped storage reservoir dominated system.

ESW's assessments conclude that after considering the effects of climate change, all four WRZs remain in surplus across the whole planning horizon, with no water resource development being driven by climate change assumptions.

Environmental Improvements

Each time ESW updates its WRMP (every five years), it agrees with its regulators a list of schemes collectively known as the Water Industry National Environment Programme (WINEP). The WINEP is an integrated list of requirements for water resources, water quality and fisheries, biodiversity and geomorphology. It consists of investigations, options appraisals and actions to protect (prevent deterioration) and improve the water environment. Actions to protect or improve the environment include changes to the Company's abstraction licences, also known as sustainability changes, and non-licence change actions, such as river restoration. The WINEP does not just consider the direct effect of abstraction. It also considers, among other aspects, catchment measures to improve the quality of water at abstraction intakes, invasive non-native species risk, fish passage and discharges to the environment.

The current PR14 AMP6 NEP (2015 to 2020) includes the following:

- Three Review of Consents Implementation schemes, namely:
    - Trinity Broads Special Area of Conservation (SAC): Sediment removal via mud pumping;
    - Geldeston Meadows SAC: Provision of a river support discharge; and
    - Alde Ore Estuary Special Protection Area (SPA): Provision of a river support discharge.
- Two Water Framework Directive (WFD) implementation schemes, both also with an Eel Regulations driver, namely:
    - River Blackwater: Provision of a River Blackwater Sluice Fish Pass; and
    - Fritton Decoy: Provision of a sluice eel pass.
- One Restoring Sustainable Abstraction (RSA) implementation scheme, namely:
    - River Stour at Cattawade: Raise abstraction cessation level from 1.5mAOD to 1.65mAOD; and install variable speed abstraction pumps to pump to a level to reduce daily fluctuation in water level. This will prevent the exposure and re-wetting of river bank which might be responsible for

the release of toxins that cause fish stress. Additionally it will help facilitate eel passage.

- Eel Regulations:
  - 15 Eel Regulations Implementation Schemes, of which ten were to improve intake screening and six to install or improve eel passes; and
  - Six Eel Regulations Investigations to investigate opportunities to facilitate eel passage.
- Water Quality / Drinking Water Protected Areas (DrWPA):
  - A programme of work under the DrWPA driver, implementing catchment schemes to protect raw water quality.

ESW has made excellent progress in delivering all of the above schemes. All of the improvements will have been delivered by 31st March 2020.

ESW has agreed a new WINEP with its regulators for AMP7 (2020 to 2025). The second iteration of the PR19 WINEP for AMP7, issued by the Environment Agency in September 2017, contains the following schemes:

- Investigations to confirm the sustainability of ESW's Suffolk groundwater abstractions;
- Investigations to establish whether raw water transfer systems increase potential Invasive Non-native Species (INNS) transfer;
- Schemes to reduce the transfer of INNS;
- Investigations relating to facilitating eel passage at two reservoir sites;
- One improvement scheme relating to the upgrade of eel screens at one Essex river intake; and
- Five catchment management schemes to protect water quality in the Company's main surface water catchments.

All of the above schemes will go forwards into ESW's PR19 Business Plan.

Household Demand Forecast

The base building block for demand forecasting is the base year population served and the projected growth in population annually over the WRMP. In line with the WRPG requirement, ESW has used local authority Plan housing growth evidence from all local authorities and has selected the Plan-based scenario.

In the case of Essex and Suffolk supply areas, the population forecasts for PR19 using the Plan-based scenario shows a growth in population over the planning horizon. This has resulted in a 34% increase in Essex population over the 40 year planning horizon and a 29% increase in Suffolk population. The population is now forecast to be 2.56M by 2059/60. Overall occupancy in the demand forecast reduces from 2.63 to 2.50 in Essex and reduces from 2.28 to 2.21 in Suffolk.

The average annual number of new homes is forecast at 7,338 in Essex for AMP7 and 1,211 in Suffolk.

The per capita consumption (PCC) in Essex and Suffolk is forecast to reduce annually across the planning horizon as a result of the Company's metering policy and water efficiency initiatives. In Essex unmeasured PCC is forecast to reduce to 150.82 l/h/d by 2059/60 with measured properties reducing to 128.32 l/h/d. In Suffolk unmeasured PCC is forecast to reduce to 140.22 by 2059/60 with measured properties reducing to 117.17 l/h/d.

The normal year forecasts have been used as the basis for dry year forecasts, and adjusted to provide figures for two climate change scenarios.

Non-household Demand Forecast

Overall non-household forecasted demand to 2060 is relatively flat, with a gradual increase over time to account for growth of non-household property numbers. This is due to the assumption built into the forecast methodology that individual customer demand will trend to a flat line over time.

Customer Metering

ESW's Current AMP6 (2015 to 2020) Metering Strategy

In Essex and Suffolk, separate metering strategies have been run since 2003/04. In Suffolk, the Company has been "optant" only metering, as required by legislation since 2000. Optant metering is where a customer requests a meter from the company and, assuming the meter can be installed at reasonable cost, the Company is required to install a meter free of charge. The customer then pays for their water and sewage on a measured basis. They also have a choice of reverting back to an unmeasured charge for two years of the meter being installed. A meter means a customer only pays for the volume of water used, which in low occupancy, high rateable value properties usually reduces their annual water bill. All unmetered customers continue to be charged according to the rateable value of their property. All new properties, and properties that have had significant alteration or installed large water using apparatus e.g. a swimming pool, are metered. In Suffolk by the end of 2019/20 meter penetration is estimated to be 68.9% of domestic properties.

In Essex, exactly the same optant, new property and high water users' strategy has been in place. However, in the early 2000s it was obvious that opting for a meter was far more popular in Suffolk than it was in Essex. The exact reason for this is unknown but the greater proportion of second homes in Suffolk, which are therefore only partially occupied, could account for it as they generally will have a low annual consumption. Historically there has also been a higher cost of water in Suffolk than Essex which may have made having a meter more financially attractive. Whatever the reason, the outcome was that the more water stressed area of Essex, compared to Suffolk, had a significantly lower meter penetration level. Looking at the declining trend in the annual number of optants in Essex, meter penetration was unlikely to increase sufficiently to support ESW's demand management aspirations if only optant metering was available.

From 2003, initially in a pilot area, metering on change of property occupier (selective) metering was introduced in Essex. Selective metering is allowed under current legislation where, if the occupier of a property has never received an unmeasured bill for water to that property, then the company is allowed to install a water meter and charge the customer on a measured basis. In reality this means ESW can meter a property when it changes hands by either being purchased or having a new tenant. This additional form of metering being added to the Essex strategy has meant that by 2019/20, 64% of domestic properties will be metered. In Suffolk this figure will be 69%.

However, ESW now believes that selective metering in Essex has probably achieved as much as it can. Whilst the Company recognised that as more properties became measured the chance of a new occupier moving in to an unmeasured property decreased, after the first two years the numbers decreased markedly.

Initially selective metering in Essex started in 2005 and the Company saw a peak of 14,235 selectively metered properties in 2006/7. However the financial crash in 2007 saw house moving plummet from 2008 onwards, with the number of selective meters falling to an average of 5,500 for the next five years. As house moves picked up, the Company did not see the expected increase in selective meters coming through and has actually seen a steady decline in numbers from 5,300 in 2011/12 to 3100 in 2016/17 against the 6,000 forecast at PR14. These numbers are far below that forecast and far below the numbers expected if approximately 10% of properties change occupier per annum. What ESW has now come to understand is that even when the number of house moves returns to normal, a high proportion of the houses coming on to the market are those that have been sold within the previous ten years. This reduces the opportunity to selectively meter dramatically as most properties have been selectively metered previously. Equally in the rented sector tenancies tend to be of fairly short duration meaning most of these properties will already have been selectively metered on their first change of occupier. However, because ESW wants to meter above the "natural" optant rate in Essex, the Company is going to introduce area metering as described below.

Changes to ESW's Draft WRMP Metering Strategy for 2020 to 2025

In Essex, the Company is to continue with the current strategy of optant metering but will no longer continue with selective metering on change of occupier of a domestic property. Instead, it is going to introduce Area Metering which it predicts should add a further 5,000 meter optants per annum to the forecast number of "natural" optants expected.

Area Metering is the name ESW is giving to a new programme of installing meters in to existing empty meter chambers, the customers will remain unmeasured but over a two year period the Company will send them a "water bill" showing what they would have paid had they opted for a meter.

As a result of ESW's mains renewal programmes over the last 30 years, including a significant replacement of mains during the 1990s for quality reasons (Section 19

Quality Programme), the Company has a large number of empty meter chambers. This has arisen because when it has renewed water mains, the Company has also taken the opportunity to renew the communication pipe (the pipe between an ESW main and the customer's curtilage) and install a meter chamber. The Company estimates that there are currently approximately 70,000 empty chambers and the Company continues to add to this number as it renews mains.

ESW's proposal is to drop meters into these chambers at a rate of 10,000 per annum, and inform the customer that whilst they remain an unmeasured customer the Company will send them "dummy bills" over a two year period showing what their water bill would be if they were metered. From the Company's customer research it forecasts that over the two year period, 5,000 of these customers will opt to go on to a measured bill. Some very early on and others when they see that financial savings are sustainable and not a single aberration. Once they opt for a meter they have a further two years in which to revert, potentially giving customers up to four years of measured bills before they become permanently metered. Equally any change of occupier to these properties, at any time, will automatically become metered. Even for those properties that chose not to become measured, or changed ownership, ESW believes knowing that the property has a meter will have a 'Hawthorn' effect on their use, certainly reducing wasteful use.

Moving to this area metering at the start of AMP7 (April 2020) would mean far less than 5,000 new optants from Area Metering in the first year of installing the 10,000 meters pa, as ESW expects the 5,000 optants over the two years. Therefore the Company proposes to begin the 10,000 meters pa from April 2018, meaning that by the first year of AMP7, the first 10,000 customers will be at their two years of "dummy" bills and a further 10,000 reaching one year of "dummy" bills. ESW intends stopping selective metering at end of March 2018 as the number of optants from Area Metering in the last two years of this AMP is likely to exceed the number of new measured properties from continuing with selective metering.

With ESW's planned level of mains renewal for the remainder of AMP7 and during AMP7, the Company forecasts there will be sufficient empty meter chambers to continue Area Metering through AMP8. At the end of each AMP the Essex meter penetration is forecast to be as below:

Table 0.2: Essex meter penetration forecast

AMP6	AMP7	AMP8	AMP9	AMP10	AMP11
64.24%	72.23%	78.35%	80.85%	82.61%	84.22%

ESW assumes an average saving from an optant metered customer having a meter installed is 5% of the unmeasured consumption or 15.63 litres/property/day. Installing 42,500 optants in AMP7 will save 664,725 litres water per day. The total AMP7 cost for the Company's Essex metering strategy is £7,174,144.

In Suffolk, ESW is to continue with the current strategy of optant metering. With approximately 69.24% of properties being metered by 2020, the number of new optants coming forward will decline to a lower level than experienced in AMP6. At the end of each AMP, the Suffolk meter penetration is forecast to be as below:

Table 0.3: Suffolk meter penetration forecast

AMP6	AMP7	AMP8	AMP9	AMP10	AMP11
69.24%	73.02%	75.25%	76.31%	77.27%	78.13%

ESW assumes an average saving from a customer having a meter installed of 5% of the unmeasured consumption from an optant or 14.03 litres/property/day. This gives an AMP7 total of water saved in Suffolk from optant metering of 41,739 litres per day. The total cost of the Company's Suffolk optant metering strategy for AMP7 = £923,225.

The overall impact of ESW's metering strategy is that the Company will install a total of 70,475 meters during AMP7 at a total cost of £8.1m. This will result in water demand savings of 0.706Ml/d.

Demand Management Strategies

Leakage Strategy

ESW's current regulatory leakage performance commitment for 2019/20 is 66Ml/d. However, a new method has been proposed by the regulator Ofwat to ensure all water companies report leakage consistently going forwards. Using the new leakage calculation method, ESW estimates that the most probable value for leakage in 2019/20 would reduce from 66Ml/d to 62.6Ml/d. For AMP7 (2020 to 2025), ESW plans to reduce leakage by 17.5% by 2024/25 to 51.6Ml/d. Beyond 2025, the Company plans to further reduce leakage by 10% over each subsequent five year period. By 2044/45, the end of the regulatory minimum planning period, this would reduce leakage to 33.9Ml/d or 54% of current leakage).

Water Efficiency Strategy

Water efficiency has remained a key strand of ESW's demand management undertakings throughout AMP6 (2015 to 2020). Having initiated the first water efficiency retrofit programme in 1997, ESW is able to demonstrate the successful delivery of industry-leading projects, schemes and initiatives spanning over 20 years. These activities have resulted in quantifiable water savings, unrivalled customer experiences and a significant contribution to the water efficiency evidence base.

The Company's strategy has, and continues to be, designed to create water efficiency programmes that make genuine savings in water as cost effectively as possible. A critical part of the programme is the monitoring of results to find out what the actual savings in water are and how sustainable they are, and customer surveys to gauge the effectiveness of the approach. Whilst this benefits ESW's water efficiency planning and ultimately the high levels of demonstrable water savings achieved, it has and will continue to contribute significantly to the industry's water efficiency evidence base, in turn aiding others in developing demand management and water efficiency strategies.

Particular achievements have been the increase in effectiveness of ESW's water efficiency retrofit projects, the strong emphasis on the measurement of water savings (at more detailed levels than household meter readings which can easily mislead), interest in the sustainability of savings, a determined focus on the delivery of sustained behaviour change and proactive attempts to share and disseminate the results, experience and learning. ESW has also received recognition for its innovative and creative approach to delivering its wide range of initiatives via a whole-town approach. Every Drop Counts is ESW's largest ever water saving programme taking a wide-reaching and community-focused approach.

Progress in AMP6 and Current Water Efficiency Strategy

Following Ofwat's water efficiency targets in AMP5, ESW designed its water efficiency strategy in AMP6 based on the direction set out in Defra's "Water for Life" (precursor to the Water White Paper) and its Statement of Obligations for PR14, which emphasised the Government's expectation that water companies will deliver overall demand reductions via demand management measures, including water efficiency. Defra also clearly stated that it expected companies to show in their Water Resource Management Plan how they will reduce per capita consumption.

The Environment Agency and Defra accepted ESW's water efficiency proposals to annually reduce PCC by 0.26 l/head/day (equating to 0.49 Ml/day) by delivering water efficiency activities in AMP6; a target that it is on track to meet. Water savings have been achieved primarily through the delivery of household water efficiency activity, applied equally to unmeasured and measured customers. Water efficiency programmes were delivered to non-households prior to retail separation in April 2017, following which it has been deemed the responsibility of retailers.

ESW's flagship project, "Every Drop Counts", uses a combination of targeted advertising and community-based marketing to maximise participation in the wide range of water efficiency projects to help communities not only save water, but energy and money too. Since the initial trial of the whole-town approach in 2014, ESW has completed 12,365 home retrofit audits and 64 business audits in four towns. The culmination of refining and improving the process annually has seen success in terms of customer participation increase each year. Participating customers that have received an Every Drop Counts water efficiency retrofit visit are each saving on average 21.3 litres per day. This equates to an annual saving of 7,775 litres which in turn results in monetary savings of approximately £21 on each participating customer's water and sewerage bills. The project to date is now saving 263,375 litres of water per day.

ESW recognises the importance of educating younger generations, and in turn has implemented highly energetic, engaging and creative programmes delivered to primary and secondary schools respectively. An example of this is a programme called Super Splash Heroes which delivered an educational play and workshop named Little Green Riding Hood. Working with a local theatre company, the programme was delivered to 119,552 pupils between 2010 and 2015 through 619 performances in 456 schools. It was a successful project that resulted in sustained behaviour change in primary school ages children. In 2016 Water Saving Week, ESW launched a refreshed programme named Super Splash Heroes. Based on the concept that the pupils themselves could become Super Splash Heroes, an educational play and workshop was created in collaboration with a national theatre company. An engaging, fast-paced and drama-based play is delivered to all pupils at participating primary schools. This is then followed by an educational workshop, led by the actors, with the aim of reinforcing the messages the pupils learnt during the play. Super Splash Heroes visit 100 schools in the ESW supply area on an annual basis, engaging approximately 200 pupils at each play/workshop.

ESW also recognises the importance of providing advice and information to customers to ensure water is used wisely in the garden during the summer months. The Company's Save a Bucket Load campaign encourages customers to keep their gardens looking their best whilst using water wisely. The programme, which has evolved and adapted each year, aims to promote sustainable water use in the garden and generate long-term behaviour change. As part of the programme, the BBC's One Show horticulturist Christine Walkden was engaged to be the 'face' of the campaign and to spread the message of 'using water wisely' in the garden. Christine gave three informative talks across our supply area to gardeners and allotment holders on the top ways to save water. The talks were located in Brentwood in Essex, Lowestoft in Suffolk and also at Howard Nurseries Ltd in Wortham near Diss in Norfolk.

Water Saving Kits and Products

In 2009, ESW became the first water company to develop a water saving kit, aimed at providing customers with a variety of 'easy-to-install' products and information about saving water in and around the home. The kit proved effective in providing customers with the tools to make their home more water efficient and also provided details about how the customers could purchase further water saving products for elsewhere within the home. The water saving kit includes a five-minute shower timer, Save-a-Flush, in-line shower regulator, twin-pack of tap inserts, universal plug and an information leaflet/questionnaire.

To date, 60,863 water saving kits have been distributed to customers, upon request, following introduction in 2009. Water Saving Kits are promoted on the ESW website, at events and by Customer Advisors in the Call Centre.

ESW also offers customers the opportunity to request a selection of products for their home and garden in the form of a bespoke kit. When requesting water saving products from the ESW website, customers have the option of requesting a 'standard' water saving kit or a 'bespoke' kit consisting of products selected from those mentioned previously and including a range of other products. The distribution of water saving kits to customers upon request has ensured that customers have enjoyed easy access to water saving products at no cost. It is believed that making such products available has made water efficiency applicable and available to a large proportion of customers.

Water Efficiency Strategy for AMP7

In AMP7, water efficiency will be more important than ever. In addition to recognising the underlying and founding principle that water efficiency is a key tool for managing demand and therefore supporting the supply/demand balance, ESW has considered the numerous and varying drivers for water efficiency that now exist. In response, ESW will deliver a water efficiency programme between 2020/21 and 2024/25 that is even greater in scale and ambition than delivered previously. With more than 20 years' experience in the delivery of water efficiency programmes, ESW is best placed within the industry to develop a strategy that will deliver quantifiable water savings and sustained behavioural change.

In Ofwat's draft PR19 methodology (Ofwat, 2017), four key themes are emphasised that will focus on benefitting customers; namely great customer service, resilience, affordable bills and innovation. It is arguable that water efficiency plays a key role in the delivery of all four outcomes. Delivering an effective, engaging and ambitious water efficiency strategy has the ability to provide unrivalled customer service, manage demand such that ESW is more resilient in the future, provide support to vulnerable customers who are struggling to pay and demonstrate innovation through the use of new technologies and approaches. Further to this, Ofwat has proposed a new common performance commitment based on per capita consumption. Alongside an effective metering strategy, this common performance commitment emphasises the importance of demand management in general, and more specifically water efficiency.

'Water Resources Long-Term Planning Framework (2015-2065)' (WaterUK, 2016) suggests that more action is needed to protect against the growing risk of drought. The report emphasises the role that water efficiency at a greater scale can play in mitigating some of the risks. The Blueprint for Water's Blueprint for PR19 also emphasises the importance of using water wisely by reiterating Ofwat's suggestion that companies need to go much further on metering and leakage reduction, as well as working with customers to help them reduce consumption. Waterwise has also published a national water efficiency strategy that calls for greater ambition and collaboration in water efficiency.

ESW is able to demonstrate the Company's commitment to encouraging its customers to use water wisely through a long history of delivering effective water efficiency strategies and programmes. The drivers (regulatory and other) detailed above add further emphasis to the importance of water efficiency for varying reasons. In turn, **ESW will commit to delivering a programme of water efficiency activities that will deliver a 2% reduction in per capita consumption (pcc) by 2024/25, equating to an annual reduction of 0.57 litres per person per day**. The impact of this water efficiency is to reduce overall PCC for ESW by 2.85 litres per person per day by 2024/25 with a further continuation of water efficiency across the planning horizon.

ESW will achieve the ambitious demand reductions stated above through a continuation of the range of activities currently delivered although at a far greater scale. Central to the water efficiency strategy in AMP7 will be the Every Drop Counts programme, taking a community-focused and wide-reaching approach to saving water through the delivery of all of ESW's activities in one town at one time. The whole-town approach ensures that ESW is able to maximise its effectiveness in terms of participation and water savings in target areas. Home water efficiency retrofits will remain a cornerstone to the strategy as a means of ensuring the existing housing stock is as water efficient as possible whilst delivering behaviour change. The Super Splash Heroes programme forms an effective means by which ESW is able to engage with future generations. ESW will continue to focus on housing associations, develop stronger links with its affordability strategy and focus on identifying and repairing internal plumbing losses. Each of the activities discussed previously will be delivered in AMP7 at a greater scale.

It is however important to highlight that the water efficiency scenery is changing, which in turn will influence the strategy as time progresses through AMP7. There will be three key priorities for water efficiency in the coming decade. Firstly, there will be a transition whereby the importance of behaviour change grows exponentially. Secondly, the delivery of home retrofits will need to become more targeted towards only those homes that will truly benefit from the programme. ESW's research and statistical analysis tells a story suggesting a limited lifespan of the home retrofit project as the stock of existing inefficient water using appliances is replaced with those that are more efficient. ESW is able to demonstrate that product installation rates associated with the home retrofit programmes are declining on an annual basis, in turn diminishing the cost-effectiveness of the projects. Thirdly, the use of smart metering / technologies will be deemed beneficial to water companies and an expectation of customers. In response, ESW will implement an innovative digital engagement platform that will underpin and assist in the delivery of these priorities whilst further supporting its drive to deliver unrivalled customer service. Linked to the digital engagement platform will be two additional themes. An innovative incentive scheme, building on the behavioural economics research undertaken by ESW in conjunction with Oxford University and the University of Chicago, will be implemented to intelligently incentivise customers. ESW will also deploy a series of smart technologies allowing more frequent and circular customer conversations around water efficiency.

Distribution Input Forecast

The overall effect on the forecast of Distribution Input (DI) is that in 2059/60, Essex will have a demand of around 12Ml/d more than today, with a population increase of 560,000 people. The Suffolk Northern Central WRZ demand is also forecast to increase by a modest 3Ml/d, with the smaller Blyth WRZ and Hartismere WRZ seeing a very small decline in demand.

Target Headroom Forecast

Target headroom can be thought of as a security margin or an allowance that takes account of any uncertainty in the WAFU and DI forecasts.

Target headroom should be considered in the context of actual headroom. This is the difference between the WAFU and DI forecasts. WAFU should be greater than the DI forecast to allow for uncertainty and ensure it can meet demand. The ‘ideal’ amount of actual headroom that a prudent water company should retain is called target headroom.

Once calculated, this target headroom allowance is added to the distribution input forecast. Providing the WAFU forecast remains above the DI plus target headroom forecast, then the water resource zone is considered to have a sufficient supply surplus.

Target headroom is illustrated in the supply demand balance graphs illustrated below. In 2018/19, at its greatest, as a percentage of DI, target headroom is ~9% in the Essex WRZ, ~14% in the Blyth WRZ, ~11% in the Hartismere WRZ and ~9% in the Northern Central WRZ.

Supply Demand Balance Forecast

A supply demand balance is best illustrated as a graph showing supply (known as Water Available For Use or WAFU) and demand (known as Distribution Input plus Target Headroom). Providing the supply line is above the demand plus target headroom line, there is a supply surplus. This means there is sufficient water to meet demand during a severe drought and so there is not a need to develop new water resources.

ESW has re-assessed its supply and demand forecasts for this draft WRMP. These assessments have confirmed that all four of the Company’s water resource zones have a supply surplus across the full planning period to 2060. Consequently, no new water resource schemes are required in this period.

This is illustrated in the final planning supply demand balance graphs below.

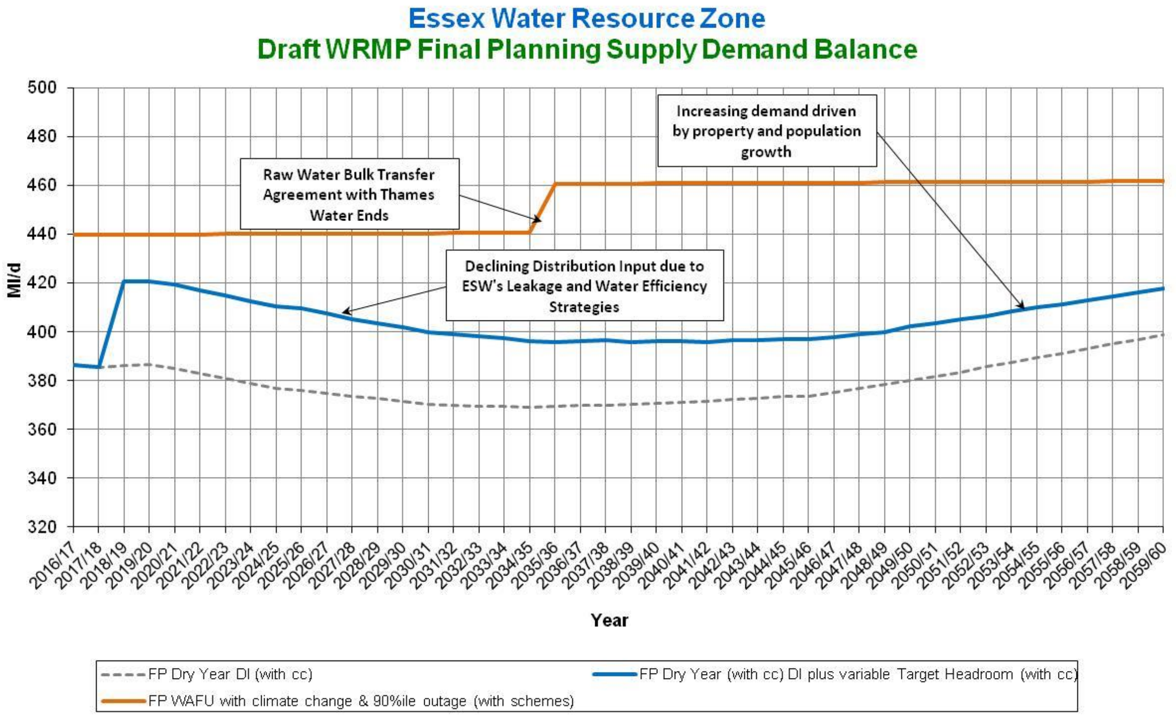


Figure 0.1: Final Planning Supply Demand Balance – Essex WRZ

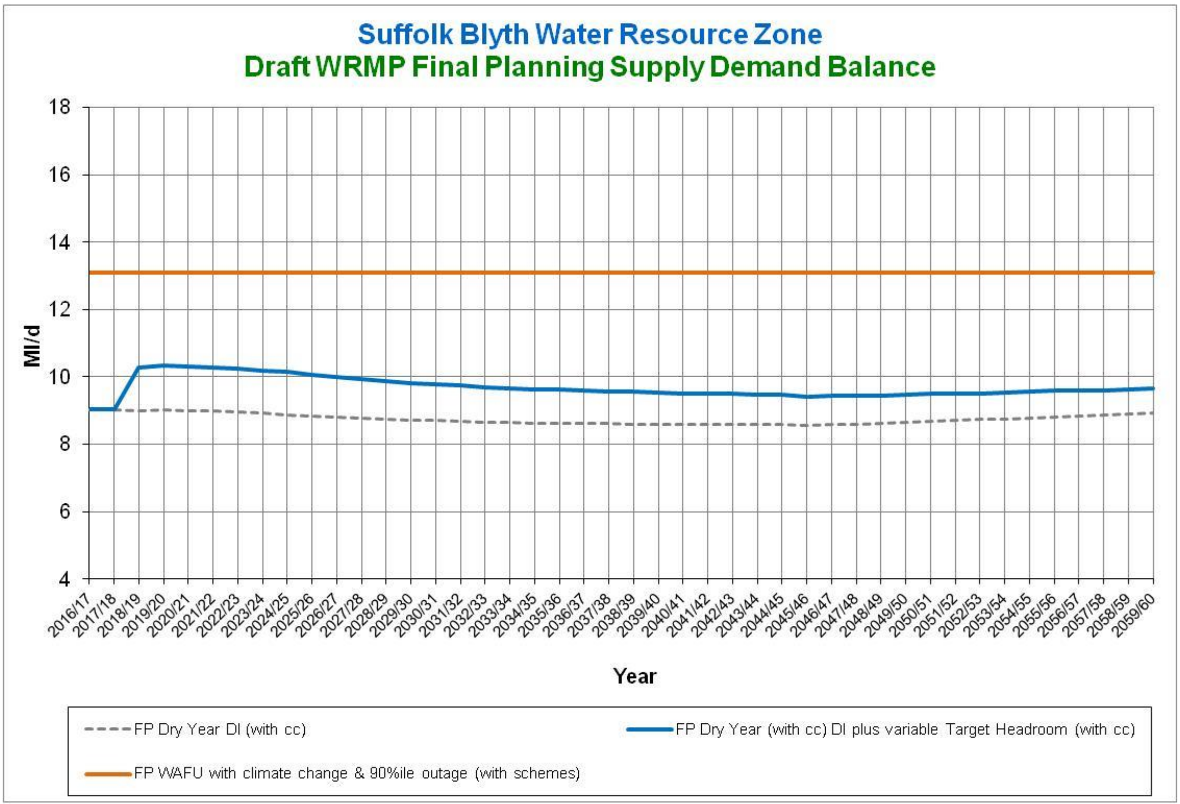


Figure 0.2: Final Planning Supply Demand Balance –Suffolk Blyth WRZ

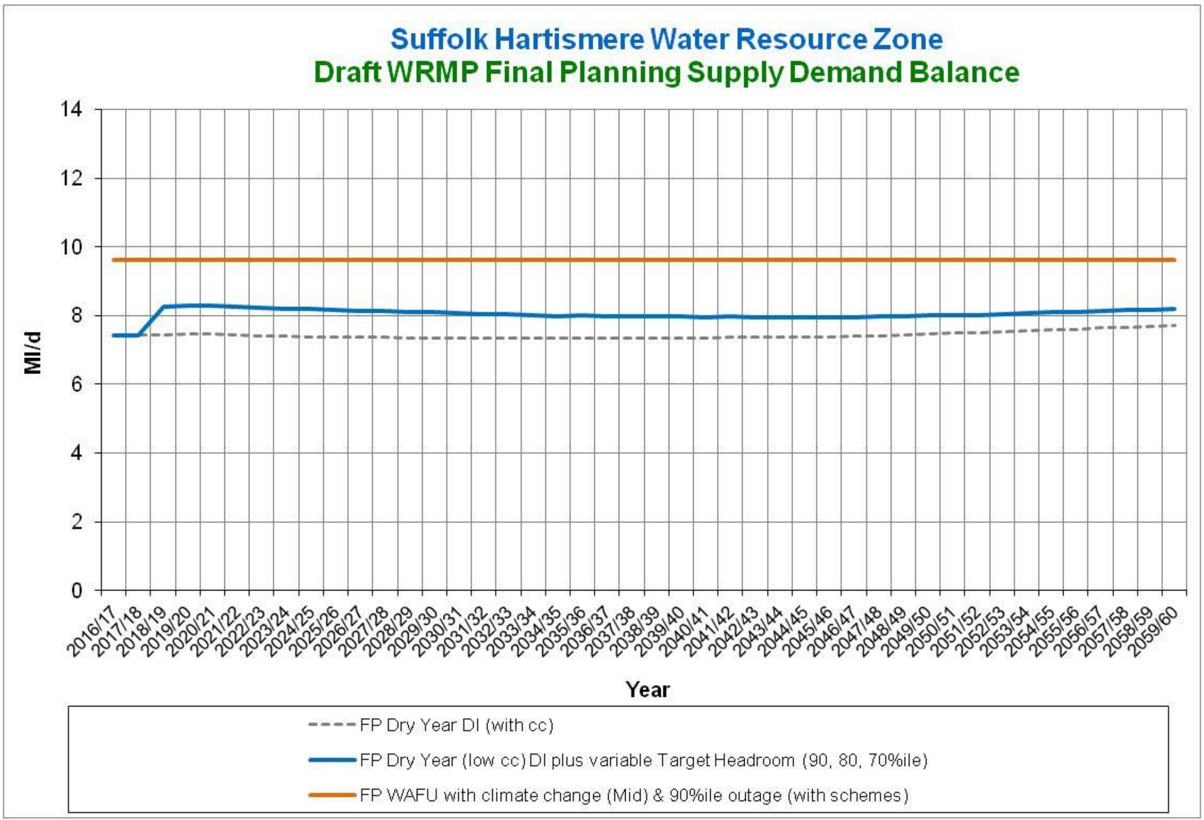


Figure 0.3: Final Planning Supply Demand Balance – Suffolk Hartismere WRZ

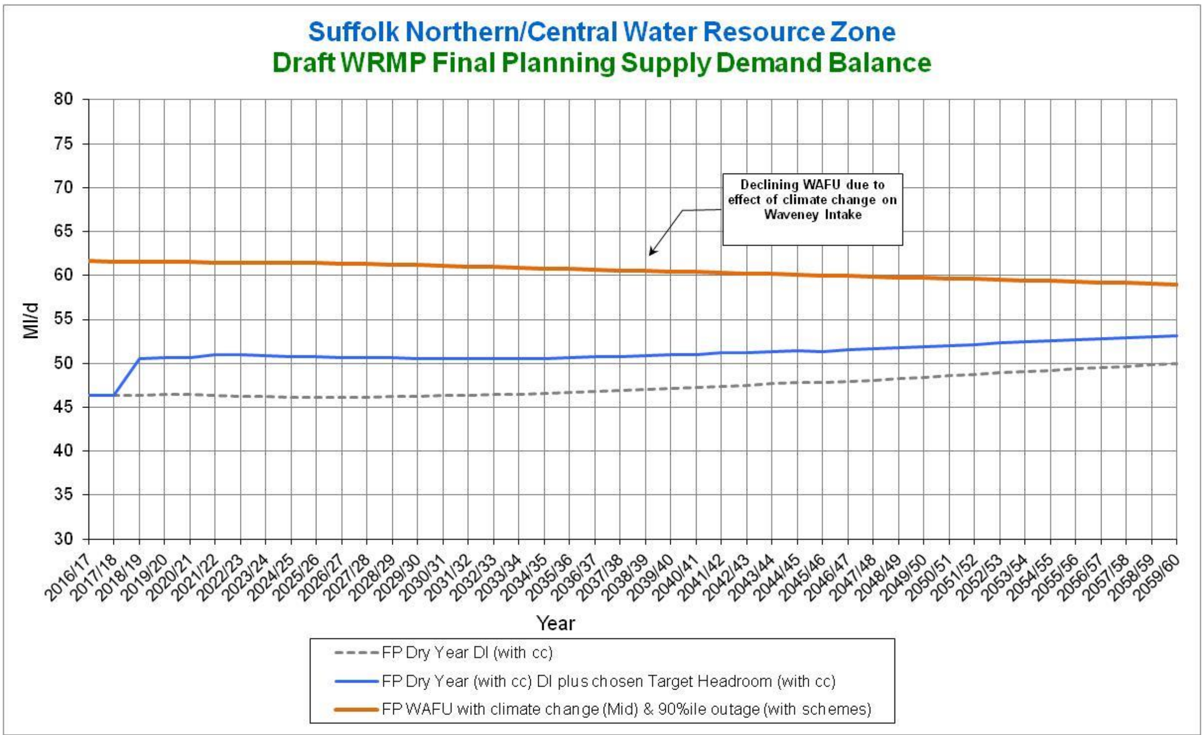


Figure 0.4: Final Planning Supply Demand Balance – Suffolk Northern Central WRZ

The supply surplus in the Suffolk WRZs is not sufficient to offer a supply to a neighbouring water company. The Essex WRZ supply surplus is less than that presented in ESW's PR14 WRMP. This is because of a recent (2015) trade of 20 Ml/d of raw water with Thames Water Utilities. Consequently, ESW can only offer 5Ml/d for trading until 2035 and then 25Ml/d from 2035 onwards.

Drought Resilience

ESW has tested the resilience of its water supply systems to a very severe drought which is calculated to occur once in every 200 years on average. The Company has used models to simulate the effects of such a drought on deployable output. The Company's modelling confirms that all four of its water resource zones are very resilient as a supply surplus would still be maintained during such an extreme drought.

CONTENTS

1.0 INTRODUCTION

1.1 Overview

This document is Essex & Suffolk Water's (ESW) draft Water Resources Management Plan (WRMP). It has been prepared following the Water Resources Management Plan (England) Direction 2017 (Defra, 2017), Defra's Guiding Principles for Water Resources Planning (Defra, 2016) and the Environment Agency's (the Agency) Water Resources Planning Guideline (the WRPG) (Environment Agency, 2017).

The WRPG requires the WRMP to demonstrate that ESW has an efficient, sustainable secure supply of water over the Company's chosen planning period which must be a minimum of 25 years. For this WRMP, the Company has prepared water demand and supply forecasts for a 40 year planning period from 1 April 2020 to 31 March 2060.

The WRMP covers the entire ESW customer supply area (see Figure 1 in Appendix 1). For the purposes of the Company's demand forecasts and supply demand balance calculations, the supply area has been split into the following Water Resource Zones (WRZ) (see Figures 2 and 3 in Appendix 1):

Table 0.4: ESW Water Resource Zones

Supply Area	Water Resource Zone
Essex	Essex WRZ
Suffolk	Blyth WRZ
	Hartismere WRZ
	Northern Central WRZ

The Essex and Suffolk supply areas are located within some of the driest areas of the country and as such face particular challenges including growing demand, uncertainty from climate change and a general lack of new intrinsic water resources. ESW has always fully embrace the concept of the 'twin track approach' to maintaining water supplies through a combination of demand management and water supply schemes and initiatives.

ESW prides itself on its track record of demand management and in delivering innovative water supply solutions such as the Langford Effluent Recycling Scheme and the Abberton Scheme, both of which are described within this Plan. The Company has amongst the lowest levels of leakage in the UK and is an acknowledged industry leader in water efficiency and water conservation. Additionally ESW is fully committed to achieving the maximum possible level of domestic meter penetration within an appropriate timescale and with our customer's support.

Despite all the rigorous work on demand management, ESW's PR09 WRMP recognised that a major water resource scheme was required in the Essex WRZ to meet the growing demand for water. The Abberton Scheme was identified as being the appropriate option for ESW to pursue during AMP5. The Abberton Scheme comprised three major elements, namely:

iv. the upgrade of the Ely Ouse to Essex Transfer Scheme (EOETS) by way of two new pipelines and an upgrade to the pumping facilities;
v. a variation to the abstraction licence at Denver in Norfolk from where water is transferred by the EOETS; and
vi. the enlargement of Abberton Reservoir.

All works were completed in 2012 providing the Essex WRZ with a PR14 supply surplus through the planning period.

In this draft WRMP, all components of the supply and demand forecasts have been reviewed using the appropriate methods recommended in the Environment Agency's (WRPG).

1.2 Regulatory Framework

This WRMP has been produced as part of a statutory process, as reflected in the Water Resources Management Plan Regulations 2007 and the Water Resources

Management Plan Direction 2017. Additionally, it has been produced with reference to the following guidance:

- Guiding Principles for Water Resources Planning, Defra, May 2016
- Water Resources Planning Guideline, Environment Agency, 2017

Additional detailed guidance and methodologies on specific aspects of the plan are referenced in relevant sections of this document.

This draft WRMP is supported by ESW's Drought Plan (www.eswater.co.uk/droughtplan), which shows how droughts will be managed, what trigger levels will be used to identify when action is required, and what measures are available to support supplies when Levels of Service (LoS) are compromised.

As all four ESW WRZs have a surplus of water across the full planning horizon to 2045, no new water resource options are required, negating the need for a Strategic Environmental Assessment.

1.3 Consultation

1.3.1 Pre-draft Water Resources Management Plan Consultation

ESW recognised the value of early communication with the many stakeholders potentially affected by and involved in the water resources planning process. It has:

- Written to all neighbouring water companies seeking their views on what should be included in our draft WRMP. Pre-draft WRMP consultation has also taken place through the Water Resources East (WRE) project and through the Ouse Working Group which are both attended by the East Anglian water companies;
- Held regular liaison meetings with the Agency and Natural England, where different elements of the draft WRMP have been discussed;
- Presented to the Company's Customer Challenge Group (known as the Water Forum) on different elements of the draft WRMP including leakage, metering, water efficiency, catchment management and drought management; and
- Presented to Ofwat and to the Consumer Council for Water.

Outcomes of the above engagement has been taken into consideration in the development of this draft WRMP.

1.3.2 Draft Water Resources Management Plan Consultation

The following statutory consultees are invited to comment on this Plan:

- Ofwat
- Environment Agency
- Secretary of State (c/o Defra)
- Any Regional Development Agencies in the area covered by the Plan

- Any elected Regional Assembly in area of the Plan
- All local authorities in the area of the Plan
- The Broads Authority
- Natural England
- The Historic Buildings and Monuments Commission for England.
- Any navigation authority in the area of the Plan
- Thames Water Utilities (TWU)
- Anglian Water Services (AWS)
- The Consumer Council for Water

ESW also welcomes comments and representation from the wider community, including customers and other interest groups.

1.3.3 Making Representation

The public consultation for this draft Water Resources Management Plan is taking place between Monday 5th March and Friday Sunday 27th May 2018. The start of the consultation will coincide with publication of the document on ESW's website:

http://www.eswater.co.uk/wrmp

Any person, including statutory consultees, stakeholders and customers, may make representations to the Secretary of State during this period.

Representations by e-mail should be sent to:

water.resources@defra.gsi.gov.uk

and be titled: "Essex & Suffolk Water Water Resources Management Plan".

Representations by post should be sent to:

Secretary of State, Department for Environment Food and Rural Affairs (DEFRA)
Essex & Suffolk Water Water Resources Management Plan Consultation
Water Resources
Department for Environment Food and Rural Affairs
Area 3D
Nobel House
17 Smith Square
London, SW1P 3JR

The Secretary of State will forward all comments on to us. ESW will then review the comments received and publish a Statement of Response by Friday 31st August 2018 on ESW's website. This will detail any changes ESW will make to this Plan as a result of the feedback received during the public consultation. Subject to approval by the Secretary of State, ESW's final Water Resources Management Plan will then be adopted and published in 2018.

1.4 Water Resources Plan Structure

Subsequent sections of this draft WRMP are as follows:

Section 2 Background Information: This section provides background information including a description of each of ESW's WRZs, progress made in implementing the Company's 2015 WRMP, confirmation of the base year and planning period and confirmation of the Company's position regarding the trading of surplus water resources.

Section 3 Water Supply: This section presents the results of the Deployable Output (DO) assessments and describes how DO has been calculated for each source and WRZ. Additionally, it describes reductions in DO, treatment works process losses and outage allowances.

Section 4 Water Demand Forecasts: This section presents the results of the demand forecast and describes in detail the method used to prepare the forecast.

Section 5 Water Efficiency: This section covers ESW's full and ongoing commitment to demand management and covers water efficiency, metering and leakage.

Section 6 Effects of Climate Change: This section presents the results of the climate change assessments and describes the methodology used. The assessments consider the effect of climate change on both baseline supply and demand.

Section 7 Target Headroom: Target headroom is a buffer between supply and demand designed to cater for specified uncertainties. This section presents the results of the target headroom assessment and describes the method used to undertake the assessment.

Section 8 Baseline Supply Demand Balance: This uses the supply and demand data from the previous sections to prepare a supply demand balance graph for each WRZ. These graphs are then used to identify whether there is likely to be a supply deficit at any point across the planning horizon.

Section 9 Options Appraisal: This section would normally cover an appraisal of all supply and demand options that would be required to ensure there is a supply surplus in each WRZ over the planning horizon. However, ESW's baseline supply demand balance confirms all four WRZs are in surplus over the whole planning horizon and so an options appraisal is not required.

Section 10 Final Water Resources Strategy: This section confirms ESW's final water resources strategy.

2.0 BACKGROUND INFORMATION

2.1 Water Resource Zones

2.1.1 Background

Essex & Suffolk Water (ESW) has geographically separate supply areas, known as the Essex supply area and Suffolk supply area (Figure 1, Appendix 1). Water is supplied to approximately 1.65 million customers in the Essex supply area and 0.27 million customers in the Suffolk supply area.

In line with the Water Resources Planning Guidelines (WRPG), ESW's Water Resources Management Plan (WRMP) is based on assessments undertaken at a Water Resource Zone (WRZ) level. The definition of a WRZ (from Water Resources Planning Tools (WR27), UKWIR, 2012a) is:

The largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which all customers will experience the same risk of supply failure from a resource shortfall.

In the case of ESW, four WRZs have been delineated, one in Essex (the Essex WRZ) and three in Suffolk known as the Blyth, Hartismere, and Northern Central WRZs. Schematic diagrams of the WRZs and associated infrastructure are shown in Figures 2 and 3 in Appendix 1 for Essex and Suffolk respectively.

None of ESW's WRZs have changed from those last reported to the Agency. The resource zones used for water resources planning purposes are described below.

2.1.2 The Essex Water Resource Zone

The Essex WRZ (see Figure 2, Appendix 1) is bounded by the Thames Estuary in the south and the Essex coastline up to Salcott in the east. The WRZ stretches as far north as Silver End and as far west as the London Boroughs of Redbridge, Barking and Havering. The WRZ includes the towns of Southend-on-Sea, Chelmsford, Witham, Brentwood, Billericay, Basildon, Grays, Dagenham and Romford.

The intrinsic water resources include the rivers Chelmer, Blackwater, Stour and Roman River, which support pumped storage reservoirs at Hanningfield and Abberton, and treatment works near Langford, Langham, Hanningfield and Layer. The remaining water sourced from inside the Essex WRZ (approximately 2% of total water supplied in the zone) is derived from groundwater via Chalk well and adit sources in the south and south west of the zone near Stifford and Roding.

Water transferred into the Essex supply area comes from two sources, namely the Chigwell raw water bulk supply from Thames Water Utilities (TWU) Lea Valley Reservoirs and the Ely Ouse to Essex Transfer Scheme (EOETS).

Of the potable water supplied in the Essex WRZ, ~20% is provided via the Chigwell raw water bulk supply. The raw water is pumped directly to ESW's treatment works for treatment and then into distribution.

In a dry year, flows in the River Stour and River Blackwater can be supported by the EOETS, owned and operated by the Agency. Raw water is transferred via pipelines and pumping stations, from Denver in Norfolk to the headwaters of the River Stour and River Blackwater (Figure 1, Appendix 1).

Additionally, in dry periods the Agency may operate its groundwater river support schemes, particularly when transfers via Denver are limited or not possible. The two schemes with potential to support river flows in Essex are the Stour Augmentation Groundwater Scheme (SAGS) and the Great Ouse Groundwater Scheme (GOGS).

The Essex rivers and their associated intakes, the pumped storage reservoirs near Abberton and Hanningfield, and associated raw water transfer pipes, pumping stations and treatment works are collectively known as the 'Essex System'. This reflects the nature of the supply network in Essex which is a highly integrated one, with a large degree of flexibility for moving raw and potable water around the zone to where it is required.

The preferred mode of operation of the Essex treatment works during the summer is for Langham, Langford, Layer and Chigwell treatment works to provide a reasonably constant base-load, with output from Hanningfield treatment works varying to meet the remaining demand.

At the end of 2003, ESW completed works to construct an innovative effluent recycling scheme near Langford. The Scheme intercepts effluent from Chelmsford Sewage Treatment Works and treats it to a very high standard at a purpose built treatment plant near Langford. Once treated, the water is discharged into the River Chelmer 3km upstream of our abstraction intake where it augments the natural flow. It is then available for re-abstraction via existing intakes supporting both Langford treatment works and storage into Hanningfield Reservoir. The Scheme can provide up to an additional 20 Ml/d of water during May to November for use within the Essex System during dry periods.

2.1.3 Suffolk Blyth Water Resource Zone

The Blyth WRZ (see Figure 3, Appendix 1) is bounded by the Suffolk coastline in the east stretching from Aldeburgh in the south to Walberswick in the north. The WRZ stretches as far west as Earl Soham, and as far north as Chediston, and includes the towns and villages of Saxmundham, Leiston, Framlingham, Peasenhall and the southern side of Halesworth. The Blyth WRZ is predominantly rural in nature.

All the water supplied within the Blyth WRZ is sourced from groundwater via Chalk and Crag boreholes.

2.1.4 Suffolk Hartismere Resource Zone

The Hartismere WRZ (see Figure 3, Appendix 1) is bounded to the north by the River Waveney, from its source at Redgrave in the west, to Mendham in the east. The zone stretches as far west as Rickinghall and Wyverstone Street, and as far south as Mendlesham Green and Aspall. The WRZ includes the town of Eye, situated on the River Dove, a major tributary of the River Waveney. The Hartismere WRZ is also predominantly rural in nature and the landscape is characterised by arable farming.

All the water supplied within the Hartismere WRZ is sourced from groundwater abstracted from Chalk and Crag boreholes. It should be noted that Syleham Treatment Works is located within the Hartismere WRZ although receives a raw water import from boreholes located in the Northern Central WRZ.

The Hartismere WRZ was particularly affected by the 1995 -1997 drought. As a result a large number of improvements were made in the zone, including the commissioning of new groundwater sources near Bedingfield and Syleham, and network improvements to enable water to be more easily transferred around the WRZ.

2.1.5 Suffolk Northern Central Water Resource Zone

The Northern Central WRZ is bounded by the River Waveney and River Bure to the west, and the Suffolk coastline from Southwold to Winterton-on-Sea in the east. The WRZ includes the towns of Lowestoft, Great Yarmouth, north Halesworth, Bungay and Beccles. Demand in the WRZ is heavily influenced by the large population centres of Lowestoft and Great Yarmouth.

Approximately 70% of the water supplied in the Northern Central WRZ is sourced from surface water, and 30% sourced from groundwater in the south of the WRZ.

Surface water is provided via four sources, namely the River Waveney near Beccles, the River Bure near Wroxham, and groundwater fed lakes called Ormesby Broad, and the Lound Ponds and Fritton Lake. Water from the River Waveney is treated at Barsham River treatment works, water from the River Bure and Ormesby Broad is treated at Ormesby water treatment works (WTW) and water from Lound Ponds and Fritton Lake is treated at Lound treatment works.

A smaller component of raw water from groundwater can be sourced from remote Chalk groundwater sources near Wroxham in the north of the WRZ, which is treated at Ormesby WTW. Larger quantities of groundwater produced in the south of the WRZ are sourced from Chalk groundwater sources near Halesworth, Holton and Beccles and Crag and Gravel wells near Southwold and Broome respectively.

The Northern Central WRZ is named to reflect the fact that historically it effectively operated as two 'sub-zones' called the Northern WRZ and the Central WRZ, although it is no longer appropriate to consider these as separate resource zones. The Northern 'sub-zone' contains Ormesby treatment works and Lound WTW, whilst the Central 'sub-zone' contains Barsham treatment works and all the groundwater sources, except those near Wroxham.

2.2 Water Resource Zone Integrity

The WRPG states that WRMPs should be built up of assessments undertaken at a WRZ level. The WRZ describes an area within which the abstraction and distribution of supply to meet demand is largely self-contained (with the exception of agreed bulk transfers).

Within a WRZ, all parts of the supply system and demand centres (where water is needed) should be connected so that all customers in the WRZ should experience the same risk of supply failure and the same level of service for demand restrictions. The WRPG accepts that there will be limitations to achieving these due to the specific characteristics of a distribution network but significant numbers of customers should not experience different risks of supply failure within a single WRZ. ESW undertook a Water Resource Zone Integrity Assessment as part of its 2019 Periodic Review (PR19) WRMP.

For all of ESW's WRZs, treated water transfers can be made between Distribution Zones (DZ) within the respective WRZ. If there is a supply deficit within a DZ, this can be balanced by an internal transfer from a neighbouring Distribution Zone and/or by substitution from other Distribution Zones within the WRZ. These intra-WRZ transfers are physically made by opening Distribution Zone boundary valves or by pumping. Consequently, a supply shortfall in one Distribution Zone can be made up from other Distribution Zones within the WRZ. Given the above, ESW's initial assessment concluded that all of its WRZs meet the WRZ definition.

The assessment, which was accepted by the Agency, concluded that all WRZs met the UKWIR/Agency definition.

ESW reviewed and updated its PR14 WRZ Integrity Assessment in February 2017 and submitted it to the Agency. The update followed the Agency's 2016 guidance entitled, "WRZ assessment methods (Water Resource Zone Integrity)".

The PR19 assessment concluded that there have been no significant changes to the infrastructure in the Essex, Blyth and Hartismere WRZs and so they remain compliant with the WRZ definition. A new scheme called the 'Lound to Gorleston Pumping Station and Pipeline' is currently being implemented in the Northern Central WRZ and will be operational in 2018/19. This means that the Northern Central WRZ will also fully comply with the WRZ definition.

2.3 Progress with Implementing the 2015 Water Resources Management Plan

The 2015 Water Resources Management Plan did not contain any supply side options as a supply surplus was maintained in all four WRZs across the full planning horizon.

ESW's AMP6 National Environment Programme (NEP) obligations will be fully met by 31 March 2020. Progress with the delivery of the AMP6 NEP is presented in Section 3.8 while progress with our leakage, metering and Water Efficiency programmes are presented in Section 5.

2.4 Sharing Surplus Water Resources

2.4.1 Background

WRZ supply / demand balance calculations were prepared in early 2017. These showed that whilst the three Suffolk WRZs were likely to all be in surplus of supply to demand over the planning horizon, there were not sufficient surpluses to make sharing with a neighbouring water company, even for a limited period, a viable option. The Essex WRZ had a small surplus supporting a trade of 5Ml/d until 2035. This increases to 25Ml/d from 2036 when a 20Ml/d bulk supply agreement with Thames Water comes to an end.

In accordance with the WRPG (Environment Agency, 2016) ESW wrote to neighbouring water companies to confirm what volumes could be potentially available for sharing (i.e. trading) with other water companies.

No water companies have asked to progress agreements to share the small available Essex supply surplus.

As with previous periodic reviews, ESW has held discussions with regional companies, specifically with Anglian Water Services, Affinity Water and Cambridge Water through the Water Resources East (WRE) project (see section 2.5 below) and also through the Ouse Working Group.

2.5 Regional Water Resources (Water Resources East)

Although ESW's WRZs are in surplus through to the end of the planning period, eventually new water resources will need to be developed for all areas. Operating in the driest part of the country, with increasing demands on current supplies of fresh water and the potential for sustainability reductions being applied to the Company's abstraction licences, ESW recognises that "new" water for potable supplies will be difficult to come by. It is also recognises that in the future, it is going to be more economically viable and politically acceptable to develop joint regional water resource schemes that benefit a number of water companies and, most probably, other abstractors.

For some East Anglian region water companies, supply-demand deficits by 2060 will become more widespread, the deficits being driven by growth, climate change and sustainability reductions to abstraction licences. In response, connectivity in supply systems may have to be increased, more trading of resources may be required along with the development of new supplies. Most demand management initiatives will have been completed by 2060. Since there are no resources available for year-round direct abstraction, options for developing these will be limited to winter storage reservoirs, water reuse schemes and aquifer storage and recovery. All of these have high CAPEX, OPEX and carbon requirements.

Given the above, the Water Resources East (WRE) project was setup with the mission to work in partnership to safeguard a sustainable supply of water for the East of England, resilient to future challenges and enabling the area's communities, environment and economy to reach their full potential. The Water Resources East project brings together partners from a wide range of industries, including water, energy, retail, the environment, land management and agriculture, who are working collaboratively to manage these challenges, building on the area's unique opportunities for sustainable future growth and pioneering a new approach to managing water resources.

The goal of the WRE project is to develop a long-term, multi-sector water resource strategy for the East. The vision is for an integrated strategy, with trade-offs between industry sectors that will balance the needs of all partners.

The project has delivered a baseline vulnerability assessment for the region. This highlights that by 2080, water supplies in some parts of the region will be vulnerable due to:

- The impact of climate change on hydrological flows and groundwater levels;
- Growth in customer demand; and
- Sustainability reductions applied to abstraction licence licensed quantities.

The project has also used modelling techniques called Robust Decision Making (RDM) and Multi-criteria Search (MCS) to identify a potential investment portfolio that will deliver water supply resilience to all sectors in the region. A plausible set of future scenarios has been developed allowing investment portfolios to be tested. These comprised different combinations of demand forecasts and supply-side options and each have been assessed on the basis of their performance against criteria designed to reflect the priorities of water companies, other industries (agriculture and power generation), regulators, customers and the environment.

ESW fully supports the Water Resources East's (WRE) project both now and in the future. ESW operates in a water stressed area and so has welcomed the opportunity to work collaboratively with a wide range of industries to develop a long-term, multi-sector water resource strategy for the East.

The baseline vulnerability assessment has highlighted that the resilience of water supplies, for example, in the county of Suffolk, could be vulnerable to future droughts by 2060. This is partly because of the reliance of the county on groundwater supplies from the Chalk and Crag aquifers and the likelihood that abstraction licences could be subject to reductions in annual licensed quantities to ensure they are sustainable. The sustainability of ESW's Suffolk groundwater abstraction licences will be investigated in AMP7 (2020 to 2025) as part of the Water Industry National Environment Programme (WINEP).

The WRE project has identified an early investment portfolio based on its performance across a wide variety of different futures and so aims to increase multi-sector water resource resilience across the region. However, as ESW has a supply surplus in all four of its water resource zones, it does not have a requirement to develop new supply schemes. In Suffolk, the size of the supply surplus precludes any trading of water. In Essex, the supply surplus is not big enough to allow ESW to make large exports (>5Ml/d) of raw or treated water to other companies until 2035.

Nevertheless, ESW recognises that in the future, there may be schemes that do involve its water supplies but that do not impact on the Company's deployable output or its own resilience. When such schemes are developed, they can be considered in future WRMPs. ESW also notes that if sustainability changes are applied to Suffolk groundwater abstractions in AMP7, this could cause a supply deficit. ESW would therefore consider any options to eliminate such a supply deficit with the WRE project.

2.6 Planning Period and Base Year

The statutory planning period for WRMPs is a minimum of 25 years, from 1 April 2017 to 31 March 2045. However, the Water Resources Planning Guideline encourages water companies to plan over a longer planning horizon. For the purposes of this Plan, the planning period is for 40 years from 2020 to 2060.

The base year for supply/demand data is 2016/17, as this was the most recent year ESW has out-turn data for, and is also in line with the WRPG.

2.7 Planning Scenarios

The baseline and final plan supply forecasts for each Water Resource Zone are based on a 'dry year' which is defined by the worst historical drought in the record used for planning. The design drought years are described in the Deployable Output section of this report (see section 3.1).

The WRPG also requires water companies to provide a supply and demand forecast for each water resource zone for a drought with a return period of 1 in 200 years. These are presented in section 3.3 for the Essex system, 3.5 for the Waveney and Bure area and section 3.7 for groundwater sources.

The following planning scenarios are included in this WRMP:

- Dry year annual average daily demand forecast (baseline);
- Dry year annual average daily demand forecast (final plan); and
- Normal year annual average daily demand forecast (baseline).

ESW's assumptions regarding the impacts of climate change on both Water Available for Use (WAFU) and demand are described in section 6.

Operational experience has indicated that critical period scenarios such as those based on Average Day Peak Week (ADPW) are not appropriate for the Essex and Suffolk WRZs as none are significantly peak constrained from a water resources perspective. In the case of the Essex WRZ, peaks can be absorbed due to the integrated nature of the supply network and the storage provided by the two large pumped storage reservoirs. Similarly, in the Suffolk Northern Central WRZ, the flexibility over utilisation of the three main surface WTWs at Lound, Barsham and Ormesby provides a buffer to impacts from peak demands. Subsequent to the 1995-1997 drought, significant investment was made in network improvements and enhancement of security of supply within the groundwater fed zones of Hartismere and Blyth. This effectively removed any residual peak/critical period concerns, and hence no ADPW or similar peak scenarios are presented in this WRMP.

2.8 Problem Characterisation and Risk Composition

2.8.1 Problem Characterisation

Problem Characterisation requires water companies to assess the vulnerability of each of their Water Resource Zones to various strategic issues, uncertainties, and risks. ESW undertook its problem characterisation assessment in 2016 and submitted the resulting report to the Environment Agency. The assessment was completed following the method outlined in the 2016 UKWIR report entitled 'WRMP19 Methods – Risk Based Planning' (UKWIR, 2016a).

The first stage of the problem characterisation assessment was an assessment of 'strategic needs'. This entailed three simple 'headline' questions that explored the size of any potential supply demand deficit, and if required, the cost of any supply and demand management options. All four of ESW's WRZs had a supply surplus in all years of the planning horizon under the Baseline scenario. At the time of the assessment, it was reasonable to assume that all WRZs would continue to have a supply surplus in this draft PR19 WRMP and so no investment would be sought to fund supply and / or demand management measures.

The second stage of the problem characterisation was an assessment of the 'complexity factors'. This stage asked whether there was concern regarding understanding of near term supply system performance, either because of:

i. Recent Level of Service failures; or
ii. Poor understanding of system reliability/resilience under different or more severe droughts than those contained in the historic record.

Given the forecast supply surplus in all four of the Company's WRZs, there were no significant concerns about understanding of near term supply system performance and we continue to meet our levels of service.

A similar question was asked regarding demand and whether the nature of current or near term demand had recently changed or was likely to change, e.g. because of large scale metering programmes or sudden changes in economics/demographics. At the time of the assessment, the nature of current and near term demand had not recently changed. Industrial demand was generally falling and domestic demand was fairly constant.

The problem characterisation assessment concluded that all four of the Company's WRZs had a "low vulnerability" score. The results of this assessment were then carried forward to the risk composition stage detailed below.

2.8.2 Risk Composition

Risk composition requires water companies to select and justify one of the following three approaches in developing their WRMPs:

i. Conventional;
ii. Resilience Tested; or

iii. Fully risk-based.

The guidance provides a summary description of the approaches and techniques for each approach for developing supply and demand forecasts and is re-produced below.

Table 2.1: Risk composition approaches

Risk Composition	What is it?	Specifics of what is Involved (supply, demand, investment)
1 – The 'Conventional' Plan	Estimates of supply capability are based on the historic record, perturbed for climate change. Any testing of droughts outside of the historic record is done using a simple 'top down' method and is only done to examine supply / demand risk under more extreme conditions (i.e. sensitivity analysis only). Uses a simple representation of dry year/normal year demand.	*Supply* – conventional 'Deployable Output' (DO) or historically based time series. *Demand* – dry year/normal year estimates. *Investment* – inputs to the Decision Making Tool (DMT) are based on analysis of the historic record and the investment programme therefore represents the 'best value' response to maintaining Levels of Service and resilience against the historic record.
2 – The 'Resilience Tested' Plan	Companies use 'Drought Events' to test the Plan and look at the implications of alternative/more severe droughts on the 'best value' investment programme. These 'Drought Events' can be derived using a variety of top down methods, but their 'plausibility' (approximate level of severity) is checked using *metrics* of rainfall, aridity or hydrology. More complex representation of demand *variability* can be tested.	*Supply* – conventional plus 'event based' DO or time series. *Demand* - conventional, or can use demand/weather models to create equivalent demands for generated events. *Investment* – Events are used to test the programme; either by comparing the resilience of similar NPV programmes, or to look at the cost implications of achieving Level of Service (LoS) commitments and resilience to droughts outside of the historic record.
3 – The 'Fully Risk Based' Plan	Companies use modelling methods to evaluate a full range of drought risks to their supply system, supported by more sophisticated approaches to matching this with demand *variability*. This is used to generate a 'best value' WRMP at a level of resilience that is linked to Levels of Service and the Drought Plan.	*Supply* – companies use generated data sets to explore the yield response to drought severity and patterns. Inputs to system-simulation DMTs are based on probabilistic sampling of the drought response. *Demand* - demand variability to drought is incorporated, although methods/complexity can vary. *Investment* the Plan is developed to represent the 'best value' response to overall drought risk, according to the Company's stated LoS and drought resilience.

The guidance states that the over-riding concept when choosing which approach to follow is that non-conventional methods (i.e. Risk Composition 2 and 3) for forecasting supply and demand should only be used where they are warranted and should be proportionate to the supply demand problem as defined in the problem characterisation stage. Methods beyond the ‘Conventional’ baseline can be chosen, but only need to be followed where there are specific concerns with the supply/demand components that mean a risk based approach is needed to better understand the supply/demand problem that they face.

ESW’s early (2016) supply and demand forecasts indicated that all four of the Company’s WRZs would have a supply surplus across the full planning period. As such, the problem characterisation assessment concluded that all four of ESW’s WRZs had a low vulnerability to supply deficits. Consequently, the ‘Conventional’ methods (i.e. Risk Composition 1) methods have been used to forecasting future demand, water supplies and target headroom to allow for uncertainty in the forecasts.

Baseline supply and demand forecasts were re-calculated during 2016/17 and these also confirmed that a supply surplus would be maintained across the statutory minimum 25 year planning horizon. Consequently, there was no need to re-assess the forecasts using Risk Composition 2 or 3 methods.

Inline with the WRPG, the Company has applied some Risk Composition 2 approaches in that each WRZ has been tested against a theoretical drought event which could occur 1 year in every 200 years on average.

2.9 Reconciliation of Data

ESW has used the Maximum Likelihood Estimation method (MLE) to reconcile the water balance at resource zone level in order to minimise the uncertainty in base year estimates. MLE provides a good framework to reconcile the water balance to ensure the sum of the estimated components equates to distribution input. The standard method for MLE is provided in an UKWIR / NRA report (UKWIR & NRA, 1995).

2.10 Sensitivity Testing

In developing this WRMP, ESW has made a number of assumptions. The Agency has highlighted the importance of including a description of the sensitivity of the WRMP to these assumptions.

The WRPG (Environment Agency, 2017) indicates that as a minimum the sensitivity analysis should consider:

i. The sensitivity of the supply demand balance to data uncertainty; and
ii. The sensitivity of the DO to leakage, climate change and sustainability reductions.

Item (i) is considered in detail within the calculation of headroom uncertainty and hence an assessment of sensitivity for each WRZ has been included in section 7.4 within the chapter on target headroom.

Item (ii) is considered in section 5 (Leakage), section 6 (Climate Change) and section 8.8 (Sustainability Reductions).

2.11 Company Policies including Level of Service

2.11.1 Customer Consultation

CCWater and YouGov research into restrictions on the use of water (June 2012) found that customers perceive three main causes of drought; lack of rain (77%), leaks from water pipes (77%) and household customers using too much water (49%). Businesses (31%), agriculture (12%), climate change (38%) and extraction of water from river (31%) were also expressed as causes of drought, but to a lesser extent.

The 1 in 20 year risk of a hosepipe ban appears to be acceptable to the majority of domestic and business research participants. Customer priorities and willingness to pay research conducted in 2011 suggested a low willingness to pay for reduced risk of water restrictions; three Essex and Suffolk participants out of forty suggested they would be willing to see their bills increase by £0.63 for a reduced risk of hosepipe bans. Two participants were less accepting of this level of risk, however their reasoning was based on inaccurate information that Essex and Suffolk Water had sold a reservoir and had facilities for desalination of sea water.

Qualitative research conducted for PR14 suggested that during a prolonged interruption to supply customers are most concerned about the plants in their gardens dying and how supply would be maintained for vulnerable customers.

2.11.2 PR19 WRMP Levels of Service

Levels of service are expressed in terms of expectations about the frequency of restrictions on use during dry years, and set out the standard of service that customers can expect to receive from their water company.

Levels of service are generally grouped into the following categories:

Level 1: Appeal for restraint
Level 2: Temporary Use Ban
Level 3: Drought Order Ban
Level 4: Reduced supply at customer tap

A Level 1 restriction is when ESW asks customers to use water wisely. For example, watering plants at night and not watering the lawn because grass is resilient to drought.

A Level 2 restriction (Temporary Use Ban or TUB) applies mainly to the domestic use of water and stops the use of a hosepipe or sprinkler for any garden watering or cleaning. For household customers, this use to be referred to as a hosepipe ban.

A Level 3 restriction (Drought Order) bans what has been applicable to the domestic customer under the Temporary Use Ban, to non domestic or commercial customers. These bans have economic consequences for businesses and have to be used as sparingly as possible.

A Level 4 restriction results in a temporary reduction or nil supply of water at the customer tap. Examples of Level 4 restrictions include:

- Reduced pressure at the customer tap (and therefore reduced flow);
- Rota cuts (e.g. 12 hours normal supply, 12 hours no supply); or
- Standpipes where supplies to customer's taps are turned off leaving customers to fill containers from an in pavement standpipe tap.

ESW does not consider the use of standpipes or rota cuts to be viable options. It is considered that they are not technically possible and that they are unacceptable in modern society. However, reducing pressure at the customer tap is viable.

The PR19 'planned' levels of service for ESW's customers are as follows:

Level 1: Appeal for restraint	1 in 10 years
Level 2: Phase 1 Temporary Use Ban	1 in 20 years
Level 3: Phase 2 Drought Order Ban	1 in 50 years
Level 4: Pressure Reduction	1 in 250 years

The levels of service for Level 1, 2 and 3 restrictions remain the same as in PR14.

The PR14 Level 4 restriction related to the use of rota cuts and the level of service was 'never' (i.e. even in the most extreme of droughts, ESW would only ever impose Level 1, 2 and 3 restrictions). However, the Agency requires ESW to state a level of service for Level 4 restrictions. As described above, it is still believed that rota cuts and standpipes should never be used but that pressure reduction to reduce the flow rate at customer's tap is viable. ESW therefore defines the PR19 Level 4 restriction as reducing pressure at the customer tap with a return period of 1 in 250 years on average. This return period is based the following:

i. Modelling for this draft WRMP has confirmed that all Water Resource Zones (WRZ) are resilient across the full 40 year planning period to a drought that occurs on average once in 200 years; and
ii. A recent water industry study called the Water Resources Long Term Planning Framework (https://www.water.org.uk/water-resources-long-term-planning-framework), indicated that while supplies can be maintained during a drought that occurs on average one in 200 years, a more severe drought could impact on supplies. The study's conclusion also supports a Level 4 restriction level of service of one in 250 years on average.

ESW customer research has showed that there was no desire amongst customers to pay more for increasing the Level 2 return period above 1 in 20 years.

In terms of actual levels of service, this can only be determined retrospectively and through consideration of return periods. The following table indicates the dates on which appeals for restraint and restrictions have been implemented within the Essex and Suffolk supply areas since 1976.

Table 2.2: ESW appeals for customer restraint and restrictions since 1976

Drought Year	Supply Area*	Appeals for Restraint	Phase 1 Temporary Use Ban (Previously known as a Temporary use ban)	Phase 2 Drought Order Ban (Previously known as Non Essential Use Restrictions)	Rota Cuts
1976	Essex	Yes	Yes	No	No
	Suffolk	Yes	Yes	No	No
1990/92	Essex	Yes	Yes	No	No
	Suffolk	Yes	Yes	No	No
1995/97	Essex	Yes	Yes	No	No
	Suffolk	Yes	Yes	No	No
2006	Essex	Yes	No	No	No
	Suffolk	Yes	No	No	No
2011/12	Essex	Yes	No	No	No
	Suffolk	Yes	No	No	No

*Restrictions in Suffolk have always been applied across the whole supply area and not in selected resource zones

2.11.3 Essex

ESW has undertaken a modelling assessment to determine the frequency of temporary use bans in Essex in terms of the historic naturalised flow time series available in the water resource planning model, *Aquator*. Total reservoir storage volumes were estimated using the average dry year demand forecast for AMP6 and the naturalised flow time series from 1933-1996. Daily combined storage for the Essex reservoirs was exported from the model and compared to the reservoir curves for the implementation of demand reduction actions. The number of days in which reservoir storage was below the reservoir curves was calculated and used to determine the actual level of service the Essex System customers could expect. The results indicate that ESW is exceeding the 'planned' levels of service due to supply surplus provided by the Abberton Scheme.

2.11.4 Suffolk

Currently there is no mechanism by which to equate levels of service with groundwater levels, therefore ESW undertook an assessment based on an analysis of historic rainfall in the surface water dominated Northern Central resource zone.

The information on actual levels of service in terms of the implementation of restrictions indicated that there was a correlation between the Essex and Suffolk supply areas, in that the same levels of appeals for restraint and restrictions have been implemented in each of the supply areas during the same drought years considered. To quantify this, a statistical analysis was carried out on the rainfall records for Barsham in Suffolk and Layer in Essex to determine the statistical significance of the relationship between rainfall in Suffolk and Essex. This assessment gave a correlation co-efficient of 0.75 for the monthly average rainfall data from 1987-2016. A further assessment was carried out on the drought years 1995-1997, and this gave a correlation co-efficient of 0.87. These results suggest that there is a strong similarity between the levels of rainfall in Essex and the levels of rainfall in Suffolk. This supports the view that actual levels of service achieved in Suffolk would be the same or very similar to those achieved in Essex, based on historic experience of the implementation of restrictions in both of these areas and the similarities in their rainfall record.

In the PR14 assessment, levels of service were also considered through modelling as part of the groundwater DO assessment (see section 3). Within the model, abstraction was reduced by 10% which is the minimum reduction in demand that the Company would expect to achieve from an appeal for restraint and a Phase 1 Temporary Use Ban (12% is considered likely). However, even before the 10% demand reduction was applied, DO was only ever constrained by the annual average daily licence and has never been resource constrained. The results of this assessment still apply.

2.12 Details of Competitors in Each Resource Zone

The Water Act 2003 amended the Water Industry Act 1991 to extend the opportunities for competition within England and Wales. Companies that are interested in supplying customers with water can now apply to Ofwat for a water supply licence. This will allow them to supply water to eligible premises anywhere within England and Wales.

The following inset appointments are located within ESW’s water resource zones:

The first is to Barking Riverside, a domestic housing development in the London Borough of Barking and Dagenham in the Essex WRZ. The inset supplier is SSE and the water is supplied by ESW. An application to include the next phase of this development (phase 2-4) is in process and the first connections of this phase were made in July 2016. The anticipated annual demand is 71.5Ml.

The second is to Woods Meadow a domestic housing development in Oulton in the Suffolk Northern Central WRZ with some commercial units in Mobbs Way. The inset supplier is Anglian Water and the water is supplied by ESW. The anticipated annual demand is 170.6Ml.

The third is to Five Oaks a domestic housing development in Chigwell in the Essex WRZ. The inset supplier is Albion Water and the water is supplied by a combination of ESW and Albion Water's own resources. The anticipated annual demand is 31Ml.

The previous Water Supply Licence (WSL >5MLD) regime supply to a food producer in the Suffolk Blyth WRZ where the supplier was Business Stream has now been relinquished and the supply returned fully to ESW.

AWS has an existing inset appointment (secured in 1997) to supply Buxted Chickens at Flixton in the Suffolk Northern Central WRZ. Buxted Chickens is located close to the ESW and AWS supply boundary and so AWS supply the water via an AWS water main.

2.13 Links to Other Plans

2.13.1 Links to Northumbrian Water Limited Business Plan

ESW is part of Northumbrian Water Limited (NWL). This WRMP also informs NWL's Business Plan for the 2019 Periodic Review of Price Limits (PR19). This covers the period from 1 April 2020 to 31 March 2025, otherwise known as AMP7.

Funding requirements to allow all strategies linked with this draft WRMP and regulatory programmes of work will be included in the PR19 Business Plan. This includes:

- Metering, leakage and water efficiency strategies that have been built into baseline distribution input calculations; and
- Schemes in the Water Industry National Environment Programme (WINEP) – currently WINEP2.

The baseline supply demand balance calculations have confirmed a supply surplus for all four WRZs across all years of the planning horizon. Therefore, no further supply or demand management schemes are required. This position will be acknowledged in the NWL PR19 business plan.

2.13.2 Links with Essex & Suffolk Water Drought Plan

ESW's Drought Plan identifies how the Company intends to manage a future drought, what trigger levels can be used to identify when action is required, and what short term measures are available to support supplies when levels of service are compromised. The benefit of drought actions has not been included in the baseline supply forecast.

Drought planning is essentially a prepared response to developing sustained dry weather (drought) conditions that have the potential to detrimentally affect public water supplies. Drought conditions are usually manifested in the form of:

- Reduced raw water availability (e.g. low river flows, low reservoir storage, low groundwater levels); and/or
- Increased demand (e.g. due to increased garden watering, showering etc in dry weather).

The WRPG states that WRMPs should be appropriately linked. The planned levels of service (see section 3) in this draft WRMP will be the same as those in the final Drought Plan when it is published in 2018. Additionally, the calculation of all elements relating to the supply demand balance are consistent in both plans.

2.13.3 Links with Environment Agency Drought Plan

An Agency document called “Drought response: our framework for England” (Environment Agency, 2017a) sets out how the Agency works with government, water companies and others to manage the effects of drought on people, business and the environment. It sets out who is involved in managing drought and how the Agency and stakeholders work together and take action to manage drought. The national framework aligns with the Agency’s operational area drought plans to provide a strategic overview for how it will manage a drought to minimise damage to the environment and to secure essential public water supply. Information in the framework and local Agency Drought Plans has been taken into account in the development of the ESW Drought Plan and therefore in this draft WRMP.

2.13.4 Links with River Basin Management Plans

The Agency has published an Anglian river basin district River Basin Management Plan (RBMP) called “Water for life and livelihoods” (Environment Agency, 2016a). The RBMP sets out the current state and pressures on the environment and sets environmental objectives and a programme of measures to improve the environment. Information in the RBMP has, where required, been used to inform the development of this draft WRMP, most notably in the development of the PR19 Water Industry National Environment Programme (WINEP) and in considering whether this draft WRMP could increase the risk of deterioration of the status of the surface and groundwaters from which ESW abstractions could impact.

2.13.5 Links with Flood Risk Management Plans

ESW has undertaken flood risk assessments to confirm whether any infrastructure including pumping stations and treatment works are at risk of flooding both now and the future. These confirm that the supply forecasts used in this draft WRMP are not compromised because of any current or future flood risk.

2.13.6 Links with Plans Produced by Local Authorities

Information from local authority Plans has been used to develop property and population forecasts which in turn have been used to develop our demand forecast (see section 4).

2.14 Habitats Regulation Assessment

All four ESW WRZs have a baseline supply surplus in each year of the planning horizon and so no new supply schemes will be developed. Consequently, a Habitats Regulation Assessment is not required.

2.15 Strategic Environmental Assessment

Directive 2001/42/EC of the European Parliament and of the Council on the Assessment of the Effects of Certain Plans and Programmes on the Environment (the Strategic Environmental Assessment Directive) was transposed into English law by the Environmental Assessment of Plans and Programmes Regulations 2004 (Statutory Instrument 2004 No.1633).

Subject to meeting defined conditions (confirmed through screening), plans and programmes require a Strategic Environmental Assessment (SEA) to be undertaken and an environmental report to be produced.

ESW has undertaken an assessment to identify whether it is required to undertake an SEA of its draft WRMP using the following guidance:

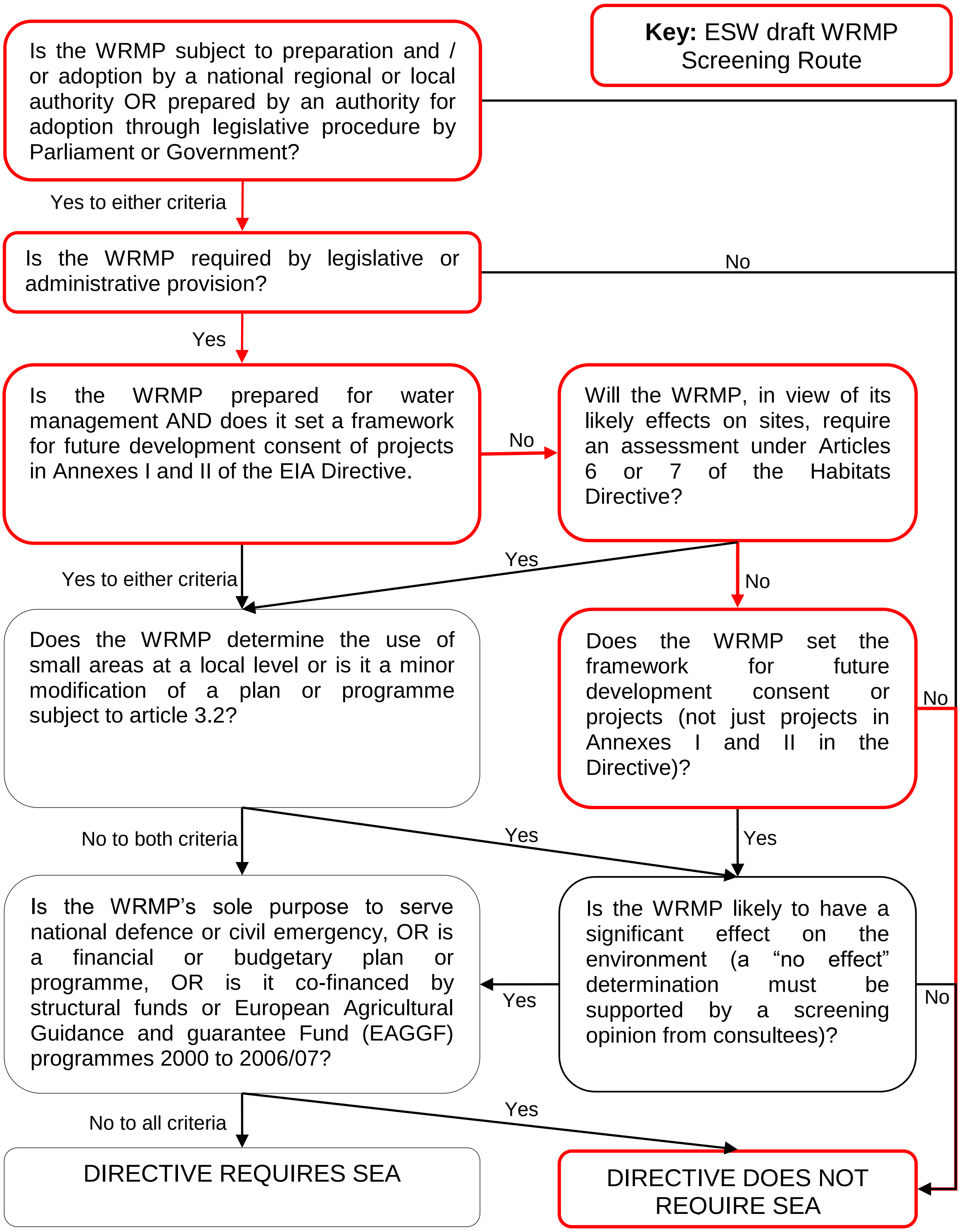
- UKWIR (2007) Guidance for Water Resources Mgt Plans & Drought Plans.

Figure 2.1 illustrates the key stages and the results of ESW's SEA screening exercise using the 2007 UKWIR methodology.

The results of the screening exercise are as follows:

i. The WRMP will be prepared and adopted by ESW who, under the EIA Directive, is considered an "authority";
ii. The WRMP is required by legislative provision, being a statutory document under the Water Act 2003 amending the Water Industry Act 1991;
iii. The WRMP will be prepared for water management although based on the current draft supply demand balance calculations, it will not contain any supply schemes;
iv. The WRMP will not be seeking permission for any schemes which will require an assessment under Article 6 or 7 of the Habitats Directive;
v. The WRMP does not set the framework for future development consent or projects (not just projects in Annexes I and II in the Directive).

Based on the above assessment, ESW concludes that its draft WRMP does not fall within the remit of the SEA Directive and therefore it is not required to undertake an SEA or prepare an SEA Environmental Report.



Source: UKWIR (2007) Guidance for Water Resources Mgt Plans & Drought Plans

Figure 2.1: Key Stages of SEA Screening

2.16 Optimisation of Existing Operations

2.16.1 Business as Usual Optimisation

The WRPG asks water companies to describe the action that the Company has taken to lower the overall costs (financial, environmental, social and carbon) of its existing operations.

Optimising existing operations is considered by the Company to be part of "business as usual". This includes minimising process losses as back washing filters more frequently than is required incurs additional pumping which has an associated financial and carbon cost. Additionally, optimisation also reduces utilisation of annual licensed abstraction quantities. This process is controlled through the close monitoring of filter performance through the use of online water quality monitors.

In 2015, the Company agreed to reduce abstraction (when resources allow) during periods of eel migration from its lower intake on the River Stour. This would increase flows over weir structures thus aiding eel passage. Further details on abstraction from the lower River Stour is provided in section 3.8.

2.16.2 Abstraction Incentive Mechanism (AIM)

Following an earlier successful pilot, ESW's Ormesby / River Bure licence has been subject to Ofwat's Abstraction Incentive Mechanism (AIM) since April 2016. The objective of the AIM is to encourage water companies to reduce the environmental impact of abstracting water at environmentally sensitive sites during defined periods of low surface water flows (Ofwat, 2017). The AIM applies once a water level or flow trigger threshold has been reached. Once flow or water level has fallen below the agreed trigger threshold, abstraction at the sensitive site should be reduced so that it is less than the agreed baseline daily quantity, and the balance is made up by increasing abstracting from an alternative, less sensitive, source.

Ormesby Broad is a more environmentally sensitive site with respect to abstraction than the River Bure, and so during dry years, when water levels in the Broad fall below the defined trigger, abstraction from the Broads is reduced and abstraction from the Bure is increased. Following the implementation of the Review of Consents mud pumping solution, which ensures that a minimum water depth is always maintained across the Broads, it is proposed that the site will remain in AIM for PR19, although the scheme will be reviewed to ensure that the water level trigger and baseline abstraction value are appropriate going forwards.

ESW is also investigating whether the abstraction from boreholes that supply Langham treatment works should be an AIM site for PR19. These boreholes are licensed for public water supply under certain emergency conditions, including drought, frost and pollution of the river. The Boreholes have been identified by the Environment Agency in the PR19 WINEP2 as causing actual serious damage to flows in the River Brett. The Environment Agency has proposed a sustainability change to the licence from 2024. The AIM scheme will be relatively complex, as it is proposed that the scheme should only cover drought and low river flow use of the boreholes, not abstraction for water quality, as this would severely constrain ESW's ability to undertake abstraction management to achieve drinking water compliance for metaldehyde and other parameters, such as nitrates. The AIM scheme would also be subject to there being sufficient water stored in Abberton Reservoir, the less sensitive alternative source, to allow back pumping to be viable. In addition, the water in Abberton Reservoir would need to be of a good enough quality so as not to compromise the treatment capability of Langham treatment works. If these issues can be overcome and a clear set of triggers and rules established, then ESW intends to include the Boreholes as an AIM site for PR19.

3.0 WATER SUPPLY

3.1 Deployable Output (DO) Overview

In developing a water resource zone (WRZ) Supply Demand Balance, water companies are required to estimate the yield of their resource zones in terms of DO, a building block in determining Water Available For Use (WAFU). DO is defined in the Water Resource Planning Guideline (WRPG) (Environment Agency, 2016) as:

"The output of a commissioned source or group of sources for the design drought you have chosen as constrained by:

- *hydrological yield;*
- *licensed quantities;*
- *environment (represented through licence constraints);*
- *pumping plant and/or well/aquifer properties;*
- *raw water mains and/or aqueducts;*
- *transfer and/or output main;*
- *treatment;*
- *water quality."*

A requirement is to assign a level of confidence to DO figures. The validity of DO assessments is related to the length of record used in the calculations, with an expectation that they should extend back to at least 1920 in order to capture the extreme droughts of the early 1920s and 1930s. The following matrix is provided to indicate the appropriate confidence label:

			LENGTH of Hydrological and/or hydrogeological data sets			
			> 99 years	71 – 99 years	< 70 years	
			A	B	C	
AVAILABILITY (and consistency) of Constraints Data	Available and of consistent quality	A	AA	AB	AC	HIGH
	Mostly available but variable quality	B	BA	BB	BC	
	Not available	C	CA	CB	CC	LOW
			HIGH		LOW	

Figure 3.1: Confidence Label Matrix

ESW has not included the benefits drawn from supply drought measures (e.g. drought permits and orders) in the baseline supply forecast.

3.2 Essex Resource Zone Deployable Output Assessment

3.2.1 Overview

The DO of the Essex WRZ has three separate components which are:

- The Essex System (including Langford Recycling Scheme);
- Essex groundwater sources; and
- Chigwell bulk supply. In a dry year, Thames Water provides ESW with a 71Ml/d raw water bulk supply.

The determination of the first element is indicated in this section. The Essex groundwater sources DO figures are summarised in section 3.6.3. The assumptions for the Chigwell bulk supply are detailed in section 3.14.1.

3.2.2 Essex System Deployable Output Assessment Approach

The DO of the Essex System is calculated using *Aquator,* a Windows-based water resource modelling system that utilises Microsoft Access to store information and data, and Microsoft Visual Basic for Applications (VBA) programming to explicitly define the behaviour of the components which are used to represent the hydrological entities in a water resources system.

The key features of the Essex System Aquator model are the single demand centre, due to the integrated nature of the raw and potable network, and the river catchment components, which are assigned the naturalised river flow time series (1910-2016) that represent the majority of raw water resource in the model. All infrastructure, licence, and operational constraints are included in the model.

Aquator models a water resource system by combining a daily multi-pass calculation of how water is to be distributed within a system together with the operating rules built into each component in the model. This approach attempts to optimise the allocation of water, by allowing demands to first reserve and then take water. The reservation of water by all demands before any one demand actually takes water allows a sharing algorithm to make decisions based on predefined rules. These rules can be replaced or modified by the user to simulate the requirements of the water resource system being modelled.

ESW uses the 'English & Welsh' method of determining DO. This method tests the resource system against a range of demands in turn until the system fails to meet the required demand during a design drought, and the highest demand the system is able to meet is the DO.

3.2.3 Model updates since PR14

Extension of the naturalised river flow record

Naturalised river flows are required in the Essex System *Aquator* model for four primary catchments, or Points of Interest:

- Chelmer to Langford
- Blackwater to Langford
- Stour to Stratford St Mary
- Ely Ouse to Denver

In all previous Periodic Reviews, flows in these rivers were derived from naturalisation studies undertaken in the late 1990s and provided a time series extending from 1 October 1932 to 31 December 1996. The critical drought defining Deployable Output in this case was 1933-34.

Flows in three of these catchments are significantly affected by groundwater abstractions, predominantly from the Chalk aquifer: the Ely Ouse, the Stour and the Blackwater, and therefore have been notoriously difficult to estimate. In recent years the Agency has undertaken extended regional groundwater modelling that includes the entire area of these four catchments. Furthermore, the Centre for Ecology and Hydrology (CEH) has recently published daily rainfall data at a 1km^2 resolution for the whole of England and Scotland extending from 1890-2015 (known as CEH-GEAR). A naturalisation study undertaken in 2015 for the Essex Rivers for 1970-2013 (Hydrology.UK, 2015, *pers. comm.*) reported substantial inhomogeneity and inconsistency in historic parts of the naturalised records on the Essex Rivers, particularly for the period prior to 1970.

These factors combine to indicate that the time was right to review the historic records and derive new, consistent and homogenous data sets for all four catchments, extending as far back as the CEH-GEAR data would allow, and preferably to at least 1920.

The exercise to achieve this was carried out in two parts:

i. Naturalise existing, reliable gauged river flows for the period 1970-2016 for all four catchments, and use these to derive flow records to the points of interest; and

ii. Using the 1970-2016 naturalised flows, calibrate, validate, and blind-test rainfall-runoff models and extend the records back as far as is sensible based on rainfall and evaporation data up to 1969.

Flows for the Essex Rivers were recently naturalised up to 2013 using data from abstraction returns and Sewage Treatment Works (STW) gauged outflows up to 2011. These required extension up to 2016 for PR19. For the Ely Ouse, naturalisation was required for the entire period to ensure a consistent methodology and homogenous data set.

The request for discharge consent data resulted in being directed to the national database. When this data was processed, a large number of consents were discovered in the Essex catchments that had not been supplied during the previous study. Furthermore, updated abstraction returns were supplied by the Agency on a licence-by-licence basis dating from 1970, which were not available for the 2015 study. This allowed differentiation between ground and surface water licence usage and summer and winter spray irrigation licence usage.

New groundwater modelling, undertaken on behalf of the Agency, extended the period of coverage from 1970-2007 to 1970-2014. The additional discharge and groundwater modelling data made it necessary to re-visit the earlier naturalisation work for the Essex Rivers. The opportunity was therefore taken to also revisit the abstraction data to include these additional effects.

Reliable and good quality gauged flow records are not available on the Essex Rivers at the points of interest (POI). Indeed, only the Stour has currently operational flow gauging at the POI, but this is not a purpose-built structure and produces data of poor quality. Upstream gauging stations were therefore utilised on all three rivers, and the contribution from the intervening un-gauged catchment then estimated. In addition to the impact of surface and groundwater abstractions, and STW discharges, the Stour and Blackwater flows required the influence of the Ely Ouse to Essex Transfer Scheme (EOETS) removing from the gauged flows. The latter has a highly variable and complex influence that changes with time of year, rate of discharge into the river, length of time the discharge is operating, and the level of flow in the receiving river. It must therefore be accounted for by manual inspection on a daily basis throughout the record.

In total, 11 upstream gauges were used in the flow naturalisation for the Ely Ouse. These gauges measure flows on rivers prior to their entry into the fens and tend to be dominated by the response of the Chalk aquifer. They account for 2225km^2, or 65%, of the total area draining to Denver (3430km^2). Much of the remaining area lies at or below sea level, below the level of the Ely Ouse itself, and therefore requires a different approach.

Flows for the 11 upstream gauges were naturalised for the period 1970-2016 using much of the same methodology as for the Essex Rivers. However, the contribution of the un-gauged area was estimated by using an areal rainfall factor on the sum of the naturalised upstream flows, and then deducting an amount for daily evaporation from the large area of open water surfaces. The same methodology was employed for all catchments in the Essex Rivers and Ely Ouse.

In order to ensure consistency and homogeneity throughout the rainfall-runoff modelling process, input rainfall and evaporation data from the same sources was used for the whole modelling period, 1910-2015. The rainfall data comprised the CEH-GEAR dataset which, when inspected, was found to have a reasonably robust description of rainfall in the study area from 1910 onwards. This was therefore selected as the start date for modelling.

Evapotranspiration data is not available throughout the modelling period and therefore had to be derived from data that was available. For this reason the East Anglia mean monthly temperature data series were used, which extend from 1910 to 2015. These were adjusted to match the mean annual temperature over a standard period for each catchment, and then converted into Potential Evapotranspiration using the Adjusted PE Model.

A rainfall-runoff model (Catchmod) was calibrated on the naturalised flow data for each of the contributing upstream catchments (1970-1992). The calibration was then tested on a validation period (1993-2006), adjusted if necessary, and then re-tested on a blind period (2007-2015), after which no further adjustments were allowed. The calibrated models were then used to derive 'natural' flows for the period 1910-1969, which were prepended to the naturalised gauged record for each station. This gave a composite record extending from 1 January 1910 to 31 December 2016 at each site. Areal-rainfall adjustment factors, and open water losses for the Ely Ouse, were then applied as for the naturalised gauged records to give four composite series representing natural flows at each of the Points of Interest for the period 1910-2016.

The new flows are generally higher than indicated in the previous records, particularly in the pre-1965 era. However, they now also include the 1920-21 drought, which is more severe for the Essex system than the 1933-34 drought and replaces it as the critical drought.

Derivation of new flow denaturalisation profiles

Naturalisation attempts to remove the influence of human activity over time from the river flow records to leave the naturally-varying response of the catchments to the historic rainfall and evaporation signals. However, these influences continue to take place and have an impact on the available water resources. They must therefore be added back in to the record, but in a way that is consistent and takes account of known and/or potential future uses by third parties.

The existing flow denaturalisation profiles in the Essex System model had been derived using 1996 abstraction return data, so it was decided to derive new profiles that relate to more recent usage.

Following discussion with the Environment Agency, separate approaches were adopted for each of the main influences, as follows:

- Surface water discharges - the most recent estimates of the total discharge for each of the upstream catchments was summed to give a monthly profile. The intervening un-gauged catchments between the upstream gauges and the POIs were checked for any additional discharges, which were then added in to the total.

- Surface water abstractions - the vast majority of these relate to spray irrigation (SI) abstractions, either for direct use in summer, or to replenish winter storage for use in the subsequent summer. SI usage is notoriously difficult to predict from one year to the next, being governed by market forces as much as land use, rainfall, and temperature. For this reason it was agreed to use the maximum licence return over the last five years (2010-2015) for each individual licence, distributing the volume abstracted equally over the months for which that abstraction is licensed. This gave a monthly profile of annually abstracted maxima. All surface water abstractions were treated in this way.

- Ground water abstractions (Essex Rivers) - the Essex Rivers were treated differently to the Ely Ouse catchments. This is because virtually all ground water abstractions in the Essex river catchments are for public water supply, and so are much more uniform, whereas in the Ely Ouse basin a large proportion are used for SI. For the Essex Rivers the Recent Actual ground water impacts were extracted from the regional ground water modelling runs as close to the POIs as was available. The mean monthly impact over the last six years of model runs (2009-2014) was derived to give a monthly profile of abstraction. This was added to the surface water abstraction monthly profile to give a total monthly abstraction profile.

- Ground water abstractions (Ely Ouse catchments) – the regional ground water (GW) modelling results do not allow for the SI method described above, so an alternative was adopted. All of the gauging stations used in this study are on unconfined Chalk, so it was assumed that all GW abstractions were to the detriment of river flows. Therefore the GW SI abstractions were treated in exactly the same way as surface water SI abstractions. Monthly public water supply abstractions, on the other hand, were averaged over the last six years and the resulting monthly profile combined with the ground water SI monthly profile to give a total GW abstraction profile. This GW profile was then added to the surface water abstraction profile to give an overall monthly abstraction profile for the gauged Ely Ouse catchments. There were no significant ground water abstractions downstream of these gauges that would affect river flows, so no further adjustments were necessary.

3.2.4 Deployable output modelling assumptions and set-up

For the purposes of DO assessment, the Essex System model has been set-up using with the following assumptions:

i. **Reference Levels of Service demand reductions:** The WRPG does not specify the percentage of demand reduction that should be used for the reference levels of service. ESW, in consultation with the Agency, has therefore applied the most appropriate reductions from the Company's planned levels of service (LoS) to the reference levels of service. The demand reductions for each scenario are shown in Table 3.1 below.

Table 3.1: Demand Reductions

Scenario		Appeal for Restraint		Phase 1 Temporary Use Ban (TUB)		Phase 2 Drought Order Ban	
		Freq.	% demand reduction	Freq.	% demand reduction	Freq.	% demand reduction
1	No restrictions	×		×		×	
2	Planned LoS	1 in 10 years	7%	1 in 20 years	5%	1 in 50 years	2%
3	Reference LoS	×		1 in 10 years	5%	1 in 40 years	2%

To reflect likely operational practice, as well as return period curves, implementation of the demand reduction actions during a model run are controlled by the 'hold' and 'delay' facility in *Aquator*. These are set to hold demand reduction actions for a minimum of 31 days once triggered; to delay the implementation of the Phase 1 Temporary Use Ban (TUB) for 21 days after Appeals for Restraint; and to delay implementation of a Phase 2 Drought Order Ban for 3 months (93 days) after a Phase 1 TUB. These delays reflect the likely time it would take to consult, and gain consent to implement, these customer demand reduction actions. The planned levels of service scenario set-up is shown below:

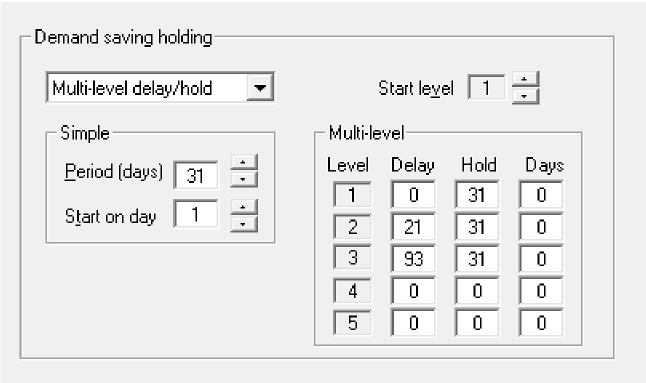


Figure 3.2: Planned Levels of Service scenario set-up

For the reference levels of service scenario, the hold and delay set-up for the demand reductions actions were altered to reflect the change from the Company's planned levels of service, shown below.

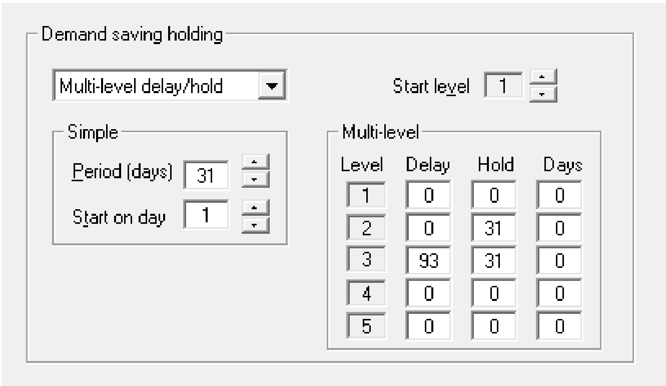


Figure 3.3: Reference Levels of Service scenario set-up

ii. **Supporting Resources:** The 'planning' control curves for EOETS and groundwater support were applied in the Hanningfield and Abberton Reservoir Group component sequences to trigger the supporting resources. The Stour Augmentation Groundwater Scheme (SAGS) and Langham groundwater resources were made available when the combined storage crossed the groundwater support curve. The Great Ouse Groundwater Scheme (GOGS) resource was made available after a delay of 28 days once the control curve was crossed, to represent operational procedure.

The frequency with which the use of SAGS and GOGS is triggered is dependent on the groundwater control curve and the demand placed on the water resource system during a model run. A new planning groundwater control curve was derived for use in the PR14 WRMP. As directed by the Agency during consultation, the derivation of the groundwater support control curve was based on the assumption that groundwater support resources should only be available in drought years, to reflect operational practice. Once derived, the control curve was used to trigger groundwater support in order to achieve the required refill reliability, and ensure that the Essex reservoirs are sufficiently full by the start of the drawdown period.

iii. **Emergency Storage:** When drought resources and demand reduction actions are included in a DO assessment, an allowance for emergency storage must be made. If the DO of the system, derived with drought resources and demand reduction actions included, is used for water resources planning purposes, inclusion of emergency storage is required to reduce the risk of the system failing if a drought more severe than the design drought was to be experienced.

During PR09, ESW worked with the Agency to find a pragmatic approach to calculating emergency storage provision. The calculation is based on the volume required to meet demand for 30 days during a drought, accounting for the supply from supporting resources, including the Langford Recycling Scheme, SAGS, Langham groundwater sources and GOGS, and also that the demand on the system will have been reduced by demand reduction actions. It is assumed that the supporting resources will be reliable throughout a drought and so the demand met by these resources is deducted from the demand placed on the reservoirs.

Emergency storage is added on top of reservoir dead storage, which by definition is unavailable for abstraction under any circumstances. The resulting emergency storage levels, which are the lowest levels the two reservoirs can be drawn down to in the model runs that include demand reduction actions, are shown in table 3.2 below:

Table 3.2: Emergency Storage Levels

	Capacity	Dead Storage Volume		Emergency Storage Volume		Emergency Storage Level	
	Ml	Ml	%	Ml	%	Ml	%
Hanningfield	26,075	3,911	15	4,005	15.36	7,916	30.36
Abberton	41,375	3,807	9.2	6,355	15.36	10,162	24.56
Total	67,450	7,718		10,360		18,078	

3.2.5 Results

Three baseline DO scenarios are required to be assessed, to demonstrate the impact of ‘levels of service’ (i.e. demand reduction actions) on DO. They are:

1. **No restrictions:** The constant rate of supply that can be maintained from the resource zone throughout the entire period of assessment, with no customer restrictions applied.
2. **Water Company planned levels of service:** The rate of supply that can be maintained from the resource zone when the system is operated to meet the Company’s planned levels of service. The DO resulting from this scenario is used in the supply demand planning tables.

3. **Reference scenario levels of service:** The rate of supply that can be maintained from the resource zone throughout the entire period of assessment when the system is operated to meet specified levels of service. These are for temporary customer use restrictions of 1 in 10 years and non-essential use restrictions of 1 in 40 years.

The DO of the Essex System under these three baseline DO scenarios is shown in Table 3.3 below.

Table 3.3: Essex System Deployable Output Scenarios

Deployable Output Scenario		Supporting Resources				Demand Reductions			Minimum reservoir drawdown level	Deployable Output (Ml/d)
		EOETS	SAGS	Langham BHs	GOGS	Appeals for restraint (7%)	Phase 1 TUB (5%)	Phase 2 Drought Order Ban (2%)		
1	No restrictions	✓	✓	✓	✓	×	×	×	Dead storage	397
2	Planned LoS	✓	✓	✓	✓	1 in 10 years	1 in 20 years	1 in 50 years	Emergency storage	392
3	Reference LoS	✓	✓	✓	✓	×	1 in 10 years	1 in 40 years	Emergency storage	392

3.3 Essex System Sensitivity Testing Against a 1 in 200 year drought

To test the resilience of the Essex System against droughts not represented within the baseline DO assessment, the Aquator Scottish Method DO Analyser was utilised. The Analyser runs the model multiple times with an incrementally increasing overall demand, similar to the English & Welsh method, however instead of ceasing the analysis at the first failure, the Analyser keeps running and for each overall demand counts the number of failure years in the analysis period.

The number of failure years occurring for each demand tested is outlined in Table 3.4. The return period of the number of failure years is then calculated based on the total record length and overall demand is plotted against the return period of each number of failure years, creating a linear trend line representing the relationship between the demand and return period, shown in Figure 3.4.

Table 3.4: Results of Essex System Aquator Scottish Method DO Assessment

Demand, Ml/d	Number of Failure Years
393	1
394	2
398	3
399	4
401	6
402	8
403	12
405	13
406	18
407	22
409	29
410	44
411	55

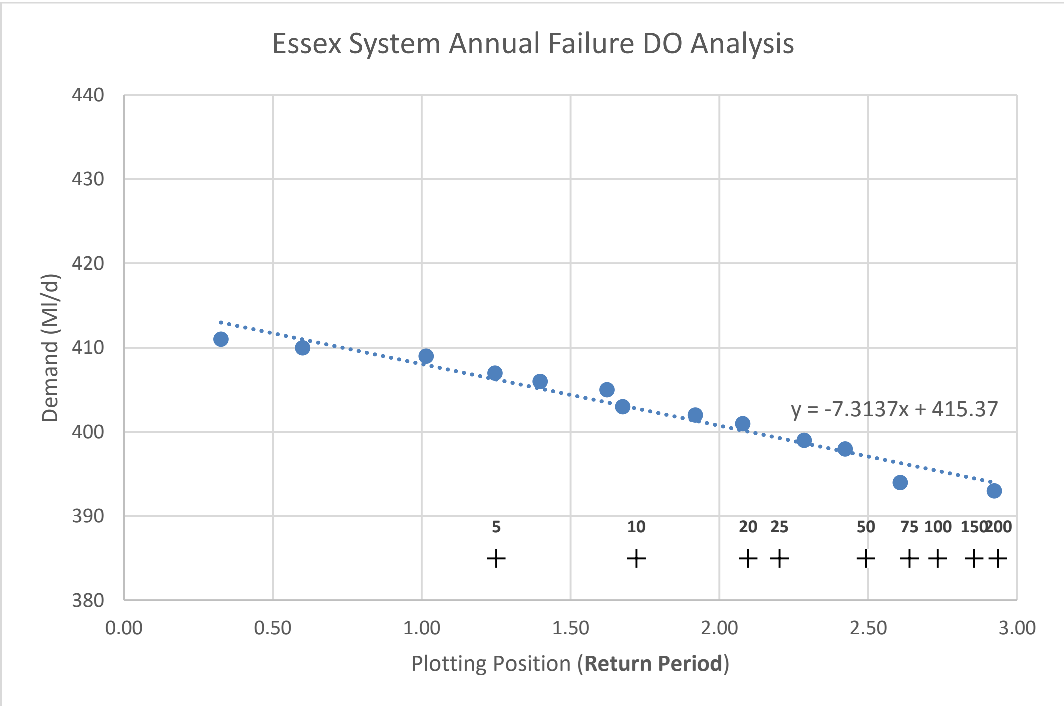


Figure 3.4: Graph of results of Essex System Aquator Scottish Method DO Assessment

For a drought with a 0.5% Annual Exceedance Probability (i.e. a 200 year return period drought), the result was a DO of 394 Ml/d, a 2 Ml/d increase from the baseline DO. This is because the baseline failure demand of 393 Ml/d, which has a 191.3 year return period, sits below the trend line in Figure 3.5, so the 200 year return period DO calculated using the trend line will be higher than the figure of 393 Ml/d.

Confidence Labelling

ESW has assigned the confidence label of 'AA' to the DO figures for the Essex System, using the matrix provided in the guidance, and reproduced in section 3.1. The Essex System is a conjunctive use system with a medium to high degree of constraints on output. The Essex System *Aquator* model includes up-to-date, validated and consistent quality constraint data and therefore is assessed as an 'A' for this parameter. ESW is confident that the model satisfactorily reflects the constraints within the system.

The length of the hydrological data set is 107 years, and it incorporates an adequate number and range of drought years, and a sufficiently severe drought (1921/22) for water resource planning purposes. Therefore for this parameter, the label 'A' has been assigned, giving an overall confidence level of 'AA'.

3.4 Suffolk Surface Water Source Deployable Output Assessment

3.4.1 River Bure and Ormesby Broad

Background

Abstraction from the River Bure, Ormesby Broad, and groundwater chalk sources in the Bure valley is authorised by a group abstraction licence (Licence number 7/34/09/*S/0054), which allows a total annual quantity of 10,000 Ml to be abstracted. The main conditions of the licence are summarised in Table 3.5 below.

Table 3.5: Ormesby / Bure Licence Conditions

<table>
<tr><th>Source</th><th>Instantaneous (l/sec)</th><th>Daily Quantity (Ml/d)</th><th>Annual Quantity (Ml/annum)</th></tr>
<tr><td>River Bure</td><td>316</td><td>27.2</td><td rowspan="2">10,000
(7,500Ml between April to October)</td></tr>
<tr><td>Ormesby Broad</td><td>581</td><td>36.3</td></tr>
</table>

An insignificant contribution is abstracted from the groundwater sources which tend to be only used as emergency sources when abstraction from the River Bure intake is not possible. This is generally due to elevated turbidity and / or nitrate concentrations following major rainfall events.

The bulk of the abstraction comes from the River Bure and Ormesby Broad, with close to the total 10,000Ml limit being abstracted in most years. The quantity abstracted from each intake often depends on the source water quality and may result in more water being abstracted from Ormesby Broad one month and less in another. However, a review of the abstraction return data shows that on average, approximately 40% of Distribution Input (DI) is satisfied by the Broad and 60% by the Bure.

Review of Consents

The Ormesby Broad and River Bure abstraction licence (7/34/09/*S/0054) was identified by the Agency and Natural England as having the potential to significantly affect the hydrology of the Trinity Broads Special Protection Area and the Bure Broads & Marshes Special Protection Area and therefore impact on the condition of the water dependant designated features. Consequently, ESW investigated the sustainability of its abstractions under the Agency's AMP3 and AMP4 National Environment Programme (NEP) while the Agency considered the abstractions under its Review of Consents process.

The abstraction licence conditions relating to the River Bure and Northern Central Boreholes 5 and 8 were reaffirmed as no likely significant effects arising from ESW abstraction.

In terms of the Ormesby Broad abstraction, the licence was modified to include an abstraction cessation level of -0.44mAOD, subject to mud pumping, to maintain a minimum water depth across the Trinity Broads system of 0.3m.

PR19 Deployable Output: Ormesby Broad

The annual quantities of water abstracted from Ormesby Broad in the following drought years was:

1995/96: 3,910Ml
1996/97: 3,489Ml
1997/98: 3,820Ml

This DO assessment is based on Ormesby Broad water levels and abstraction quantities for the year 1996/97. This is because:

- 1996/97 is the year the abstraction cessation level is based on;
- 1996/97 follows a preceding dry year in 1995/96; and
- The NEAC regional groundwater model shows that groundwater levels in 1996/97 were lower than those during other drought years including 1976.

Given the above, the annual average DO for 1996/97 is:

$$\frac{3{,}489\ \text{Ml/annum}}{365\ \text{days}} = 9.56\ \text{Ml/d}$$

A drought worse than 1996/97 could happen, in which case Broad water levels could fall below the abstraction cessation level when abstracting the same quantity of

Broad water as that in 1996/97. However, a new abstraction regime was implemented in 2015 to:

i. ensure that the same annual quantity abstracted in 1996/97 can be abstracted while still maintaining a Broad level above the new abstraction cessation level; and
ii. ensure compliance with the Abstraction Incentive Mechanism (AIM).

The new abstraction regime required the development of control bands (see Figure 3.5 below), each of which specifies a different ratio of source water that should be abstracted. When winter Broad levels are high, it is possible to abstract a greater proportion of Broad water which otherwise would be pumped from the Muckfleet Channel and lost to sea.

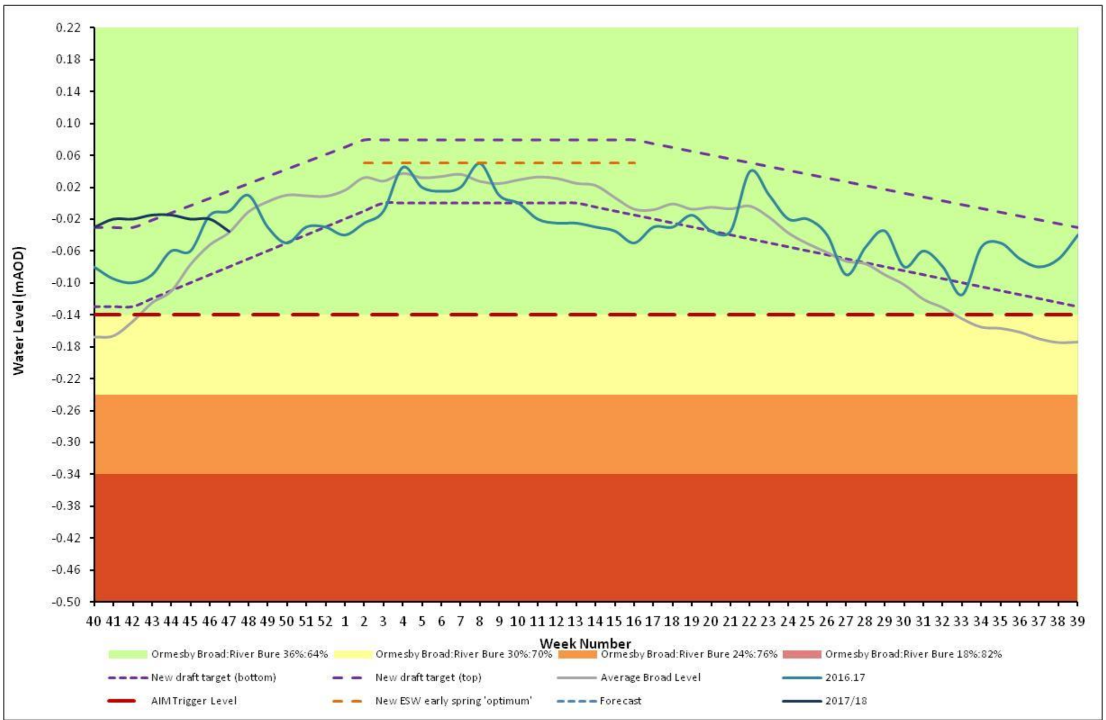


Figure 3.5: Ormesby Broad Abstraction Regime

Conversely, as Broad levels fall, the proportion of source water abstracted from the Broad reduces, thus conserving Broad storage. This is important for two reasons:

i. To manage Broad levels so that they remain above the cessation level; and
ii. To ensure that some storage above the cessation level remains should abstraction from the River Bure be constrained by the Bure Minimum Residual Flow (MRF) conditions (as was the case on 38 days during the 1976 drought)

Where abstraction from the Bure is constrained by the MRF, the balance required to meet customer demand would have to be met by the Broad and from increased transfer from the Lound supply zone. Under this scenario, Broad abstraction may need to be higher than the control band ratio would normally allow. However, this would be possible, as with the new abstraction regime, Broad storage will be greater than it otherwise would have been.

The peak DO for Ormesby Broad is 10.7Ml/d. This is based on the quantity of water that can be treated through the Candy process stream.

PR19 Deployable Output: River Bure

There are flow conditions on the licence relating to abstraction from the River Bure as set out in the East Anglian (Bure Valley) Water Order 1964.

When the rates of flow in the River Bure, as measured by the Agency gauging station at Ingworth, correspond with those specified in Table 3.6 below, the daily rate of abstraction must be reduced accordingly.

Table 3.6: River Bure MRF Conditions

Rate of Flow at Ingworth GS (Ml/d)	Daily Rates of Abstraction from the River Bure not to exceed (Ml/d)
≥38.88	27.2
<38.88 but ≥36.29	22.73
<36.29 but ≥33.26	20.45
<33.26	18.18

The River Bure pumping station is capable of abstracting the full unrestricted daily licensed volume of 27.2Ml/d.

Historical Droughts

River Bure flow data from the Agency's Ingworth gauging station from 1975 to 2011 is presented in Figure 3.6. The characteristic drought year for the zone is 1976 but there are a number of other dry years in the record particularly in the early 1990s that may be useful to assess. The total annual flow and minimum daily flow was calculated for each year of the data set and those five years with the lowest in respect of both measures, as shown below in Table 3.7, were investigated further by plotting the flow duration curve for each year (Figure 3.7).

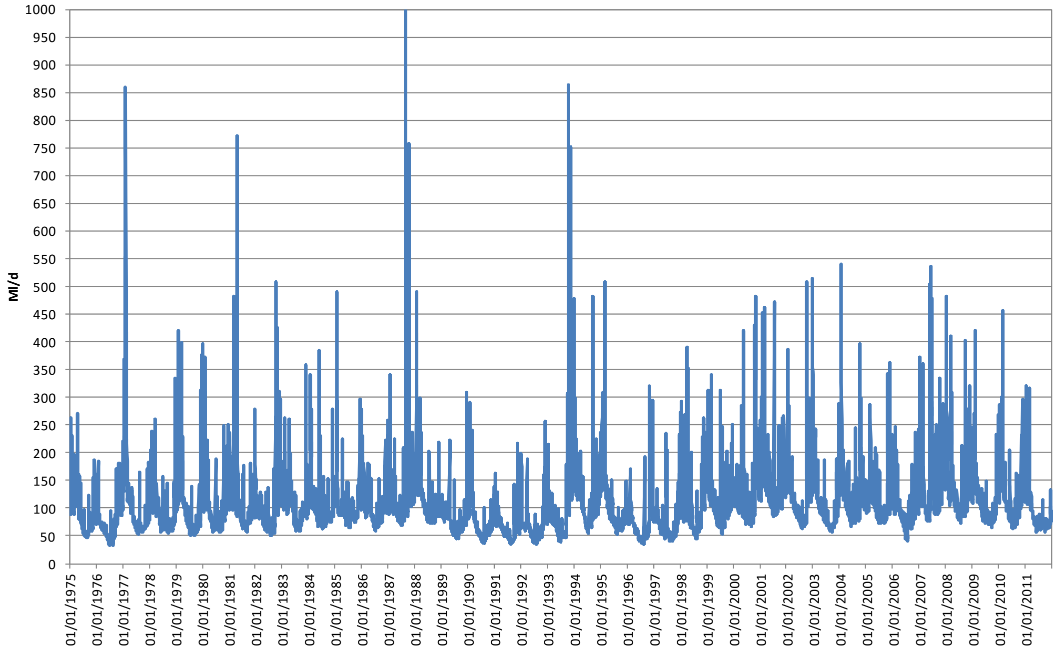


Figure 3.6: River Bure flow at Ingworth gauging station (1975-2011)

Table 3.7: River Bure Total Annual Flow

Year	Total Annual Flow (Ml)
1991	23,745
1992	25,507
1996	26,626
1990	26,869
1976	27,617

Year	Minimum daily flow (Ml/d)
1976	33.09
1992	34.13
1996	34.82
1991	35.08
1990	36.81

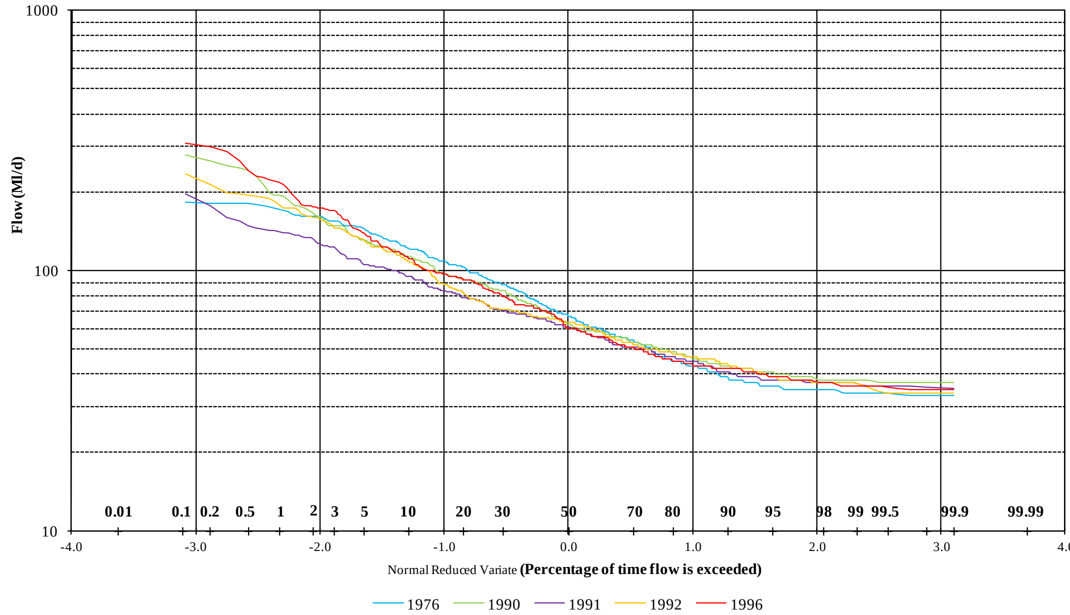


Figure 3.7: Flow duration curves for the five driest years on record at Ingworth Gauging Station (1975-2011)

The low flow end of the flow duration curve is the most pertinent to this assessment, specifically the flows below 38.88Ml/d, as this is the first trigger requiring the abstraction rate to be reduced. By comparing the flow duration curves it can be seen that 1976 experienced flows of less than 40Ml/d for the most number of days, and so this year has been used to assess water availability in a worst case scenario.

Assessing river water availability

<u>Daily Abstraction</u>

Daily mean river flow at Ingworth gauging station for 1976 was used to assess how constrained abstraction from the River Bure could be if a drought of similar severity were occur again. 1976 is characterised by low flows from January through to September as shown in Figure 3.8.

Assessment of the data from Ingworth gauging station from 1976 shows that a flow equal to or greater than 38.88Ml/d occurred on 327 days (89.6% of the time), which could support the maximum daily licensed abstraction of 27.2Ml/d, with continuous abstraction at this rate achievable between 1 January and 23 June, and 28 August and 31 December, with an additional period of 26 days between 16 July and 10 August (Figure 3.9).

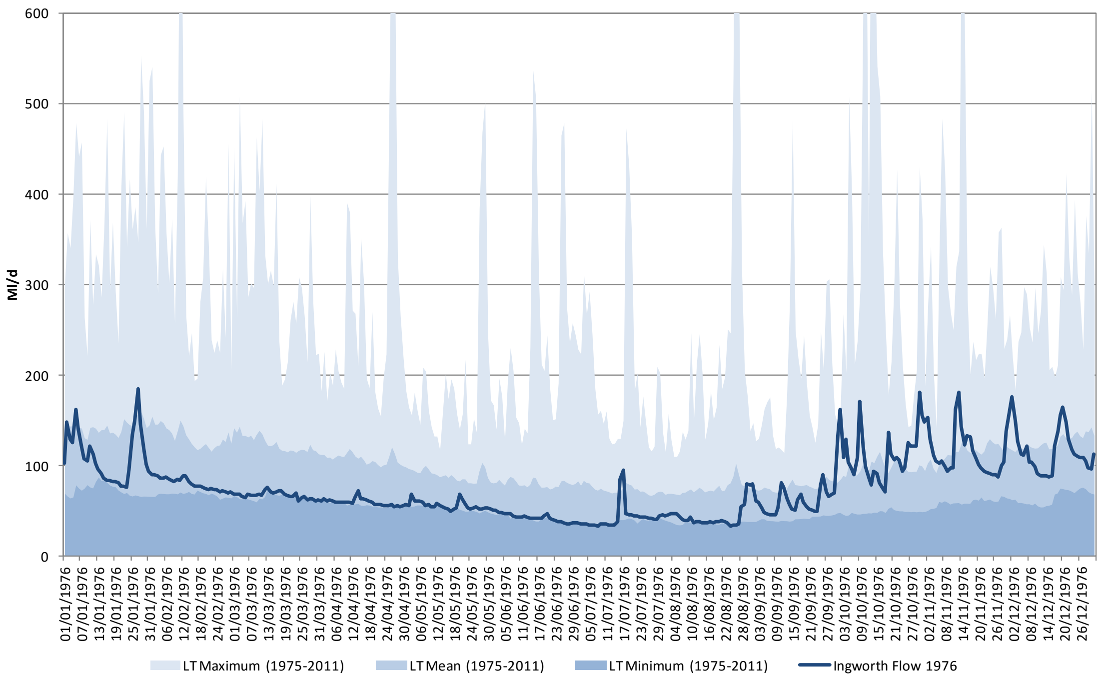


Figure 3.8: River Bure daily mean flow at Ingworth gauging station during 1976 and long term (1975-2011) minimum, average and maximum flow

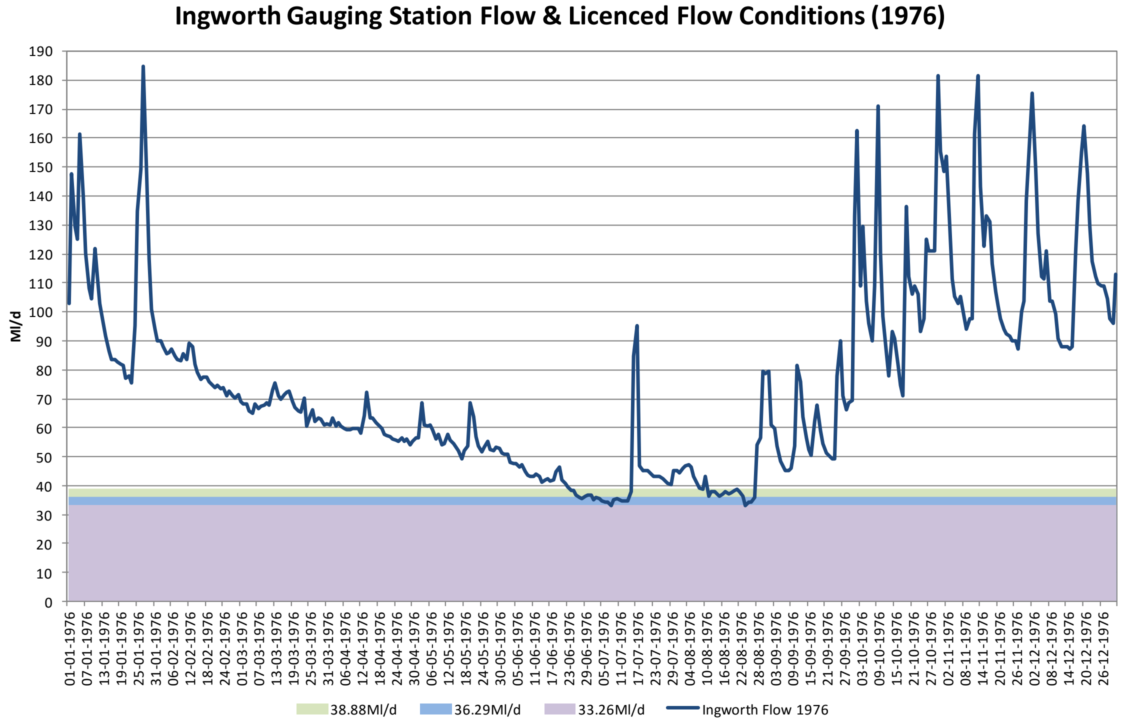


Figure 3.9: River Bure flow at Ingworth during 1976 and the flow conditions for a reduction in ESW abstraction

A flow less than 38.88Ml/d but equal to or greater than 36.29Ml/d, which could support a daily licensed abstraction of 22.73Ml/d, occurred on 18 days (4.9% of the year), during the last week of June and middle of August.

A flow less than 36.29Ml/d but equal to or greater than 33.26Ml/d, which could support a daily licensed abstraction of 20.45Mld, occurred on 18 days (4.9% of the year), between 27 June and 14 July, and for 4 days in August.

A flow of less than 33.26Ml/d, which would require a reduction in ESW abstraction from the River Bure to 18.18Ml/d, occurred on 2 days (0.5% of the year), on 8 July and 24 August.

Given the above, taking an average of the following gives a dry year annual average DO of 26.67Ml/d:

- 327 days at 27.2Ml/d
- 18 days at 22.73Ml/d
- 18 days at 20.45Mld
- 2 days at 18.18Ml/d

The Broad Dry Year Annual Average (DYAA) DO has been calculated to be 9.56Ml/d, and the Bure DYAA DO to be 26.67Ml/d. The sum of the DO values (36.23Ml/d) is significantly higher than the annual average daily allowance of the group abstraction licence of 27.4Ml/d, therefore it is assumed that the maximum DO would be taken from the Broad (9.56Ml/d) and the Bure DYAA DO is reduced to 17.84Ml/d for reporting purposes.

Given the full daily licence of 27.2Ml/d was achieved on 327 out of 365 days, the peak DO is 27.2Ml/d.

<u>Annual Abstraction</u>

The daily flow at Ingworth gauging station in 1976 was used to calculate the daily volume that would have been available for abstraction, adhering to the required reduction in abstraction rates as river flow decreases. These daily volumes were then summed up to give a total annual abstraction volume of 9,735Ml, less than the annual licensed volume of 10,000Ml, which includes all of the raw water sources for Ormesby WTWs (Ormesby Broad, River Bure and groundwater sources). This calculation indicates that even in a severe drought, almost the whole Ormesby annual abstraction licence could potentially be taken from the river source. Thus, abstraction from Ormesby Broad could in theory be reduced to adhere to potential new abstraction cessation levels, in favour of abstraction from the River Bure if resources are available from this source.

PR19 DO Assessment Summary

The PR19 DO figures are as follows:

Table 3.8: PR19 DO

	Source Average DO Ml/d	Peak DO Ml/d
River Bure	17.84	27.27
Ormesby Broad	9.56	10.70
Northern Central Borehole 8 *	0.54	6.80
Northern Central Borehole 5 *	0.47	6.80
Ormesby Bure Group Licence	**27.40**	**51.57**

* Groundwater sources are operated by ESW as emergency use groundwater sources due to elevated nitrate and silica. Average DO is based on dry year annual average utilisation.

All of the 10,000Ml/annum licensed quantity was abstracted in each of the drought years from 1995 to 1997. This provides further confidence that the combined average DO figures for the Bure and Ormesby Broad (which equate to the equivalent annual licensed quantity of 27.4Ml/d) are robust.

3.4.2 River Waveney DO Assessment

The water resource software *Aquator* was used to develop a model of the system, which included the River Waveney's catchment inputs, the Agency's river support groundwater sources which are collectively known as the Waveney Augmentation Groundwater Scheme (WAGS), and the licence constraints of the Shipmeadow intake. This assessment is detailed in the report *River Waveney Water Resource Modelling & Deployable Output Calculation* (Essex & Suffolk Water, 2009)

DO is the maximum demand that can be continually met through a critical drought period, which for the River Waveney is the drought experienced in 1976. The DO of the Shipmeadow intake on the River Waveney was calculated to be 13.8Ml/d using Aquator.

The DO of the Shipmeadow intake is constrained by the low river flows during the summer of 1976. Figure 3.10 shows the modelled river flow at the Shipmeadow intake, and how the licensed abstraction volume is reduced to 20.5Ml/d when the river flow falls below 53.4Ml/d, and further reduced to 13.6Ml/d when the river flow falls below 45.9Ml/d.

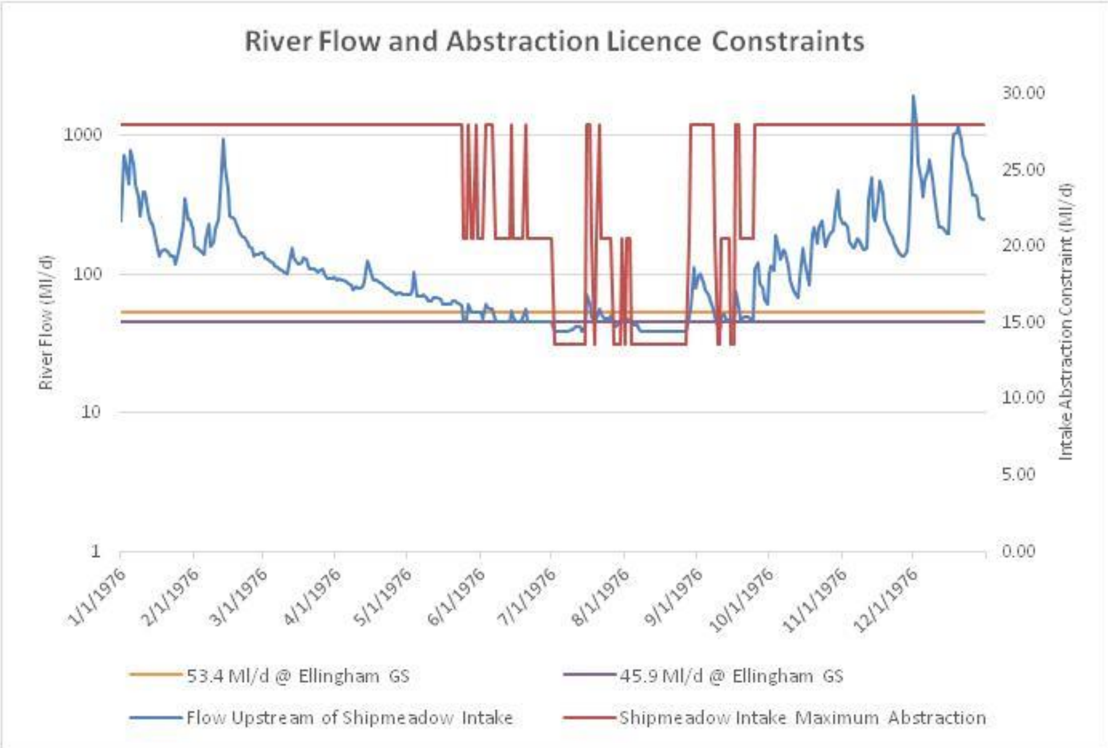


Figure 3.10: Waveney flow and abstraction licence constraints

It can be seen from Figure 3.10 that between January and May, and September and December, 1976, there is sufficient river water to support potential abstraction of the maximum daily licensed volume of 28Ml/d. Quantifying this availability is required to inform future resource and infrastructure development of Barsham WTWs and the Northern Central Water Resource Zone.

3.4.3 Lound and Fritton Lake DO Assessment

Background

Fritton and Lound Lakes are located within the Northern Central WRZ near to the coastal town of Lowestoft. Fritton Lake has no conservation designations while Lound Lakes are designated a County Wildlife Site.

Abstraction licence 7/34/19/S/60 authorises abstraction from the lakes at the following licensed quantities:

- Annual licence: 2,955Ml/annum
- Annual average licence: 8.10Ml/d
- Peak daily licence: 20.40Ml/d

Abstraction is via an intake located on Lound Run pond. Surface water flows into Lound Run Pond from other Lound ponds to the east and from Fritton Lake to the west. The water is then treated at Lound WTWs before being pumping into the distribution network for onward supply to customers.

Fritton Lake is thought to be a flooded peat digging while Lound lakes were created at the start of the 20th century for the purpose of water storage. They were dug along the valley line of a natural watercourse, which would originally have drained into the River Waveney. The lakes are spring-fed from the underlying Crag aquifer, although runoff, direct rainfall and some small dykes also contribute to the volume of water stored in the lakes. In addition to losses from evapotranspiration, outflows include discharge from Fritton Lake into the River Waveney and ESW abstraction.

PR19 DO Assessment

The average and peak DO figures for Lound Lakes and Fritton Lake used in the previous four periodic reviews were 8.09Ml/d and 13.40Ml/d respectively. This assumed DO was licence constrained where the annual licensed quantity is 2,955 Ml and the equivalent annual average daily licence is 8.095Ml/d.

The surface area and storage capacities for Fritton and Lound Lakes are as follows:

Table 3.9: Lake Surface Area and Volume

Lake	Surface Area (km^2)	Storage Volume (Ml)
Fritton Lake	0.56	4,453
Lound Lakes	0.13	121
Total	**0.69**	**4,574**

Fritton Lake comprises 81% of the total open water but 97% of the total lake storage. Consequently, this assessment focuses on Fritton Lake.

Figure 3.11 shows minimum, mean and maximum Fritton Lake water levels for the period 1992 to present. The minimum (lowest) surface water level is a combination of water levels observed in the drought years of 1991/92 and 1996/97.

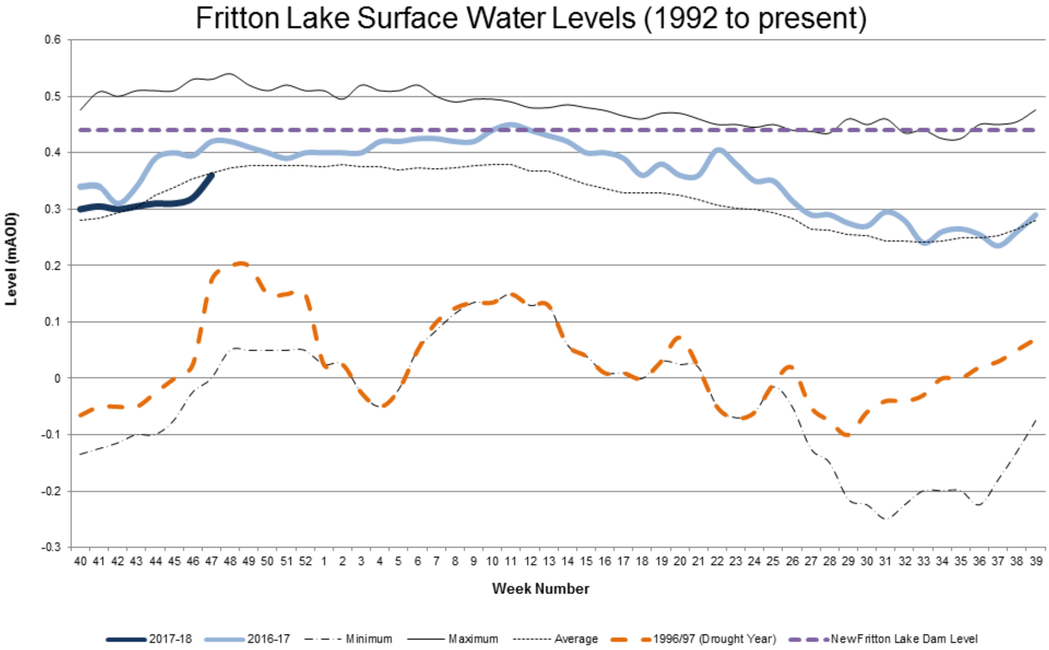


Figure 3.11: Fritton Lake Min, Mean and Max Water Levels

Figure 3.12 below also shows the lowest advisable pumping level and the typical lake bed level.

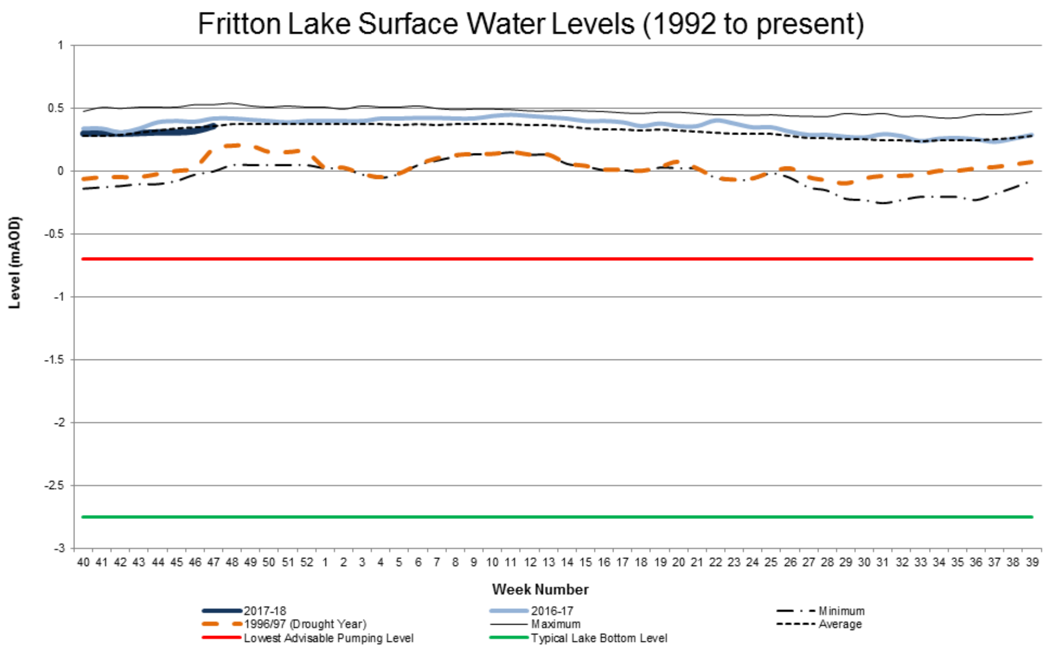


Figure 3.12: Fritton Lake Min, Mean and Max Water Levels with Constraints

Lake levels always remained above the lowest advisable pumping level which is determined by the bed level of Lound Run Channel which connects Fritton Lake to Lound Run Pond.

A water balance model for Fritton Lake does not exist. However, it is possible to calculate an indicative water balance based on an observation that Fritton Lake water level increases by 100mm for every 25mm of rainfall as measured at Lound WTWs. This relationship is used to determine inflows for the drought year of 1996 and for an average year.

1996 Scenario

Annual rainfall: 467mm
Rainfall / Storage relationship: 1 to 4

467mm x 4 = 1868mm (1.87m)

Using the Fritton Lake storage tables, 1.87m is equivalent to a volume of 2,303Ml/annum (78% of the annual licence).

Average Year Scenario

Annual rainfall: 630mm
Rainfall / Storage relationship: 1 to 4

630mm x 4 = 2520mm (2.52m)

Using the Fritton Lake storage tables, 2.52m is equivalent to a volume of 3,203Ml/annum (108% of the annual licence).

These estimates are supported by Figure 3.13 below which shows that following the low lake levels in 1992/93, lake levels quickly recovered to a level that necessitated Internal Drainage Board (IDB) pumping into the River Waveney. However, lake levels in the 1996/97 recharge season only recovered to ~0.2mAOD reflecting the below average winter rainfall and recharge. Nevertheless, even following a dry summer in 1997, lake levels fully recovered in the 1997/98 winter following above average rainfall.

IDB pumping to the River Waveney has been required in all subsequent years.

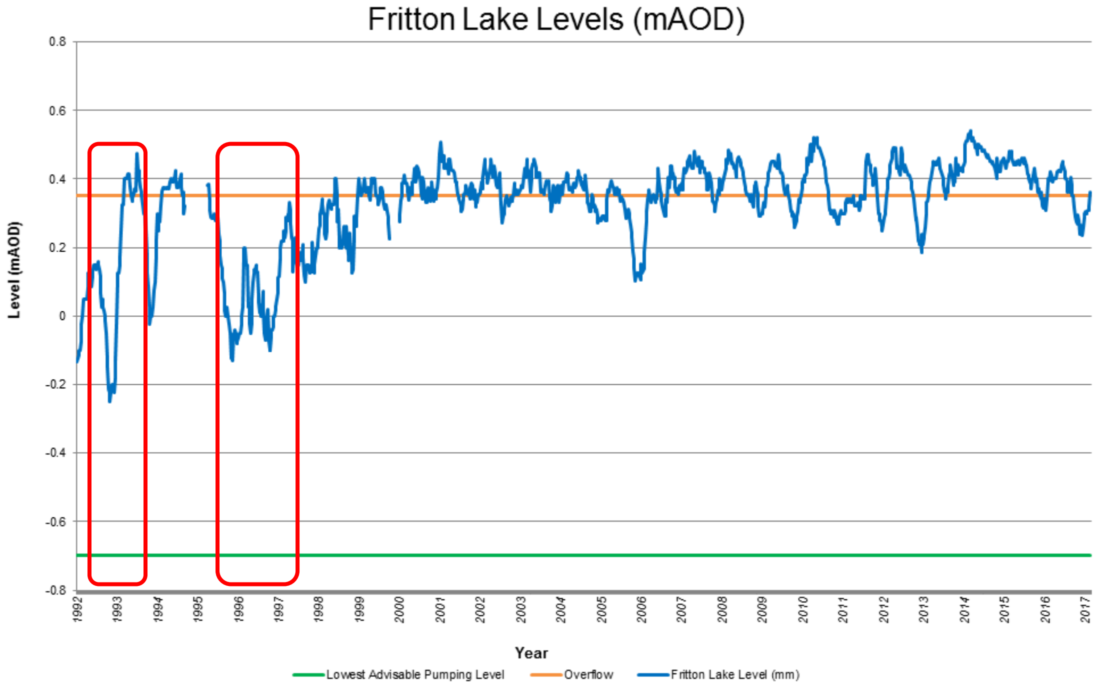


Figure 3.13: Fritton Lake Surface Water Levels

Crag groundwater levels have previously been monitored by ESW at Lound WTW. Figure 3.14 below presents groundwater levels for the period 2007 to 2012.

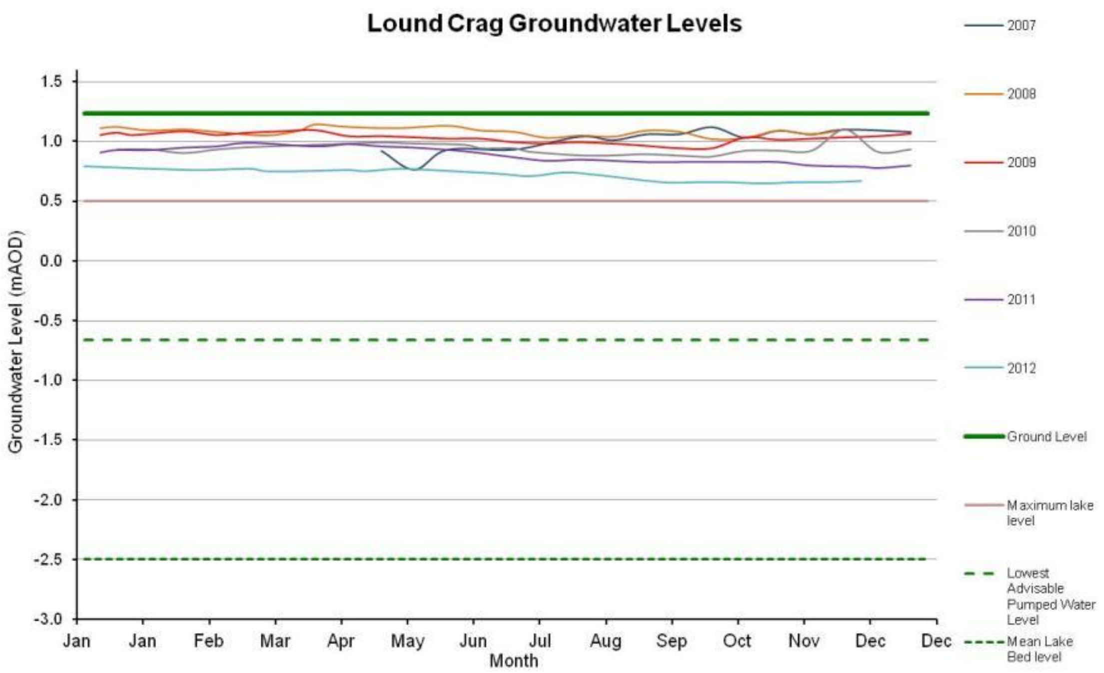


Figure 3.14: Lound Crag Groundwater Levels

The time series includes data for the 2012 drought although not for a 1990s drought year. However, even in 2012, groundwater levels are significantly above Fritton Lake bed level and indeed above the top lake water level. This suggests that there would always have been the potential for vertical groundwater flow into Fritton Lake. Monitoring of groundwater levels in the Lound boreholes will recommence once the Environment Agency has confirmed the next drought for the area.

Summary

An estimated Fritton Lake inflow (rainfall, runoff, tributary inflows and groundwater inflow) suggests that in a drought year, inflow may be in the region of 78% of the annual licence while in an average year, this increases to 108% of the annual licence.

Although in a drought year, inflows account for only 78% of the annual licence, the remaining 22% can be supplied by Lound Lakes to the east of Fritton Lake.

The annual licensed quantity of 2,955Ml/annum was fully utilised in 1995/96 and 1996/97 and was satisfied by abstraction from both Fritton Lake and Lound Ponds. As the full annual licence was utilised in these drought years without any significant adverse effects, the average and peak DO values are assessed to remain at 8.09Ml/d and 13.40Ml/d respectively.

Further Work

ESW had intended to develop a water balance model in AMP7 so that the water balance calculation could be refined, specifically the groundwater inflow and lake discharge to the River Waveney. However, it has not been possible to install a flow gauging station on the outlet of Fritton Lake due to ground conditions and the lack of power. Additionally, the preferred gauging station would be a v-notch weir with an ultrasonic probe. However, it is not possible to install a v-notch weir as this would create a further barrier to eel passage.

3.5 River Waveney and River Bure DO Sensitivity Testing Against a 1 in 200 year drought

3.5.1 River Waveney

To test the resilience of the River Waveney system to a drought not represented by the baseline DO assessment, the Aquator model was run with stochastic inflows for a 0.5% Annual Exceedance Probability (i.e. 200 year return period) drought. The stochastic weather data was generated for the Water Resources East project and then imported into the Agency's regional model to generate a River Waveney flow sequence for a 1 in 200 year drought. Two sets of flows were provided – one for a naturalised scenario, and one for a fully licensed scenario. The results of the assessment are provided in the table below.

Table 3.10: Results of River Waveney Stochastic Drought Assessment

Flow Scenario	DO (Ml/d)	Change from baseline (Ml/d)
Naturalised	4.7	-9.1
Fully Licensed	4.5	-9.3

Both sets of stochastic flows produce a significant drop in DO, indicating that a 1 in 200 year drought would constrain resource from the River Waveney.

3.5.2 River Bure

To test the resilience of the River Bure to a drought not represented by the baseline DO assessment, the assessment process was repeated using stochastic flows for a 200 year return period drought. The stochastic weather data was generated for the Water Resources East project and then imported into the Agency's regional model to generate a River Bure flow sequence for a 1 in 200 year drought. Two sets of flows were provided – one for a naturalised scenario, and one for a fully licensed scenario. The results of the assessment are provided in the table below.

Table 3.11: Results of River Bure Stochastic Drought Assessment

Flow Scenario	DO (Ml/d)	Change from 26.67 Ml/d baseline (Ml/d)
Naturalised	22.89	-3.78
Fully Licensed	22.84	-3.83

Both results for the 1 in 200 year drought are higher than the 17.84Ml/d baseline DO ESW are reporting for this draft WRMP, therefore a 1 in 200 year drought would not constrain DO for the River Bure.

3.6 Essex and Suffolk Groundwater Source Deployable Output Assessment

3.6.1 Methodology

DOs for Essex and Suffolk groundwater sources have been determined using the standard UKWIR methodology entitled "A Methodology for the Determination of Outputs for Groundwater Sources" (UKWIR, 1995a).

This methodology has been used to determine dry year annual average DO and is based on utilising either analytical test pumping data and/or operational data (including drought periods) in the form of water level/output data to assess source performance.

A graph of this information on a water level-output plot can then be utilised to determine a lower bounding 'drought curve' for the source. The drought curve can then be compared with key water-level and output constraints such as licence limits, pump capacity, water treatment works capacity, deepest advisable pumping water level and pump intake depth in order to determine DO. The DO is defined as the point at which the drought curve intersects the most restricting water-level or output constraint.

The DO determination for the average demand condition ideally utilises average monthly source output and monthly lowest pumping water levels in drought years. Where only analytical step pumping test data has been used, this has been extrapolated to 200 days in order to estimate the likely draw down that would occur over longer periods of time than those typically encountered during step test pumping.

An example of a DO assessment using the above methodology is illustrated in Figure 3.15 below.

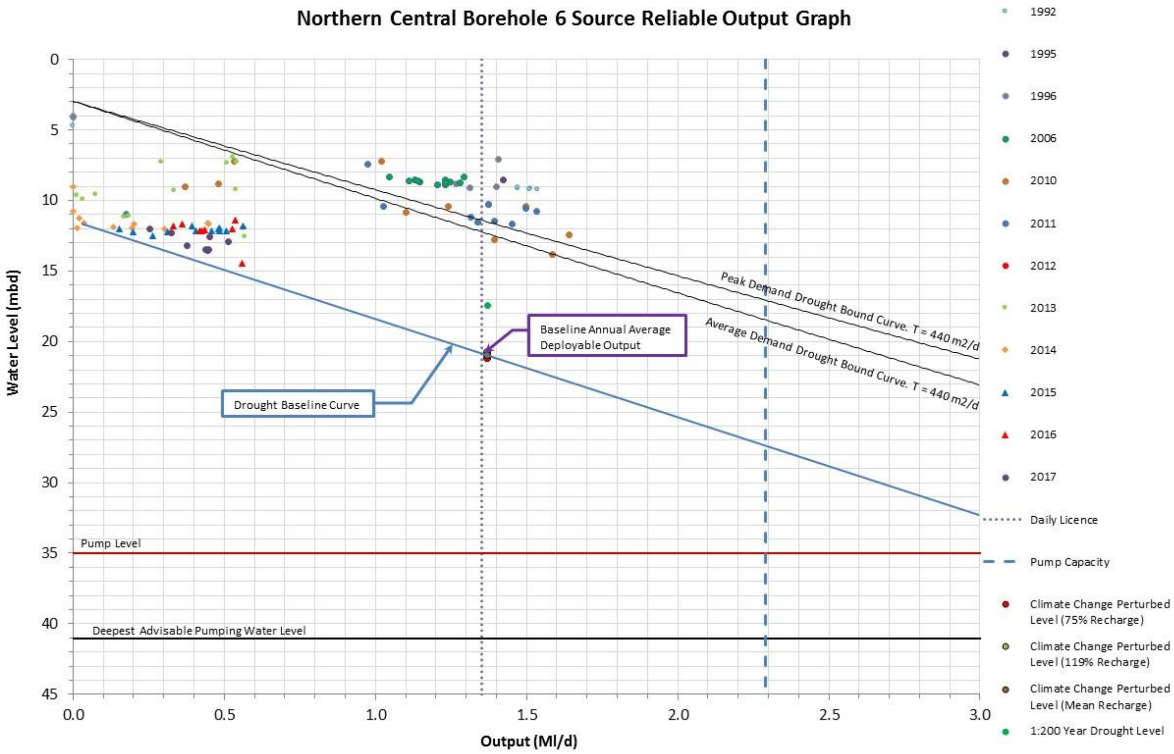


Figure 3.15: Example Deployable Output Assessment

3.6.2 Confidence Labelling

As in ESW's PR09 and PR14 WRMPs, the operational and test pumping data sets used in this assessment often include the 1991/92 and 1996/97 droughts unless the groundwater source was developed after this date. In order to assess whether there are any other droughts prior to the 1990's, ESW requested that the Agency's NEAC and Essex regional groundwater models were run back to 1970 (this is the model's earliest possible start date), thereby including the 1976 drought. The baseline (no climate change) model runs show that the lowest groundwater levels were observed in 1997. This is illustrated in Figure 3.16 below.

Figure 3.16: Example Baseline Model Run (1970 onwards)

This finding provides for a robust assessment given the wider data availability and also that it is a recent drought and so groundwater source performance and ESW's ability to maintain supply is well known.

ESW has assigned the confidence label of 'AC' to the Essex and Suffolk groundwater source DO figures using the matrix provided in the guidance, and reproduced in section 3.1. The constraints data is available and of a consistent quality (A) while the length of the hydrogeological record is less than 70 years (C). Although the assessment is based on less than 70 years of data, the regional model runs go back to 1970 and incorporate an adequate number and range of drought years including those of 1976 and in the 1990's.

3.6.3 Essex Groundwater Source Deployable Output

DOs for the Essex groundwater sources near Stifford, Roding and Colchester have been determined using the above approach.

The results of the PR19 WRMP DO Assessment are detailed in a report entitled Essex & Suffolk Water Deployable Output Assessments (ESW, 2017a).

The following table summarises the groundwater DO figures determined for the Essex resource zone:

Table 3.12: Essex Groundwater DO

Source	Annual Average Deployable Output (Ml/d)
South Essex Well 1	3.5
South Essex Well 2	3.4
Colchester Borehole 1	1.93

3.6.4 Suffolk Resources Zones Deployable Output

Annual average DOs for the Suffolk groundwater sources have also been determined using the above UKWIR methodology.

The following table summarises the groundwater DO figures determined for the Suffolk water resource zones.

Table 3.13: Suffolk Groundwater DO

Source	Average DO		Peak DO	
	(Ml/d)	Constraint	(Ml/d)	Constraint
Blyth				
Blyth Borehole 1	3.170	Distributed Annual Licence	4.546	Daily Licence
Blyth Borehole 2	2.210	Annual Licence	2.730	Daily Licence
Blyth Borehole 3	2.270	Annual Licence	2.935	Daily Licence
Blyth Borehole 4	3.110	Annual Licence	3.888	Daily Licence
Blyth Borehole 5	0.290	Distributed Annual Licence	1.137	Daily Licence
Blyth Borehole 6	0.780	Distributed Annual Licence	0.909	Daily Licence
Blyth Borehole 7	2.850	Distributed Annual Licence	3.864	Daily Licence
Hartismere				
Hartismere 1	0.548	Annual Licence	1.600	Daily Licence
Hartismere 2	0.630	Annual Licence	1.091	Daily Licence
Hartismere 3	0.450	Annual Licence	0.900	Daily Licence
Hartismere 4	0.000	Emergency Use Only	3.637	Daily Licence
Hartismere 5	3.020	Annual Licence	3.637	Daily Licence
Hartismere 6	1.250	Annual Licence	2.273	Daily Licence
Hartismere 7	2.749	Annual Licence	5.364	Daily Licence
Northern Central				
Northern Central Borehole 1	7.120	Annual Licence	7.274	Daily Licence
Northern Central Borehole 2	3.410	Annual Licence	3.410	Daily Licence
Northern Central Borehole 3	2.000	Annual Licence	2.592	Daily Licence
Northern Central Borehole 4	2.356	Annual Licence	2.356	Daily Licence
Northern Central Borehole 5	0.470	Annual Licence	6.900	Daily Licence

Source	Average DO		Peak DO	
	(Ml/d)	Constraint	(Ml/d)	Constraint
Northern Central Borehole 6	1.350	Distributed Annual Licence	2.273	Daily Licence
Northern Central Borehole 7	1.510	Distributed Annual Licence	2.455	Daily Licence
Northern Central Borehole 8	0.540	Annual Licence	6.900	Daily Licence
Northern Central Borehole 9	1.900	Distributed Annual Licence	2.273	Daily Licence
Northern Central Borehole 10	2.279	Annual Licence	2.279	Daily Licence
Northern Central Borehole 11	1.230	Annual Licence	1.630	Daily Licence
Northern Central Borehole 12	0.000	Emergency Use Only	0.000	Emergency Use Only

3.7 Groundwater Deployable Output Sensitivity Testing Against a 1 in 200 Year Drought

To test the resilience of ESW's groundwater sources to a 1:200 year drought, Amec Foster Wheeler (AFW) was employed to carry out groundwater modelling using the Northern East Anglian Chalk (NEAC) and Essex regional groundwater models.

The stochastic weather data generated for the Water Resources East project was imported into the Agency's regional groundwater models. 1949/50 was determined as being equivalent to a 1 in 200 year drought. The model runs were carried out from January 1900 to December 1990 inclusive, and included a new 4R and Modflow run in each case. New rainfall inputs to 4R were created using the Trace 41 Rainfall and Potential Evapotranspiration (PET) stochastic dataset for nine gauges (V33, V34, V35, V37, V38, V39, V40, V41 and V42). The timeseries data was distributed spatially using Thiessen polygons. This data did not include one gauge in every MORECS square, therefore the PET data for each gauge was simply assigned to the containing Thiessen polygon in the same manner as the rainfall.

Three model runs were carried out for each regional model; 1 in 200 year Naturalised, 1 in 200 year Fully Licensed (FL) and 1 in 200 year Recent Actual (RA) with ESW sources at FL. It was agreed with the Agency that the most realistic model run was the RA run with all ESW sources at FL, with the exception of the North Essex boreholes and Waveney Augmentation Groundwater Scheme (WAGS), which used utilisation and abstraction rates from ESW's Aquator model.

Each NEAC and Essex model run (i.e. Naturalised, FL and RA) with ESW sources at FL used the same processed rainfall and PET timeseries dataset described above (specific to the model) to maintain consistent climatic conditions. Differences between runs were in the representation of abstractions and discharges.

Modelled groundwater heads for all of ESW's groundwater sources were determined. Further details of the sensitivity testing carried out by AFW is presented in a technical note on the 1 in 200 year drought modelling (AFW, 2017).

For each groundwater source the lowest modelled historical water level experienced between 1970 and 2014 was compared with the lowest modelled 1 in 200 year drought groundwater level during 1949 and 1950. The difference between these two groundwater level heads was then applied to the drought baseline curve for each groundwater source reliable output graph to determine whether there was likely to be a reduction in DO due to a 1 in 200 year drought.

The following graph presents an example of how the drought baseline curve was adjusted for Northern Central Borehole 6 to take into account the modelled change in groundwater level for a 1 in 200 year drought event, to determine whether this would affect the DO of the source.

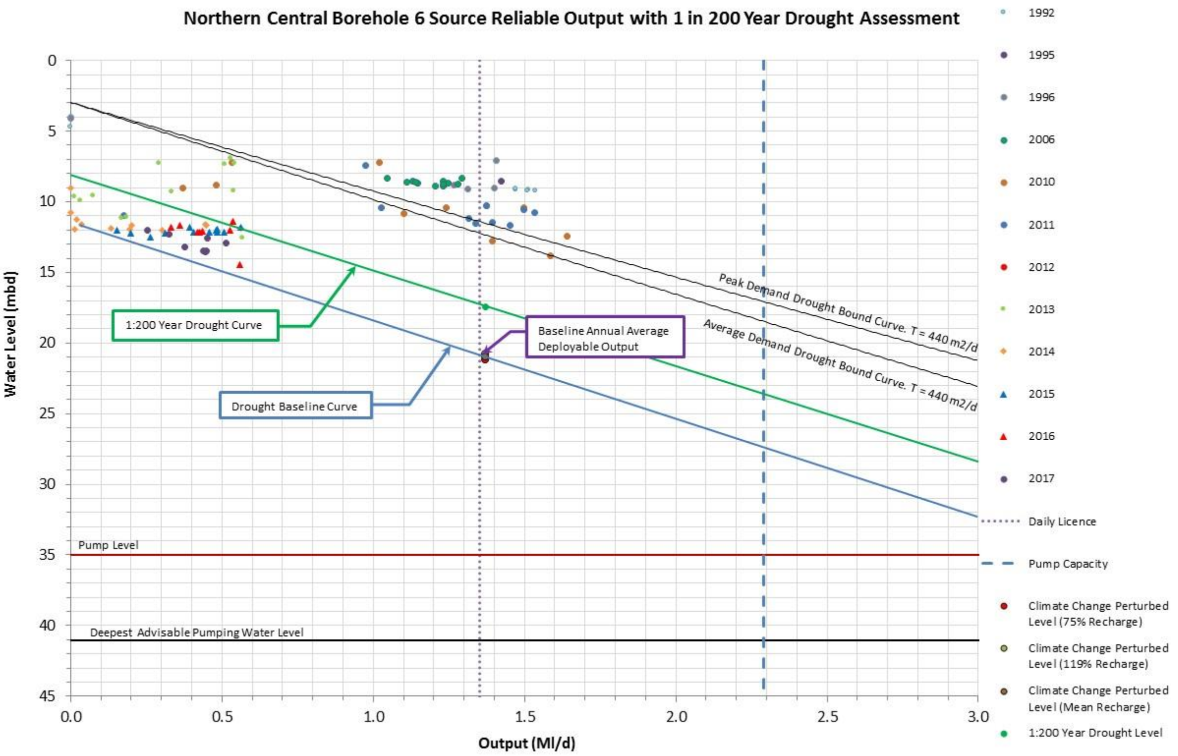


Figure 3.17: Northern Central Borehole 6 reliable output with 1 in 200 year drought

From the groundwater modelling assessment all ESW sources were found to be resilient to a 1 in 200 year drought, with no decline in DO. The only exception was the South Essex Well 2 which showed a reduction from 3.4Ml/d to 1.95Ml/d.

Further details of this work and the perturbation level applied to each ESW groundwater source for a 1 in 200 year drought is provided in ESW's groundwater deployable output report (ESW, 2017a).

3.8 Water Industry National Environment Programme & Effect on Deployable Output

3.8.1 Background

The Water Industry National Environment Programme (WINEP) is a list of environmental requirements produced by the Environment Agency and Natural England that water companies should include in their business plans submitted to Ofwat. It was previously called the National Environment Programme.

The WINEP is an integrated list of requirements for water resources, water quality and fisheries, biodiversity and geomorphology. It consists of investigations, options appraisals and actions to protect (prevent deterioration) and improve the water environment. Actions to protect or improve the environment include both licence changes, also known as sustainability changes, and non-licence change actions, such as river restoration.

WINEP actions generally fall into one of the following categories:

- Investigation;
- Options Appraisal; and
- Implementation

Investigations are required where the Agency suspects that an abstraction could be having an adverse effect on the environment but where the level of certainty is low. Consequently, investigations are required to raise the level of certainty so that conclusions can be drawn over the sustainability of the abstraction. Where an investigation concludes an abstraction is sustainable, the licence is re-affirmed. Where an investigation concludes an abstraction is un-sustainable, then a sustainability reduction (i.e. a reduction in the annual and / or daily licensed quantities) is quantified and then implemented.

Options appraisals are required where a sustainability reduction causes a supply deficit. The appraisal considers a series of options which will:

- Reduce demand to eliminate the supply deficit;
- Increase supplies to eliminate the supply deficit; and
- Mitigate any impact on the environment to a level whereby the sustainability reduction is no longer required.

The preferred option may comprise of either one measure or a series of supply, demand and mitigation measures.

The WINEP does not just consider the direct effect of abstraction. It also considers, among other aspects, catchment measures to improve the quality of water at abstraction intakes, invasive non-native species risk, fish passage and discharges to the environment.

The sections below describe:

- Our progress on delivering our PR14 AMP6 National Environment Programme; and
- The PR19 AMP7 Water Industry National Environment Programme.

3.8.2 AMP6 National Environment Programme (NEP)

The PR14 AMP6 NEP included the following:

- Three Review of Consents Implementation schemes:
  - Trinity Broads SAC: Sediment removal via mud pumping
  - Geldeston Meadows SAC: Provision of a compensation discharge
  - Alde Ore Estuary SPA: Provision of a compensation discharge
- Two WFD implementation schemes, both also with an Eel Regulations driver:
  - River Blackwater: Provision of a River Blackwater Sluice Fish Pass
  - Fritton Decoy: Provision of a sluice eel pass
- One Restoring Sustainable Abstraction (RSA) implementation scheme:
  - River Stour at Cattawade: Raise abstraction cessation level from 1.5mAOD to 1.65mAOD; and install variable speed abstraction pumps to pump to a level to reduce daily fluctuation in water level. This will prevent the exposure and re-wetting of river bank which might be responsible for the release of toxins that cause fish stress. Additionally it will help facilitate eel passage.
- Eel Regulations:
  - Fifteen Eel Regulations Implementation Schemes, of which ten were to improve intake screening and six to install or improve eel passes.
  - Six Eel Regulations Investigations to investigate opportunities to facilitate eel passage.
- Water Quality / Drinking Water Protected Areas (DrWPA):
  - A programme of work under the DrWPA driver, implementing catchment schemes to protect raw water quality.

Summary descriptions of the various schemes and investigations are given below:

Trinity Broads SAC

The Trinity Broads (the Broads) are located in east Norfolk and comprise of five interconnected shallow lowland lakes including Ormesby, Ormesby Little, Rollesby, Lily and Filby Broads.

ESW's public water supply abstraction from Ormesby Broad was identified by the Agency as having the potential to significantly affect the hydrology of the Broads and therefore impact on the condition of the water dependant designated features. ESW completed NEP investigations in both AMP3 and AMP4 which fed into the Agency's Review of Consents (RoC) process.

These investigations concluded that while the Broad water inflows and outflows were balanced, a minimum Broad water depth of 30cm was not maintained across the extent of the Broads in a drought year. These areas tended to be close to the margins, within bays and near to Filby Bridge and Rollesby Bridge. Consequently, ESW's River Bure & Ormesby Broad abstraction licence (7/34/09/*S/0054) was modified in 2015 to include a Broad abstraction cessation level of -0.14mAOD. This new abstraction cessation level would have constrained abstraction in a drought year and would have reduced deployable output. Consequently, following the completion of a comprehensive options appraisal, it was agreed with the Environment Agency and Natural England that the abstraction cessation level could be reduced to -0.44mAOD (the lowest drought water level observed in 1996/97), subject to the removal of sediment to ensure that a minimum water depth of 30cm is maintained going forwards across the extent of the Broads.

ESW completed a significant investment project between September 2016 and April 2017 to remove 10,000 cubic metres of nutrient rich mud from shallow areas of the Broads which had accumulated over decades. As well as maintaining water depths during drought years, removing this mud will encourage the growth of water plants which provide important habitat for wildlife and will also help to maintain clear water supplies to the local water treatment works. The project involved the hydraulic pumping of approximately 50,000 cubic metres of sediment and water which was pumped up to 1km into 'geobags' – huge woven polypropylene bags that retained the solid material and allowed for surplus water to be removed. This was the first time that geobags have been used for a project on this scale in the UK. The de-watered sediment was then used as a soil improver for local farmland.

The work was carefully planned with Norfolk Wildlife Trust, Natural England and local landowners to prevent any disturbance to breeding birds, for which the site is so important.

Following completion of the project, the NEP implementation scheme has now been signed off by the Agency allowing the Ormesby Broad abstraction cessation level to be reduced from -0.14mAOD to -0.44mAOD.

Geldeston Meadows

Geldeston Meadows is designated a Site of Special Scientific Interest (SSSI) for its botanical and invertebrate interest and forms part of the Broadland Special Area of Conservation and Broads Special Protection Area. It is located in the Waveney Valley in Norfolk and comprises grazing meadows, ditches with Magnopotamion or Hydrocharition-type vegetation and alluvial woodland.

In AMP4, both ESW and AWS investigated the effects of their respective local groundwater abstractions on the water dependant features of the site. These investigations concentrated on the effect of historical and current abstraction and concluded that abstraction was unlikely to have a significant effect on groundwater supply to Geldeston Meadows.

The Agency also investigated the effect of historical and fully licensed abstraction as part of its RoC process. Its investigations supported Water Company conclusions regarding historical abstraction although concluded that fully licensed abstraction could cause significant effect.

Given the outcome of the Agency's RoC investigations, ESW and AWS prepared a comprehensive options appraisal to identify and appraise a series of options that could be implemented to mitigate against potential significant adverse effects whilst minimising any adverse effect on the Water Companies' resource zone supply demand balances.

The Companies' preferred option was to make a compensation discharge into the Geldeston Meadows ditch system. This, along with two new water level management structures, will enable the site conservation objectives to be met.

A compensation discharge of up to 1.35Ml/d will be made in a dry year similar to or drier than the 1996/97 drought.

Infrastructure is now in place allowing a compensation discharge to be made in future drought years.

Alde Ore Estuary

As part of its RoC process, the Agency has assessed the effect of ESW's Group licence (Blyth WRZ) to establish whether abstraction from local groundwater sources could have significant adverse effect on the Alde Ore Estuary designated features of interest.

The flow from the River Alde is seen as a significant component of the freshwater contribution to the western areas of the Alde Estuary. Since groundwater levels influence base flow and therefore river flow, groundwater abstraction authorised under the Benhall Group Licence could affect flows in the River Alde. This reduction in flow could increase the mudflat and estuary salinity and reduce the area of grazing marsh. These changes could alter the habitat and food sources available to over-wintering wild fowl and could reduce their numbers.

The Agency completed a comparison of observed river flows against the Alde Ore Estuary's Minimum Residual Flow requirement. This confirmed a drought year deficit of ~70Ml between June and September (Environment Agency, November 2013, *pers. comm.*).

ESW completed a comprehensive options appraisal to establish how the MRF could be maintained with least impact on the Benhall Group licence DO.

The Company's preferred option to make a 1.6Ml/d compensation discharge during drought directly into the River Alde has since been implemented.

Fritton Decoy Eel Pass

A dam is located on the outlet of Fritton Decoy to prevent a significant volume of the lake from draining to tide. However, the wooden structure inhibited eel passage when lake levels were low.

In fulfilment of our AMP6 NEP obligations, an improved eel pass will be installed.

River Blackwater Sluice Fish Pass

The Blackwater Sluice at Langford maintains water levels within the upstream channel to allow ESW to abstract water from its River Blackwater intakes. The structure is also operated to manage flood flows.

The Environment Agency is concerned that the structure prevents fish and eel passage, both up and down stream.

A project has commenced to deliver a new fish pass structure by April 2020. The structure will require a minimum of 3Ml/d flow to allow it to function. The top of the fish pass will be located upstream of ESW's Blackwater intake and Langford Mill intake. Consequently, the 3Ml/d loss of water has been included in the Essex WRZ Aquator model. This has reduced the Essex WRZ DO by 1 Ml/d.

Lower Stour

ESW investigated the potential impact of its raw water abstraction from the North Channel of the Lower River Stour on the Essex/Suffolk border in AMP5. Although there was little evidence, the Agency was concerned that ESW's abstraction from the northern channel could, at times, reduce river levels and expose river-bank sediment. It suggested that this exposure could result in microbes present in the sediment releasing an exotoxin. The exotoxin could then be flushed into the water when the river level rose again and could affect the health of fish.

To prevent such an effect, ESW has since agreed with the Environment Agency to raise the abstraction cessation level from 1.5mAOD to 1.65mAOD and to install variable speed pumps at its Brantham intake. This will allow variable abstraction to maintain a constant level and will have the following benefits:

i. A more consistent river level will decrease the extent of river bank subjected to the exposure/submersion cycle reducing the potential source of exotoxin;
ii. A narrower range of level fluctuation will increase the frequency of wetting and drying and may reduce the potential production of exotoxin by actinomycetes in the river bank; and
iii. Raising the cessation level from 1.5mAOD to 1.65mAOD will result in deeper water in shallow margins and increase the area of habitat available for fish.

The Agency also thought that abstraction of water from the northern channel was resulting in insufficient flows over Judas Gap weir such that the weir becomes a barrier to eel migration.

ESW has since:

i. Undertaken to install eel screens on the Brantham river intake to prevent eels from being drawn into the intake and from being pumped to Abberton Reservoir; and
ii. Agreed to reduce or stop abstraction at Brantham at key times during the autumn to facilitate the downstream migration of eels, subject to water resource status. This is coordinated by the Environment Agency chaired Ely Ouse Essex Transfer Scheme (EOETS) Operators Group.

Eel Regulations Schemes

The Company is on track to complete its planned Eel Regulations programme during AMP6. So far improved eel screens have been installed at the Lound intakes in Suffolk. Improved screens are due to be installed at the remaining seven intakes by March 2020.

Eel passes have been installed at the Muckfleet Sluice, Stratford St Mary (Glenfield Gates) and Beeleigh Control Gates. Improved or new eel passes are due to be installed at the remaining three locations by March 2020.

All required investigations have been completed at Ormesby Broad, Hanningfield (three sites), Abberton and the Fritton / Lound system.

At Ormesby Broad, the summary outcome of the investigation was that although the Ormesby draw-off intake is non-compliant with The Eels (England and Wales) Regulations 2009 based on Environment Agency defined life stages expected to be present given the distance from tidal limit, best practice screening for smallest life stage expected to be present (elvers) is not cost-beneficial and less than best practice screening (for eels ≥30 cm) is also not cost-beneficial. The most appropriate Alternative Measure is the incorporation of a slow-start to pumping regimes.

Flow velocities in the vicinity of the Ormesby intake are typically (75% of time) within the sustained swimming capabilities of eels ≥ 5 cm and observations showed eels of 84 to 154 mm were not involuntarily drawn into the intake structure under the highest pumping rates used during spring / summer. Therefore, the Ormesby draw-off intake is not considered to present a high risk to eel through entrainment and loss, particularly because the current population is skewed towards adult life stages.

The investigation recommended that slow start-up be incorporated into operating regimes and that screening be improved to best practice or near best practice within future routine maintenance / refurbishment programmes.

At Hanningfield the summary outcome of the investigation was that although both draw-off towers are non-compliant with The Eels (England and Wales) Regulations 2009 based on Environment Agency defined life stages expected to be present given the distance from tidal limit, best practice screening (2 mm) is not cost-beneficial and less than best practice screening to protect eels ≥30 cm is also not cost-beneficial. The most appropriate Alternative Measure is trap and transport, namely periodic netting to remove the existing resident stock and translocate eels to locations nearby in the River Chelmer / Blackwater. The Sandon Brook Intake is also non-compliant; however, eels are likely absent from the watercourse upstream, with no possibility of ingress, so it is considered that no further action is required at this time.

At Abberton the summary outcome of the investigation was that although the draw-off intake is non-compliant based with The Eels (England and Wales) Regulations 2009 based on Environment Agency defined life stages expected to be present given the distance from tidal limit, best practice screening (2 mm) is not cost beneficial. Less than best practice screening is already in place at the draw-off (5 mm spacing) and this is considered sufficient to protect the eel life stages known to be present, as evidenced by empirical eel population surveys conducted in the main reservoir in 2017. No further action is considered necessary at this intake at the present time. The causeway pumping station which conveys water from the central to the main section of the reservoir is non-compliant (75 mm bar screen), however, replacement of the existing screen with best practice screening (2mm) is not cost beneficial.

Appropriate Alternative Measures are: 1) trap and transport of resident eels to Roman River / Colne estuary, 2) installation of an up-and-over eel pass to enable upstream ingress of eel from Layer Brook in combination with a long-term trap and transport programme, 3) investigate options to enable both natural ingress and egress. These options will be developed further during AMP7.

Drinking Water Protection Areas / Water Quality schemes

Ten surface drinking water protected areas (DrWPA) are deemed to be ‘at risk’ from pesticides, including:

- River Bure and Trinity Broads (Norfolk);
- River Waveney (Norfolk Suffolk border);
- River Stour (Suffolk / Essex border);
- Roman River (Essex);
- Layer Brook and Abberton Reservoir (Essex);
- River Blackwater (Essex);
- River Chelmer (Essex); and

- Hanningfield Reservoir (Essex).

For further information, please see section 3.11 below.

3.8.3 AMP7 Water Industry National Environment Programme (WINEP2)

The Environment Agency's guidance entitled "Sustainable Abstraction" (Environment Agency, 2017c), states that WRMPs should include the requirements set out in the Water Industry National Environment Programme (WINEP), which sets out measures needed to protect and improve the environment. By April 2018, there will be have been three iterations of the WINEP as follows:

- WINEP1: Issued in March 2017;
- WINEP2: Issued on 29 September 2017; and
- WINEP3: To be issued on 30 March 2018.

The Environment Agency has applied a traffic light system to WINEP2 to indicate certainty of measures. It expects all green and amber sustainability changes, as defined in WINEP1, to be allowed for in draft WRMPs as adjustments to final plan deployable output.

WINEP 2 was issued after most water companies' supply and demand forecasts had been completed. Therefore, where it was not possible to allow for new WINEP2 green and amber schemes to be included in the draft WRMP, the Environment Agency has asked water companies to consider these schemes and their associated sustainability reductions as a supply demand balance scenario, rather than as a reduction in deployable output in the final plan supply demand balance calculation.

The second iteration of the PR19 WINEP for AMP7, issued by the Environment Agency in September 2017, contains the following schemes:

Restoring sustainable abstraction

- Twenty four Water Framework Directive (WFD) investigations and options appraisals, of which twenty are WFD groundwater investigations for impact on groundwater, three are for impacts on flow and one for impacts on a Heavily Modified Water Body (HMWB). The groundwater investigations are likely to be grouped together as six schemes, relating to the impacted water bodies. ESW has agreed with the Agency that these investigations and options appraisals will be completed in AMP7 with any implementation schemes being delivered in the first two years of AMP8.

- One sustainability change implementation scheme for the Langham Boreholes. This site has been identified by the Agency as causing actual serious damage to the River Brett and the Company is working with the Agency and other abstractors, including Anglian Water Services (AWS) and Affinity Water, to understand the effect of the Company's abstraction on groundwater and related surface water bodies. ESW has not allowed for a sustainability reduction in this draft WRMP. ESW will work with the Agency, AWS and Affinity Water on a joint investigation and if required, options appraisal, in AMP7. Any required option would be implemented in AMP8.

Invasive non-native species (INNS)

- Eight INNS investigations and options appraisals, covering all the Company's raw water transfer systems, and other pathways of potential INNS transfer. This will involve undertaking risk assessments of the risk of spreading INNS and then an options appraisal of the available measures to reduce any identified risks.

- Three INNS no deterioration schemes, relating to implementation schemes for other, i.e. non-water transfer, pathways of INNS movement, developing a companywide INNS strategy and supporting partnership projects to address INNS transfer.

- One INNS monitoring and surveillance scheme, which is likely to be removed before WINEP3;

Biodiversity

- One scheme relating to NERC delivery.

Eel Regulations

- Two investigations relating to facilitating eel passage at Hanningfield and Abberton Reservoirs.

- One improvement scheme relating to the eel screens at Wormingford intake.

Water Quality / Drinking Water Protected Area (DrWPA)

- Five DrWPA no deterioration schemes for catchment management work to protect water quality in the Company's main surface water catchments. (See Section 3.5).

All of the above schemes will go forwards into ESW's PR19 Business Plan.

3.9 Abstraction Reform

3.9.1 Allowances for Abstraction Reform

ESW has not planned for any changes to DO as a result of abstraction reform. This is because the Agency expects that at the time of reform, abstraction licences will be sustainable, or a plan will be in place to make them sustainable.

On transition, new permits will be issued based on current licence quantities and conditions. As no new licence controls will be imposed, this will not impact deployable output.

3.9.2 Emergency Abstraction Licences

The WRPG (Environment Agency, 2017) states that licensed volume required for emergency purposes will only be available for those purposes and asks water companies to clearly state which sources are used for emergency purposes in their WRMPs and what the emergency purposes are.

ESW has the following emergency use abstraction licences:

Table 3.14: Emergency Abstraction Licences

Abstraction Licence Number	Emergency Use Conditions
8/36/15/*G/0092	To be used when it is not possible to take the required quantities of water from the River Stour to supply Langham Treatment Works due to drought, frost and pollution in excess of treatable limits.
7/34/19/*G/0135	To be used when it is not possible to take the required quantities of water from the River Waveney to supply Barsham Treatment Works due to pollution in excess of treatable limits.

3.10 Climate Change

A detailed explanation of the effects of climate change on supply and demand is covered in section 6 of this report.

Additionally, an allowance for the uncertainty in the level of climate change incorporated into assessments is covered within the Company's target headroom assessment which is covered in section 7 of this report.

3.11 Protection of Drinking Water Protected Areas

In most cases, the main risk is from metaldehyde, a widely used molluscicide for the control of slugs. However, all DrWPAs, except the River Bure and Trinity Broads, are also at risk from propyzamide, carbetamide, and clopyralid.

The source of the pesticides is generally from agricultural activities in the catchments. In order to protect the DrWPA from further deterioration, the area of land where land management practices and other activities can impact on water quality at ESW's abstraction intakes have been designated by the Agency as

Safeguard Zones (SGZ). The Agency has also prepared SGZ action plans which detail measures designed to protect the water quality in the DrWPA. Additionally, national and local initiatives are in place to raise awareness and to work with pesticide users to try and reduce the impacts of pesticide use on the DrWPAs. Some of these initiatives are targeted specifically at controlling pesticide use while others are more generic and aim to encourage good agricultural practice. Details of all actions are shown in the following action plans:

- River Waveney: https://ea.sharefile.com/d-s699f38f03b94b8ea
- River Bure & Trinity Broads : https://ea.sharefile.com/d-sc2c2eeb70a44bd1b
- River Blackwater, River Chelmer, and Hanningfield Reservoir: https://ea.sharefile.com/d-s6174492392940f79
- River Stour, Roman River, Layer Brook and Abberton Reservoir: https://ea.sharefile.com/d-s9846327223d4ecd9

Currently there are no groundwater SGZ for ESW. However, risks to groundwater are considered as part of the ESW's water safety planning process and action would be taken where there was a perceived risk.

In order to help protect raw water sources, ESW employs catchment advisors to work in each of the catchments from which it abstracts. Their purpose is to engage with all stakeholders such as farmers, landowners and agronomists with the aim of reducing nutrient, sediment and pesticide runoff from land to the rivers. It is expected that this work will contribute to an improvement in river water quality and therefore reduce outage as a result of nitrate, turbidity, algae and pesticide diffuse pollution. Further information on ESW's catchment advisors' work can be found on the website:

https://www.eswater.co.uk/your-home/environment/catchment-management.aspx

In AMP6 much of ESW's catchment work has been focussed through the 'Pesti-wise' programme:

https://www.eswater.co.uk/your-home/environment/Pesti-wise.aspx

Pesti-wise was launched in April 2015 in three catchments; Roxwell Brook and Layer Brook in Essex and Dickleburgh Stream in Norfolk. Pesti-wise aims to work with farmers and their agronomists to deliver practical guidance and on-farm solutions that helps minimise pesticide run-off and supports sustainable agriculture.

Key objectives are to:

i) Prove the concept that voluntary action can reduce raw water concentrations of key pesticides in catchment water-bodies; and
ii) Determine the level of engagement, adoption of best practice, and scale of investment, required to achieve the observed pesticide reductions.

The desired outcome is to reduce average and peak pesticide concentrations at the sub-catchment outlets, compared to a control catchment and the pre-intervention dataset.

Some form of engagement, a 1.1 visit or a telephone call has been delivered to farmers covering 94% of the land area in the Pesti-wise catchments. 87% of the land holding has had face to face engagement. Those remaining who have had no engagement typically farm less than 10ha within the catchment and/or have no arable land. As part of this programme 34 equipment grants and seven infrastructure grants have been paid out to farmers. Attempts to engage will continue over the remainder of the AMP.

Although a good level of engagement has been achieved there is still work to be done in terms of improvements to water quality. It has become clear that ‘one size’ does not fit all and ESW needs to ensure that its approach for AMP7 recognises the differences across the catchments and looks at how the Company can work better with external partners to help deliver a wider range of benefits.

For AMP7 ESW plans to implement a grant scheme that will replace Pesti-wise with a new scheme that will consider a wider range of diffuse pollutants and measures supported by the development of a new grant delivery system. This will allow other stakeholders to bring in money that will fund other ecosystem service improvements that are not a priority to ESW.

Pesticides (particularly metaldehyde), colour and cryptosporidium can compromise ESW’s Overall Drinking Water Quality (ODWQ) compliance. Currently, there is no affordable treatment process for metaldehyde removal. Abstraction management is effective at managing diffuse pollution when reservoir storage is healthy. However, when this is not the case, there is less scope for abstraction management which increases the risk of failures. Therefore, abstraction management needs to be used in conjunction with catchment management.

ESW’s pesticide focus is likely to be on paid for metaldehyde substitution – ESW’s AMP6 work supports that this will be by far the most cost effective method of reducing metaldehyde in raw waters. ESW also intends to run a multi-benefits project, possibly a reverse auction, in partnership with the local Rivers and Wildlife Trusts.

ESW believes that the above drinking water catchment management projects will help to deliver against two key customer outcomes which are that ESW supplies ‘clean, clear drinking water that tastes good’ and provides ‘a reliable and sufficient supply of water’. In a wider context, they will also deliver on ESW’s environmental outcome to ‘help to improve the quality of rivers and coastal waters for the benefit of people, the environment and wildlife’.

3.12 Invasive Non-native Species (INNS)

As part of its work to update its Water Resource Management Plan for PR19, the Company is required, for the first time, to review whether current abstraction operations and future solutions will risk spreading invasive non-native species (INNS), and propose measures to manage that risk.

A supporting report "Essex & Suffolk Water (2017b) Draft Raw Water Transfer INNS Risk Assessment Report" presents the approach, methodology and outputs used to review the risk of spreading INNS via existing raw water transfers within ESW.

The report shows how ESW has carried out baseline risk assessments to assess the risk of spreading INNS via the Company's existing raw water transfers, based on information available at the time of the assessment and following the guiding principles and scope set out in Environment Agency guidance. As the Agency has purposefully not set out a specific risk assessment methodology, the method used has been developed in-house and will be further refined and developed as part of the work planned under the PR19 WINEP.

Information from a variety of published sources, and expert knowledge from technical and operational staff within ESW, has been used to populate a data spreadsheet to describe the source, pathway and receptor for each raw water transfer, to identify any known INNS species currently present and to identify any existing measures which may reduce the risk of spreading INNS via each transfer, based on the suggested information requirements set out in the Environment Agency's "PR19 Driver Guidance – INNS" document.

A pick list of options and associated scores (between 0 and 10) was developed by ESW technical staff for each aspect of each raw water transfer. The scores were added together to give a total risk score calculated out of a theoretical maximum score of 100. The total risk score was then adjusted to take into account any existing measures that might reduce the risk of spreading INNS during the raw water transfer. Multiplying the total risk scores, by the appropriate mitigation measure score, gave a final risk score for each transfer. The raw water transfers were then ranked according to the total and final risk scores.

Existing measures to reduce the risk of spreading INNS via raw water transfers, that are employed at some ESW sites, include transferring water direct to a WTW process and partially treating transferred water with low doses of chlorine (specifically for mussel control). In addition, several key river intakes will have improved screens, likely to be 2mm mesh, installed as part of the Eel Regs programme of works within the current AMP6 NEP.

The baseline risk assessment, taking into account existing INNS mitigation measures, indicates the highest risk transfers for spreading INNS are those associated with the Environment Agency's Ely Ouse to Essex Transfer Scheme (EOETS), to Abberton and Hanningfield Reservoirs and to the Stour and Blackwater. Other high scoring transfers include the two natural catchment inflows to Abberton and Hanningfield reservoirs, and other raw water transfers within the Langham / Abberton and EOETS systems.

The Environment Agency's "PR19 Driver Guidance – INNS" acknowledges that: "Reducing the risk from existing raw water transfer pathways will be a gradual process, guided by understanding of the feasibility and costs of mitigation measures." A complete options appraisal for measures to mitigate the risk of spreading INNS via existing raw water transfers will be carried out as part of the Company's obligations within its PR19 WINEP.

This is the first time that a review of raw water transfers for the risk of transferring INNS has been included within the WRMP and Periodic Review processes, so no comparison is available with the PR14 WRMP.

3.13 Outage

3.13.1 Background

ESW's outage allowance assessment is presented in detail in a separate supporting report, *Outage Allowance Report - Periodic Review 2019* (2017c). A summary of the assessment is provided below.

Outage is defined in the UKWIR report *Outage Allowances for Water Resource Planning* (UKWIR, 1995b) as:

"A temporary loss of deployable output"

Outage events can be divided into *planned outage* and *unplanned outage*. The UKWIR report defines planned outage as:

"A foreseen and pre-planned outage resulting from a requirement to maintain source works asset serviceability".

Unplanned outage is defined as:

"An outage caused by an unforeseen or unavoidable legitimate outage event affecting any part of the source works and which occurs with sufficient regularity that the probability of occurrence and severity of effect may be predicted from previous events or perceived risk".

The report also provides a definitive list of what is to be considered as legitimate unplanned outage. The categories include:

1. Pollution of Source
2. Turbidity
3. Nitrate
4. Algae
5. Power Failure
6. System Failure

The recommended approach described in the UKWIR report *Outage Allowances for Water Resource Planning* (UKWIR, 1995b) has been used as the basis for calculating outage allowance. The UKWIR approach provides a good basis for assessing the outage data, although it leaves a number of areas open to interpretation. Therefore, several assumptions have to be made and the approach adapted to the available data and the resulting modelling software output.

3.13.2 ESW's Adapted Methodology

The methodology used by ESW to determined outage allowance comprises the following 3 stages:

Data Gathering and Interpretation

Essex Water Resource Zone

Treatment works daily output data for the period April 2012 to March 2017 inclusive were used as the basis to calculate outage magnitude and duration.

Actual daily works output spreadsheets were compared against planned output for each treatment works. The former contain notes recording the reasons for any divergence of actual output from the planned output. Although the Essex treatment works are planned to operate at a minimum threshold production rate, at times staff plan 4 to 6 weeks in advance to reduce the output at a treatment works. This may be for a variety of operational reasons, for example, to allow for maintenance work to be carried out, if a reduction in demand is expected, or if raw water quality is expected to be poor and will increase the amount of chemicals required to treat the water. This additional information is used in conjunction with the minimum threshold production rates to identify when legitimate outage events have occurred and to ensure that outage was not over-estimated. However, during a confirmed outage event, its magnitude in Ml/d was calculated using the minimum threshold production rate, not the planned output. If during the event planned output was below the minimum threshold production rate then this method ensured that outage was not under-estimated.

If the treatment works output data indicated a reduction in output, supporting evidence to confirm if a legitimate outage event had occurred was sought from qualitative records, such as notes and weekly reports from the Strategic Network, Water Quality and Water Supply departments. If no information could be found in these reports the Water Supply Department was consulted to search onsite treatment works diaries for information.

Additionally, the reports noted above were also fully reviewed for evidence of the occurrence of outage events and if the issue would have prevented maximum output being achieved if required. Raw output data from the relevant time periods was then reviewed to identify if an actual reduction in output occurred and also to calculate the relevant magnitude of the event.

Suffolk Water Resource Zones

Treatment works daily output data for the period April 2012 to March 2017 inclusive were used as the basis to calculate outage magnitude in Ml/d and outage duration in days. The data had undergone validation and cross-checking against pumping flows to ensure any errors in telemetry recording had been identified and rectified.

For surface water treatment works, this data was compared against Production Plan (target output) spreadsheets for Barsham, Lound and Ormesby WTWs. For the remaining treatment works, which have no associated target outputs, a method to define a minimum guideline output figure was used. This was calculated from the yearly average output minus 10% of that average. If the daily output fell below this guideline value a potential outage event was deemed to have occurred.

To validate the methods of identifying potential outage events, the works outputs were also graphically displayed to enable visual identification of sharp troughs in output or longer periods of lower output uncharacteristic for a particular works. Generally, periods of reduced output that appeared significant through visual identification had also been identified through the mathematical methods.

Potential outage events identified through the data analysis described above were cross-referenced with a range of qualitative information sources, to confirm their legitimacy and determine the reason for the event. These included Water Supply Department monthly reports, Works Status reports, Maintenance and Planning Department records and Water Quality weekly reports. If no qualitative evidence could be found to confirm a potential outage event indicated by the output data, details were passed to the Suffolk Water Supply team to cross-reference with onsite treatment works daily dairies. Where there was correlation between a quantitative data source and a qualitative source, and there was confirmation of the legitimacy of the outage, then the event was included in the assessment. Where no correlation existed between information sources, the potential outage event was discarded from the assessment.

The Suffolk groundwater source works are not operated to minimum production threshold rates in the same way as the Essex Resource Zone source works. This is due to the demand-reactive nature of many of the works, particularly the small groundwater works, and also because of the interconnectedness of the resource zones, where several works directly supply the same district storage tank or supply area. Ensuring consistency in calculating outage magnitude required developing a set of mathematical procedures, the use of which depended upon the source works and suitability of data set for a particular procedure. Where output was consistent, the average output from the 7 days previous to an event provided a baseline figure which was then used to calculate the deficit in output during the event. Where works output was highly variable or uncharacteristic just previous to an event, the minimum guideline output figure previously identified by taking the yearly average output minus 10% of that average, was used as a baseline figure.

Development of Triangular Distributions

As found during the previous periodic review assessments, there were insufficient outage events to enable triangular distributions to be developed for each category of outage. Therefore, for the Essex WRZ, all outage events at each works were collated by month. For the Suffolk WRZ, all outage events for all of the source works in each zone were collated. The minimum, best estimate and maximum daily magnitude and outage event duration was then calculated using these combined data sets. These figures correspond to the least credible; most likely and maximum credible values discussed in the UKWIR (1995a) methodology and required to form the triangular distributions.

Due to the small number of outage events in some months, in order to determine the most likely daily outage magnitude it was necessary to first round the data to the nearest whole number (Ml) for the Essex WRZ and to one decimal place for the Suffolk WRZs, before calculating the best estimate (average or mode) figure.

Monte Carlo Analysis

The UKWIR (1995a) methodology indicates a Monte Carlo simulation of 500 iterations would be considered sufficient to provide a satisfactory derived distribution. However, the UKWIR report *An Improved Methodology for Assessing Headroom* (2002) recommends that a typical number of iterations might be 5000 and this figure has been used in preference.

The minimum, most likely and maximum figures calculated using the legitimate outage events data were entered into a spreadsheet to define triangular distributions to represent the spread of outage event magnitude and duration, at each water treatment works for each month of the year in the case of the Essex WRZ, and for each WRZ for each month in the case of the Suffolk WRZs.

Monte Carlo analysis was conducted using the risk analysis software package Crystal Ball. For the Essex WRZ, each iteration combines outage magnitude and duration for each month, at each works, based on random sampling across each triangular distribution. During the course of the simulation the results from each trial are combined in pre-defined forecast cells which calculate the total monthly outage in Ml for each month at each water treatment works. These results were then combined in a second tier of forecast cells to calculate the total monthly outage for the Essex WRZ in Ml/d. This calculation was carried out using the following formula:

$$\text{Essex Total Monthly Outage} = \frac{\text{Total monthly outage of Langham + Layer + Langford + Chigwell}}{\text{Total number of days in data set} \times \text{Total number of treatment works}}$$

In this calculation the total monthly outage for the Essex WRZ is calculated by summing the total monthly outage from each water treatment works, giving a value in Ml. This is then converted into Ml/d by dividing this monthly total by the total number of days in the data set for each month (for example the January data set for each water treatment works contains 5 years of data comprising of 31 days, giving a total of 155 days) and multiplying by the number of treatment works in the Essex WRZ being assessed (in this case 4). The final multiplication allows for the double counting of days that would result if an outage event occurred at the same time at different water treatment works. A final forecast cell sums the total monthly outage volumes for the WRZ to produce an average daily outage in Ml/d.

For the three Suffolk WRZs, each iteration combined outage magnitude and duration, with pre-defined forecast cells calculating the total monthly outage in Ml for each month in each resource zone. This was then converted into Ml/d by dividing the monthly total by the total number of days in the data set for each month in the same way as described above for the Essex WRZ. A final forecast cell sums these monthly outage volumes to produce a final average daily outage figure in Ml/d for each Suffolk WRZ.

In order to demonstrate the repeatability of the Monte Carlo results, three simulations were run for each WRZ and the standard deviation of each percentile assessed.

3.13.3 Data Analysis Results

Table 3.15 summarises Essex WRZ outage data, in terms of outage magnitude and duration, experienced at the Essex WTWs from 2012/13 to 2016/17.

Table 3.16, Table 3.17 and Table 3.18 summarise the same outage data for the three Suffolk WRZs.

Table 3.15: Summary of Essex outage data

Water Resource Zone		Raw Water Source	Planned	Unplanned - Algae	Unplanned - Nitrates	Unplanned - Pollution of Source	Unplanned - Power Failure	Unplanned - System Failure	Unplanned - Turbidity	Grand Total
Total Ml										
Essex	Chigwell	Reservoir	552	4,775				1,516		6,843
	Langford	River	3,862	1,232	1,215	1,357	57	330	1,912	9,965
	Langham	River	5,145	4,303	92	1,855		2,030	502	13,927
	Layer	Reservoir	3,996	17,351				219	13,442	35,007
	Total		**13,555**	**27,661**	**1,308**	**3,212**	**57**	**4,096**	**15,856**	**65,743**
Total Days										
Essex	Chigwell	Reservoir	14	229				64		307
	Langford	River	112	68	95	167	2	35	71	550
	Langham	River	282	219	12	115		109	36	773
	Layer	Reservoir	104	456				9	240	809
	Total		**512**	**972**	**107**	**282**	**2**	**217**	**347**	**2,439**
(Average Ml/d)										
Essex	Chigwell	Reservoir	0.30	2.62	-	-	-	0.83	-	3.75
	Langford	River	2.12	0.68	0.67	0.74	0.03	0.18	1.05	5.46
	Langham	River	2.82	2.36	0.05	1.02	-	1.11	0.28	7.63
	Layer	Reservoir	2.19	9.51	-	-	-	0.12	7.37	19.18
	Total		**7**	**15**	**1**	**2**	**0**	**2**	**9**	**36**
(Average Days / Year)										
Essex	Chigwell	Reservoir	2.80	45.80	-	-	-	12.80	-	61.40
	Langford	River	22.40	13.60	19.00	33.40	0.40	7.00	14.20	110.00
	Langham	River	56.40	43.80	2.40	23.00	-	21.80	7.20	154.60
	Layer	Reservoir	20.80	91.20	-	-	-	1.80	48.00	161.80
	Total		**102**	**194**	**21**	**56**	**0**	**43**	**69**	**488**

Table 3.16: Summary of Suffolk Blyth outage data

Water Resource Zone		Raw Water Source	Planned	Unplanned - Algae	Unplanned - Nitrates	Unplanned - Pollution of Source	Unplanned - Power Failure	Unplanned - System Failure	Unplanned - Turbidity	Grand Total
Total Ml										
Blyth	Benhall	Groundwater	70.99							70.99
	CFG	Groundwater						3.77		3.77
	Coldfair Gr	Groundwater	29.29							29.29
	Parham	Groundwater				3.84		1.51		5.35
	Saxmundh	Groundwater					0.53		16.94	17.47
	Total		**100.28**			**3.84**	**0.53**	**5.28**	**16.94**	**126.86**
Total Days										
Blyth	Benhall	Groundwater	77							77
	CFG	Groundwater						3		3
	Coldfair Gr	Groundwater	39							39
	Parham	Groundwater				13		6		19
	Saxmundh	Groundwater					3		55	58
	Total		**116**			**13**	**3**	**9**	**55**	**196**
Average Ml/d										
Blyth	Benhall	Groundwater	0.04	-	-	-	-	-	-	0.04
	CFG	Groundwater	-	-	-	-	-	0.00	-	0.00
	Coldfair Gr	Groundwater	0.02	-	-	-	-	-	-	0.02
	Parham	Groundwater	-	-	-	0.01	-	0.00	-	0.01
	Saxmundh	Groundwater	-	-	-	-	0.00	-	0.03	0.03
	Total		**0.06**	**-**	**-**	**0.01**	**0.00**	**0.00**	**0.03**	**0.11**
Average Days / Year										
Blyth	Benhall	Groundwater	15.4	0	0	0	0	0	0	15.4
	CFG	Groundwater	0	0	0	0	0	0.6	0	0.6
	Coldfair Gr	Groundwater	7.8	0	0	0	0	0	0	7.8
	Parham	Groundwater	0	0	0	2.6	0	1.2	0	3.8
	Saxmundh	Groundwater	0	0	0	0	0.6	0	11	11.6
	Total		**23.2**	**0**	**0**	**2.6**	**0.6**	**1.8**	**11**	**39.2**

Table 3.17: Summary of Suffolk Hartismere outage data

Water Resource Zone		Raw Water Source	Planned	Unplanned - Algae	Unplanned - Nitrates	Unplanned - Pollution of Source	Unplanned - Power Failure	Unplanned - System Failure	Unplanned - Turbidity	Grand Total
Total Ml										
Hartismere	Eye	Groundwater	80.8085			52.2383571				133.047
	Mendlesham	Groundwater	2.9776			0.58		111.118571	47.6813	162.357
	Rickinghall	Groundwater	3.67833			0.54082857	0.43564286			4.65481
	Grand Total		**87.4644**			**53.3591857**	**0.43564286**	**111.118571**	**47.6813**	**300.059**
Total Days										
Hartismere	Eye	Groundwater	90			60				150
	Mendlesham	Groundwater	7			1		172	83	263
	Rickinghall	Groundwater	11			2	1			14
	Grand Total		**108**			**63**	**1**	**172**	**83**	**427**
Average Ml/d										
Hartismere	Eye	Groundwater	0.04	-	-	0.03	-	-	-	0.07
	Mendlesham	Groundwater	0.00	-	-	0.00	-	0.06	0.03	0.09
	Rickinghall	Groundwater	0.00	-	-	0.00	0.00	-	-	0.00
	Grand Total		0.05	-	-	0.03	0.00	0.06	0.03	0.16
Average Days / Year										
Hartismere	Eye	Groundwater	18	0	0	12	0	0	0	30
	Mendlesham	Groundwater	1.4	0	0	0.2	0	34.4	16.6	52.6
	Rickinghall	Groundwater	2.2	0	0	0.4	0.2	0	0	2.8
	Grand Total		21.6	**0**	**0**	**12.6**	**0.2**	**34.4**	**16.6**	**85.4**

Table 3.18: Summary of Suffolk Northern Central outage data

Water Resource Zone		Raw Water Source	Planned	Unplanned - Algae	Unplanned - Nitrates	Unplanned - Pollution of Source	Unplanned - Power Failure	Unplanned - System Failure	Unplanned - Turbidity	Grand Total
Total Ml										
Northern Central	Lound	Reservoir		166.404786						166.405
	Ormesby	Reservoir							3.73157143	3.73157
	Southwold	Groundwater	65.8378			573.735657				639.573
	Total		**65.8378**	**166.404786**		**573.735657**			**3.73157143**	**809.71**
Total Days										
Northern Central	Lound	Reservoir		164						164
	Ormesby	Reservoir							4	4
	Southwold	Groundwater	138			1035				1173
	Total		**138**	**164**		**1035**			**4**	**1341**
Average Ml/d										
Northern Central	Lound	Reservoir	-	0.09	-	-	-	-	-	0.09
	Ormesby	Reservoir	-	-	-	-	-	-	0.00	0.00
	Southwold	Groundwater	0.04	-	-	0.31	-	-	-	0.35
	Total		0.04	0.09	-	0.31	-	-	0.00	0.44
Average Days / Year										
Northern Central	Lound	Reservoir	0	32.8	0	0	0	0	0	32.8
	Ormesby	Reservoir	0	0	0	0	0	0	0.8	0.8
	Southwold	Groundwater	27.6	0	0	207	0	0	0	234.6
	Total		27.6	**32.8**	**0**	**207**	**0**	**0**	**0.8**	**268.2**

3.13.4 Monte Carlo Simulation Results

The results of the Monte Carlo simulation are summarised in Table 3.19 for the Essex WRZ and Table 3.20, Table 3.21 and Table 3.22 for the Suffolk WRZs. The results for the three simulations are shown along with the calculated standard deviation between the results for each percentile, to demonstrate the high degree of repeatability, with a variation of just fractions of a mega-litre. Therefore, it was decided to use the results from the first model run to determine the outage allowance figure for inclusion in the supply demand balance.

Table 3.19: Essex WRZ Monte Carlo results

Percentile (%)	Return Period	Forecast Values (Ml/d)		
		Planned	Un-planned	Total
50	1 in 2 years	5.44	21.51	26.96
80	1 in 5 years	6.31	23.43	29.74
90	1 in 10 years	6.75	24.49	31.23
95	1 in 20 years	7.12	25.42	32.54
96	1 in 25 years	7.22	25.59	32.82
98	1 in 50 years	7.48	26.12	33.60

Table 3.20: Blyth WRZ Monte Carlo results

Percentile (%)	Return Period	Forecast Values (Ml/d)		
		Planned	Un-planned	Total
50	1 in 2 years	0.59	0.06	0.65
80	1 in 5 years	0.73	0.08	0.81
90	1 in 10 years	0.81	0.09	0.89
95	1 in 20 years	0.88	0.10	0.97
96	1 in 25 years	0.91	0.10	1.00
98	1 in 50 years	0.96	0.10	1.07

Table 3.21: Hartismere WRZ Monte Carlo results

Percentile (%)	Return Period	Forecast Values (Ml/d)		
		Planned	Un-planned	Total
50	1 in 2 years	0.23	0.38	0.61
80	1 in 5 years	0.29	0.45	0.74
90	1 in 10 years	0.32	0.48	0.80
95	1 in 20 years	0.34	0.51	0.85
96	1 in 25 years	0.35	0.52	0.87
98	1 in 50 years	0.37	0.54	0.91

Table 3.22: Northern Central WRZ Monte Carlo results

Percentile (%)	Return Period	Forecast Values (Ml/d)		
		Planned	Un-planned	Total
50	1 in 2 years	0.20	0.92	1.12
80	1 in 5 years	0.25	1.07	1.32
90	1 in 10 years	0.27	1.16	1.42
95	1 in 20 years	0.29	1.23	1.51
96	1 in 25 years	0.29	1.24	1.54
98	1 in 50 years	0.31	1.30	1.61

3.13.5 Return Period Evaluation

The results in tables 3.19 to 3.22 show that the outage allowance figures decrease with increasing return period frequency. Thus a 1 in 5 year return period has a lower outage allowance than a 1 in 10 year return period.

The figures corresponding to the 50th percentile (1 in 2 year return period) for planned outages and 90th percentile (1 in 10 year return period) for unplanned outages has been selected to represent the outage in each WRZ, and are shown below in Table 3.23. The 1 in 10 year return period aligns with ESW's first drought action, which is 'appeals for restraint' and is the percentile used to define the unplanned outage allowance in previous periodic reviews. The 50th percentile has been used for planned outage. ESW believes that this it is acceptable as the majority of the planned outage is due to investment in assets and so these assets are less likely to result in outage in future years. These values represent the level of risk that ESW find acceptable to plan for in each WRZ, and that best reflect the level of uncertainty in outage likely to be experienced in the future over the planning horizon.

There are no significant developments planned for the supply systems in the ESW WRZs. Therefore, ESW feels that it is appropriate to use the same outage allowance figure for all years across the planning horizon. An assessment of actual outage will continue to be conducted on an annual basis, as required for the WRMP Annual Update and regulatory return, and will identify any unforeseen changes in the amount of outage being experienced by the treatment works, and if appropriate may trigger a revision of how outage allowance is profiled across the planning horizon.

Table 3.23: PR19 WRMP Outage Allowance figures and percentage of DI.

Water Resource Zone		PR19 WRMP Outage Allowance (Ml/d) (Unplanned = 90 percentile and Planned = 50 percentile)	Percentage of WRZ DI (%)
Essex		29.93	7.6
Suffolk	Blyth	0.68	0.07
	Hartismere	0.71	0.09
	Northern Central	1.36	0.3

3.13.6 Opportunities to reduce outage

The WRPG (Environment Agency, 2017) states that, where appropriate, water companies should identify potential options for reducing outage allowance for inclusion in an options appraisal to solve a supply demand deficit. ESW's draft dry year annual average supply demand balance calculations indicate that all four of the WRZs will have a surplus across the full planning horizon. Consequently, no investment will be driven by a resource deficit and therefore it is unnecessary for ESW to conduct an options appraisal.

However, as part of routine investment and operations, some of the factors that result in outage will continue to be managed. For example, ESW has an ongoing programme of asset maintenance to refurbish abstraction and treatment works infrastructure, such as pumping stations. This should reduce the occurrence of unplanned system failures but will likely require planned outage to allow for works to be carried out. A good example of this is at Layer WTW in Essex where outage was significantly higher during 2016/17 than in previous years. The unplanned outage was due to poor water quality in Abberton Reservoir which supplies Layer WTW. Prolonged algal blooms were the main cause of the unplanned outage which appear to also have been an issue for other water companies in the south east. Consequently, water industry research is ongoing to understand the cause. To reduce Layer WTW unplanned outage in future years, a number of the Layer WTW slow sand filters were fully refurbished during the 2016/17 winter. Unplanned outage during 2017 has been significantly less.

Pollution of ESW's groundwater sources is minimised through both the design of the wells and boreholes and through an ongoing inspection programme. As a minimum, all of ESW's groundwater sources have a full inspection every five years. This includes a CCTV inspection as well as geophysical logging to identify the condition and any emerging issues with the well or borehole. Once an emerging issue has been identified, mitigative action is taken either in the form of refurbishment of the existing borehole (e.g. re-lining) or by constructing a replacement borehole.

Langford WTW and Langham WTW both suffer outage as a direct result of poor river water quality, largely due to the intensive agricultural activity in the catchments. ESW employs catchment advisors to work in each of the catchments ESW abstracts from. Their purpose is to engage with all stakeholders such as farmers, landowners and agronomists with the aim of reducing nutrient, sediment and pesticide runoff from land to the rivers. It is expected that this work will contribute to an improvement in river water quality and therefore reduce outage as a result of nitrate, turbidity and algae, and the risk of outage due to pesticide pollution, as agricultural activity intensifies over the planning horizon. Further information on ESW's catchment management work can be found on the website www.eswater.co.uk/catchmentmanagement.

3.14 Raw and Potable Water Transfers and Bulk Supplies

3.14.1 Essex Raw Water Imports - Chigwell Bulk Supply

The Chigwell bulk supply arrangement is captured in an agreement between the Metropolitan Water Board (now TWU) and South Essex Waterworks Company (now ESW) dated 30 May 1963.

In summary, the agreement allows, under normal operating conditions, for a bulk water supply of 91Ml/d on average, not exceeding 118Ml/d on any one day, from TWU to ESW. The bulk supply is provided from the King George and William Girling Reservoirs in the Lea Valley, potentially supported by abstraction directly from the River Lea at defined intakes, if required.

TWU and ESW met in September 2007 to jointly reconfirm interpretation of the agreement with respect to how the bulk supply is operated in the event of a drought affecting either party. The results of this meeting can be summarised as follows:

- Clause 2b of the bulk supply agreement refers to what will happen in the event of TWU imposing a temporary use ban on its domestic customers. If ESW also applies a temporary use ban on its customers then the full average quantity of 91Ml/d remains available to ESW. The last occasion this occurred was in 1976. If ESW does not impose a temporary use ban on its domestic customers, then the supply from TWU is reduced by 25%. This was the situation in 2006.

- Within the agreement is also a statement that during an "unusual drought" TWU shall supply to ESW such quantities as shall represent "fair apportionment" of the water available. ESW has agreed with TWU that "unusual drought" will in future be defined as when TWU have entered their stage 3 drought restrictions (implemented powers for a non-essential use ban). Fair apportionment will not be pre-emptively defined as the circumstances of each particular drought differ spatially and temporally (evidenced by 1995/97 and 2005/06). This will be considered however at the time that stage 3 restrictions are put in place. The apportionment will be derived from the relative shortfall in DO that each company is experiencing.

Therefore in future droughts affecting ESW the potential for temporarily increasing the bulk supply will be dependent on TWU's own resource situation, the nature and spatial distribution of the drought, and demand in the Chigwell area.

On the basis that historically there has not yet been an 'unusual drought' within the TWU area that has affected the transfer of water to Essex, then the average demand DO of the transfer has been assumed to be 91Ml/d. Although currently viewed as unlikely, there must be some uncertainty as to whether the 91Ml/d could be continued to be supplied in the future, particularly in the event of an unusual drought affecting the TWU area. The uncertainty associated with the bulk supply has therefore been included with headroom uncertainty and is outlined in chapter 7 of this document.

3.14.2 Essex Raw Water Exports

ESW's PR14 supply demand balance for the Essex WRZ allowed ESW to offer the following temporary raw water trade to other water companies:

- 20Ml/d from 2015 to 2030
- 15Ml/d from 2030 to 2035
- 0Ml/d from 2035 to 2040

Subsequently a further agreement, made between ESW and TWU in 2014, allows for a raw water export of 20Ml/d from ESW to TWU. This trade is captured in ESW's Supply Demand Balance by simply reducing ESW's take (and therefore Chigwell WTW DO) from 91Ml/d to 71Ml/d. This negated the need for any new pipeline or pumping station infrastructure.

3.14.3 Essex Water Resource Zone Potable Water Imports

There is one treated water import from AWS into the Essex WRZ near Silver End, which has averaged 0.9Ml/d over the previous five years. Accordingly, this is the figure that has been adopted for planning purposes.

3.14.4 Essex Water Resource Zone Potable Water Exports

The Essex WRZ has the following potable water exports:

Table 3.24: Potable water exports from the Essex WRZ

Water Company	Export (Ml/d) Average of previous five years
AWS	2.4
Affinity Water	0.021
SSE Water	0.31
Total	**2.7**

The above exports have been adopted for planning purposes except for the AWS export. AWS has determined that ESW's export (principally via Tiptree) has an effective maximum average transfer of 3.05Ml/d, although the actual transfer has historically been much less than this. For reasons of consistency ESW has adopted the same figure for planning purposes.

3.15 Process Losses

Process losses in the form of raw and treatment works operational use are included in the calculation of DO for the Essex WRZ through incorporation in the Essex water resources system model Aquator. The bulk of the allowances used in the model relate to Langford WTW which assumes 7% treatment process losses (i.e. water that is not returned to source). In the case of all the other Essex works (Hanningfield, Layer, Langham and Chigwell) it is assumed that all the treatment process water is returned to source.

In the case of the Suffolk WRZs, process losses are not directly included in the definition of DO and hence an allowance for process losses has been separately defined and considered as an additional reduction in DO.

Process losses are defined as the sum of raw water operational use and losses, and treatment works operational use and losses. Raw water losses and operational use in Suffolk are assumed to be zero. Suffolk WTWs losses are also assumed to be zero but treatment works operational use (TWOU) is a feature of many of the works.

TWOU is defined as treatment process water i.e. the net losses from filter washing that exclude water returned to source waters. ESW has recently re-quantified these process losses using the latest information on works performance, and the results have been factored into the supply calculations. This calculation is based on the number of filter washes per day multiplied by the volume of water used in each wash. This is repeated for each filter and then the sum of filter washes is summed to give a treatment works loss in Ml/d. A summary of the results is provided below.

Table 3.25: Treatment Works Process Losses

Treatment Works	Source Water	Total Volume WW per day (Ml/d)	Deployable Output (Ml/d)	% Process Losses
Barsham	Groundwater & Surface Water	3.36	14.71	12.00%
Bedingfield	Groundwater	0.00*	0.55	0.01%
Benhall	Groundwater	0.24	6.28	3.78%
Broome	Groundwater	0.14	2.36	6.00%
Coldfair Green	Groundwater	0.34	4.48	7.50%
Eye	Groundwater	0.02	0.63	2.47%
Holton	Groundwater	0.03	1.51	2.16%
Lound	Surface Water	0.00**	8.10	0.00%
Mendlesham	Groundwater	0.03	0.45	5.71%
Ormesby	Surface Water	0.00**	27.40	0.00
Parham	Groundwater	0.009	0.29	3.14%
Redgrave	Groundwater	0.01	3.02	0.34%
Rickinghall	Groundwater	0.1	1.25	8.35%
Saxmundham	Groundwater	0.06	0.78	8.03%
Syleham	Groundwater	0.26	4.75	5.41%
Walpole	Groundwater	0.07	4.20	1.69%
			Average	**4.16%**

* Treatment works with wash water recycling directly to process
** Treatment works where all process losses returned to source

For individual works in Suffolk (apart from those where water is returned to source) TWOU averages approximately 4.16% of treatment works deployable output.

The WRPG (Environment Agency, 2017) states that water companies should consider options to reduce losses where there is a supply demand balance deficit or it makes sense to do so. This draft WRMP does not forecast a supply deficit in any of the WRZs. However, when upgrading or constructing new treatment works in the future, filter wash water recycling will be considered subject to compliance with the Drinking Water Inspectorate (DWi) guidelines and regulations regarding the recycling of process water and cryptosporidium risk.

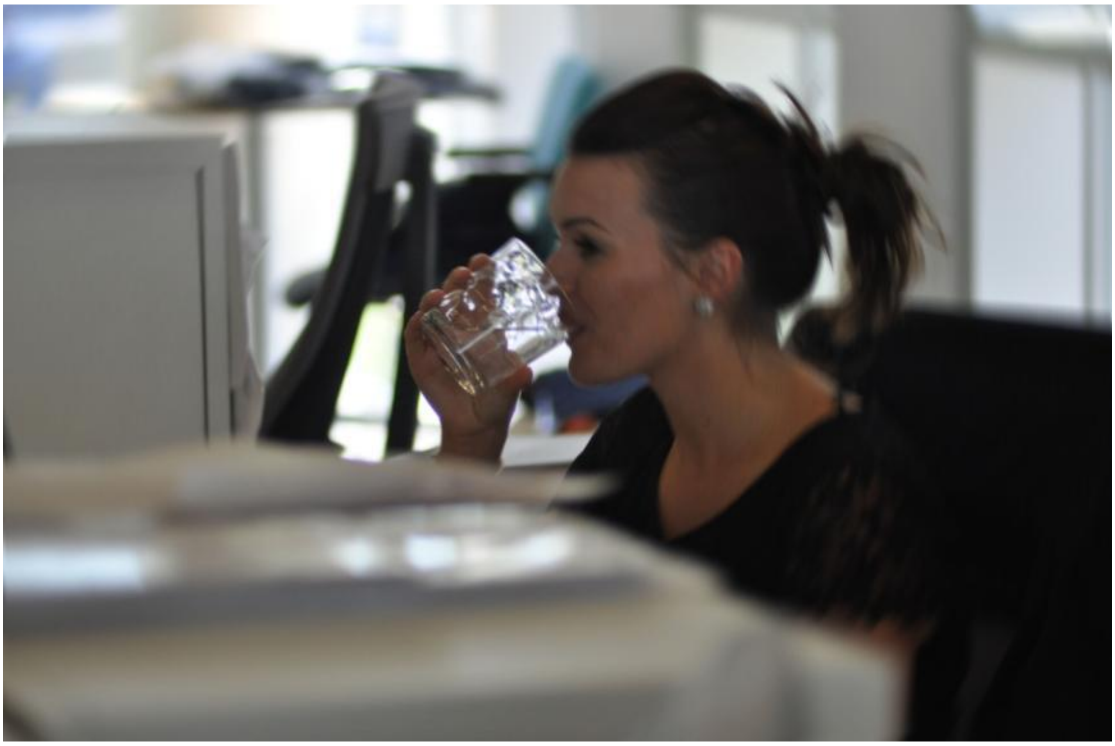
3.16 Zonal Summary of Deployable Output and WAFU

The following table summarises the results of the supply calculations for each of the Essex and Suffolk resource zones for the 2016/17 base year and assuming the mid climate change scenario. The sensitivity to supply around climate change is discussed in chapter 6.

Table 3.26: Zonal Summary of Supply Parameters for 2016/17 Base Year (Ml/d)

Resource Zone	Total DO of own sources 2016/17	Reductions in DO in 2016/17 (see text)	Outage	WAFU Own Sources 2016/17	Balance of Raw and Treated Water imports/exports	Total WAFU 2016/17
Essex	400.81	0	29.93	350.61	69.2	439.78
Suffolk Blyth	14.68	0	0.68	13.12	0	13.12
Suffolk Hartismere	8.65	0	0.71	7.63	2	9.63
Suffolk Northern/Central	70.02	0	1.36	67.23	-2	61.72

4.0 WATER DEMAND FORECAST



4.1 Introduction

The methodologies used to prepare the demand forecasts have followed published best practice as defined in WRMP19 Methods – Household Demand Forecasting (UKWIR, 2016b), WRMP19 methods – Risk based planning (UKWIR, 2016a), Methods of Estimating Population and Household Projections and Customer Behaviour and Water Use 12/CU/02/11 (UKWIR, 1995c) and (UKWIR / Environment Agency, 2002).

Forecasts have been prepared for the Essex and Suffolk areas separately. The Suffolk forecast has then been apportioned into the Suffolk WRZs. Normal year forecasts have been made against a 2016/17 normalised base year, which has been amended from the published Annual Regulatory report figures to incorporate the rebasing process for properties as well as normalising the 2016/17 PCCs. This ensures a smooth projection from the base year into the forecast.

The normal year forecasts have been used as the basis for dry year forecasts, and adjusted to provide figures for two climate change scenarios.

4.2 Base Year

As outlined in section 4.10, 2016/17 is classed as a ‘normal year’ as it exhibited normal rainfall totals and temperatures through the year. Therefore no weather related adjustments have been made to base year demands for the forecast. The PCC’s have been normalised based upon the water balance being re-based.

In order to forecast from a normal year, the PCCs for both measured and unmeasured customers have been ‘normalised’ against trend.

<u>Normalised PCCs Unmeasured</u>

The unmeasured normalised PCC for 2016/17 is calculated from the re-basing of the water balance.

Essex – Unmeasured PCC
2016/17: 160.29
2016/17: 161.12 (rebased)
PCC adjustment: +0.83

To ensure the trend for micro-components is consistent with the WRMP, total PCC has been adjusted by +0.83 across the forecast.

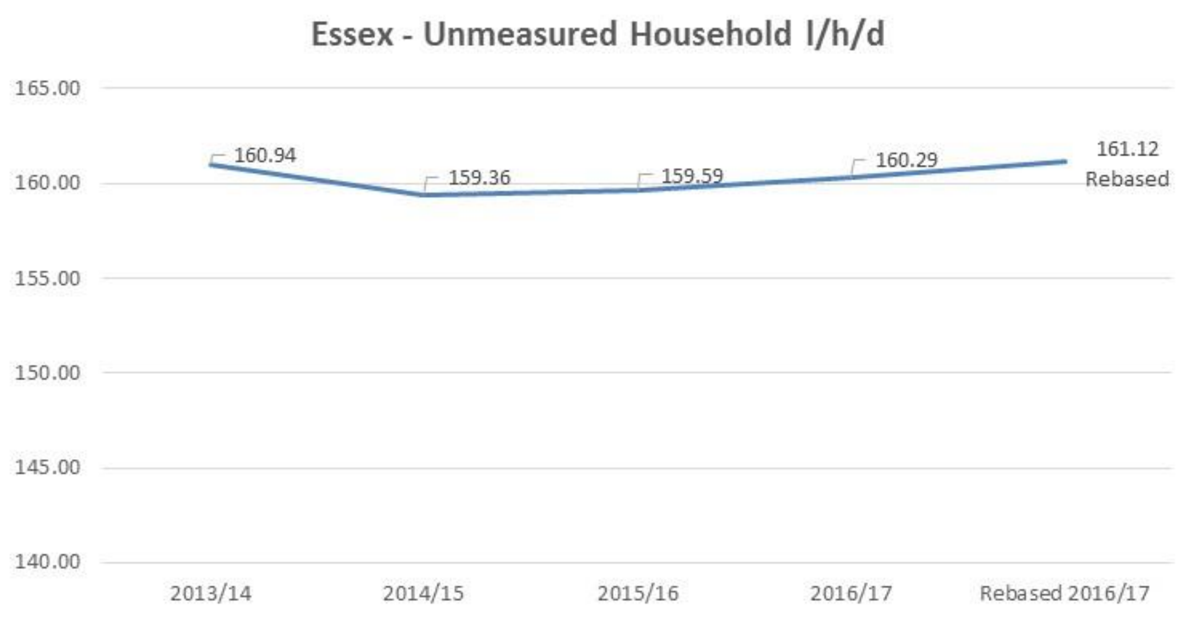


Figure 4.1: Essex Unmeasured Household PCC

Suffolk – Unmeasured PCC
2016/17: 147.15
2016/17: 147.91 (rebased)
PCC adjustment: +0.76

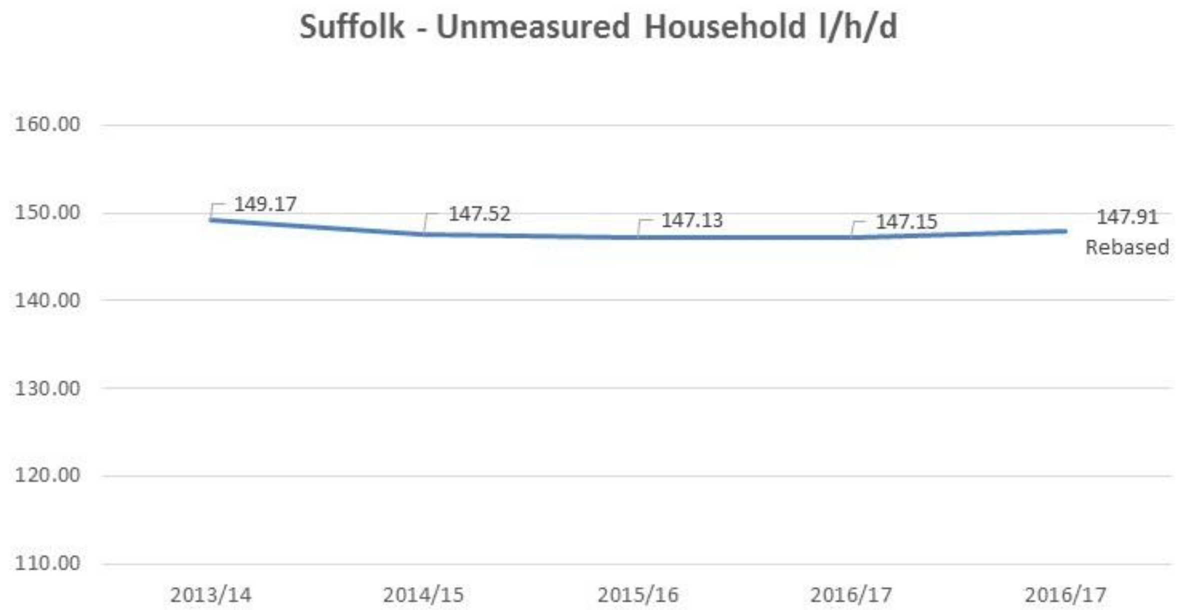


Figure 4.2: Suffolk Unmeasured Household PCC

To ensure the trend for micro-components is consistent with the WRMP, total PCC has been adjusted by +0.76 across the forecast.

<u>Normalised PCC's Measured</u>

The measured PCC has been rebased by using the 2016/17 reported PCC from the re-based water balance.

Essex – Measured PCC
2016/17: 142.73
2016/17: 139.85 (rebased)
PCC adjustment: -2.87

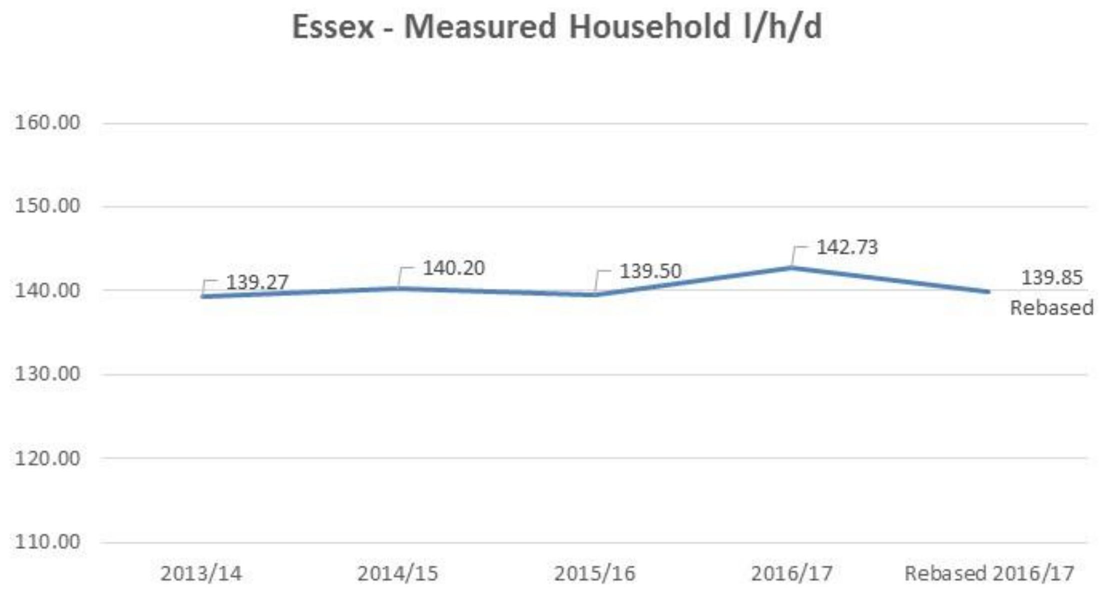


Figure 4.3: Essex Measured Household PCC

Suffolk - Measured PCC
2016/17: 125.20
2016/17: 128.41 (rebased)
PCC adjustment: +3.21

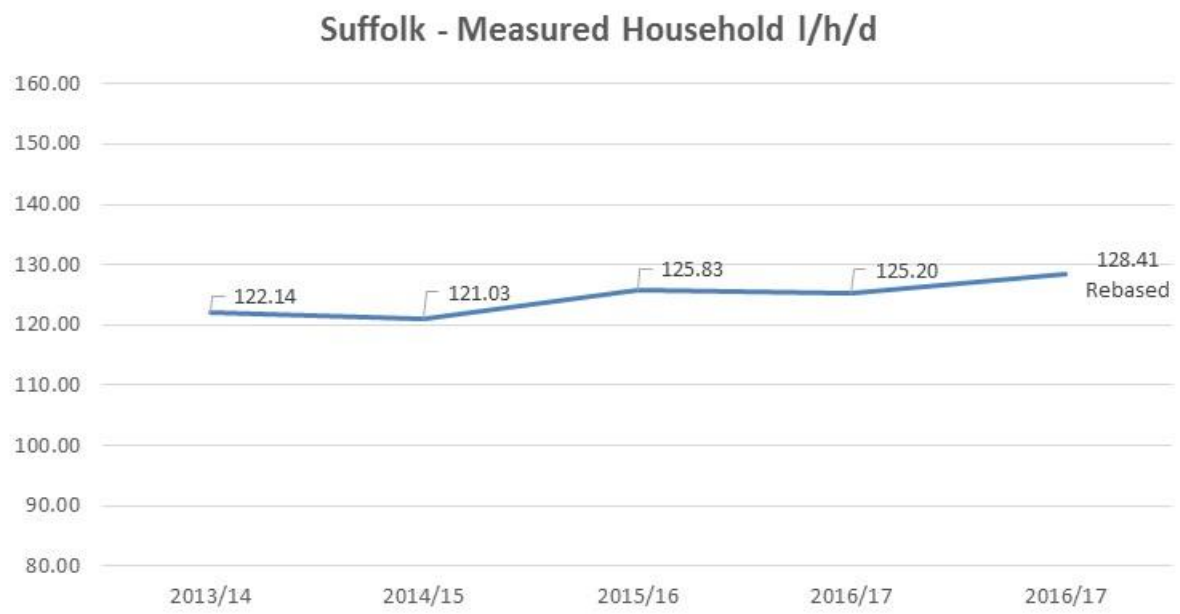


Figure 4.4: Suffolk Measured Household PCC

To ensure the trend for micro-components is consistent with the WRMP, total PCC has been adjusted across the forecast by the values stated above.

In addition, at the end of each AMP period ESW believes the best approach is to group all the metered households, metered by the base year, into a single group, which ESW calls “Existing Metered”, for forecasting forward. This is because households which became metered through customers opting for a meter, will in time have new occupiers and no longer exhibit characteristics of a new optant household. Also from AMP to AMP ESW’s metering policy changes, which impacts upon the type of households metered, and over time the balance of low occupier / low consumption and high occupier / high consumption households varies between the unmeasured and metered categories.

4.2.1 Per Capita Consumption (PCC)

The unmeasured PCC estimate has been determined from ESW’s unmeasured individual household monitor, the Study of Water Use (SWU). Properties on the study have a meter and data logger installed which collects consumption data every 15 minutes. Once all the data has been validated and leaks checked and removed, daily and monthly summary flows are calculated. The summary flows include minimum, maximum and average flows, either on a daily or monthly basis. To calculate the annual PCC, the daily consumption for each property is determined. This means that the number of properties used in the PCC calculation is determined on a daily basis. As a result, loggers with faulty data for that period can be ignored, allowing the PCC calculation to use as many properties as possible over the whole 12 months. The daily summary flows and validated manual meter readings are used in the PCC calculation. The logged data is given the greater priority in the calculation but where no logger information is available, the manual readings are used.

The total monitor sample contains 1,136 properties after any meter optant households, empty properties, leaks and outlying data have been removed. The best estimate of supply pipe leakage (see section 4.2.4) is added to the calculated household consumption figures to provide the water delivered to unmeasured households.

For more information about the Study of Water Use and how the unmeasured PCC is calculated please refer to the Study of Water Use Technical report (ESW, 2017d).

4.2.2 Water Delivered Measured Households

The average water consumption for measured households for 2016/17 has been rebased by using the normalised measured PCCs. This is then increased to allow for meter under-registration. An estimate of supply pipe leakage for internally metered households is added to this to provide the water delivered figure.

The volume of water delivered to measured households continues to increase, due to the effects of the metering.

4.2.3 Water Delivered Unmeasured Non-household

ESW's estimate of consumption for unmeasured non-household consumption has been based on the research reported eight years ago, in which unmeasured customers were compared with metered properties of the same type (e.g. shops, warehouses) and also compared the rateable values of metered and unmetered properties. It has been assumed that an unmeasured customer consumes 50% of a similar metered property, based upon the relationship between rateable value and consumption and the average rateable value of unmeasured properties being 50% of that of equivalent measured properties.

There are currently only 2,624 unmeasured non household properties in ESW. It should be noted that because of the very small number of properties involved, this group only accounts for 0.18% in Essex and 0.11% in Suffolk of total non-household demand.

4.2.4 Supply Pipe Leakage

The same methodology for quantifying supply pipe leakage has been used since 2006, when a project was undertaken to improve ESW's estimates. Regular review of current practices has taken place in this time although no methodology has improved the accuracy of quantification of supply pipe leakage. For this project, unmeasured leakage flows were collected from the SWU and measured leaks were gathered from the customer billing database, which stores information collected on leakage allowance forms. Two databases (measured and unmeasured) were compiled, through which the average volume, duration and frequency of leaks could be calculated. It was recognised that the measured database had limitations because generally only larger leaks are recorded because they have been detected through meter readings. Similarly, the SWU leaks have not been left to run as long as undetected leaks on unmeasured households could run for and mainly referred to properties within the Essex area.

It was established early on that every leak would start with similar characteristics irrelevant of the property meter status. It was also suggested that every leak has a hypothetical flow rate, at which the leaks become 'noticeable'. The average leakage volume of the 'noticeable' stage could be taken from the respective databases. The importance of determining the average duration, frequency and flow rate of leaks before they reach the hypothetical 'noticeable' stage was recognised.

The SWU leakage records provided daily flow rates. Analysing these in detail allowed a 'natural rate of rise in leakage' curve specific to ESW to be constructed. From this, it was possible to assume that the average leak will run for a period at a flow rate of 0.0073 l/sec (regarded as so small that it cannot be noticed). Once noticeable, the duration, frequency and volume of leaks depend upon the meter status of the property. The frequency of occurrence of leaks was 0.014 for unmeasured properties and 0.004 for measured properties. The frequencies were calculated using population and leakage figures specific to each year.

Calculations revealed average daily leakage volumes of 27.12 litres per property per day for unmeasured properties in Essex and 12.94 litres per property per day for measured properties in Essex. For Suffolk it was necessary to calculate equivalent values due to the very small size of the database. This gave figures of 14.22 litres per property for unmeasured properties and 6.78 litres per property for measured properties. Supply pipe losses are then allocated to the various categories of properties, on the assumption that losses from the typical externally metered household property will be lower than those of unmeasured or internally metered properties. This assumes that externally metered household customers will notice any unexpected increase in their consumption and will inform us sooner than the other categories of customer. Final supply pipe loss values are shown in Table 4.1.

Table 4.1: Supply pipe loss values

	Essex (l/p/d)	Suffolk (l/p/d)
Unmeasured Hsehld SPL	28.00	14.00
Measured Hsehld/Measured Non-Hsehld SPL (Ext)	14.00	07.00
Measured Hsehld SPL (Int)	28.00	14.00
Unmeasured Non-Hsehld SPL	28.00	14.00
Empty Property SPL	28.00	14.00

4.2.5 Meter Under-Registration

The allowance for household and non-household meter under-registration is consistent with the results found in the Review of Meter Under-Registration (WRc, 2009). The results were as follows:

- Under-registration figures for household meters have been calculated based on the data supplied to WRc, as: ESW: 3.98%
- Under-registration figures for non-household meters have been calculated based on the data supplied to WRc, as: ESW: 4.31%

4.2.6 Void Properties

Base year property figures are taken from the Company billing database. This includes the total number of void properties each year. The forecasted voids are a consistent percentage of the total properties.

Table 4.2: Forecasted void properties

	Essex	Suffolk
Unmeasured Households	4.3%	4.3%
Measured Households	3.8%	4.1%
Unmeasured Non-Households	26.1%	6.0%
Measured Non-Households	13.1%	10.1%

4.2.7 Operational Use and Water Taken Unbilled

As a result of the work carried out for the Annual Return (Ewans Associates, 2002) operational use continues to be assessed using similar methods to those applied in the Northumbrian Water area. This review looked at developing methodologies for determining all aspects of operational use and water taken unbilled and included site measurements for certain parameters. Since the review, wherever possible, the methodologies supported by Ewan's report have been used and new data input where it has become available. Some improvements have been made generally in the data reporting such as the standpipes hired now being metered.

The reported figure for operational use covers volumes used for treatment works' use, service reservoir and tower cleaning, third party bursts, flushing, new mains and rehabilitation.

Water taken legally unbilled includes the following components:

Table 4.3: Components of water taken legally unbilled

Treatment Works	Sample Taps, Filters, CRITS
	Property Use
Service Reservoirs, Tower & PS Sites	Reservoir & Tower Cleaning
	Commissioning New Sites
	Sample Taps
Bowser & Tanker Filling	Bowser
	Tanker
Third Party Bursts	
Flushing	Routine / Planned
	Repair / Reactive
New Mains	Distribution Mains
	Trunk Main
	Infrastructure Maintenance
	New Development
SPL Voids	Supply Pipe Leakage Void Properties

The reported allowances for metered volumes have been determined from individual accounts and meter readings.

Water taken illegally unbilled includes an estimate of consumption of occupied void properties, based on ESW's recent void inspections, and an assessment of illegal hydrant use, based on methods from the Ewan's report (Ewan Associates, 2002).

4.2.8 Bulk Supplies

The bulk supplies are as follows for 2016/17 (Ml/d).

Table 4.4: Bulk supplies for 2016/17

Chigwell Import	84.30
Imports [Cressing]	0.86
Anglian Water Export	2.40
Affinity Bulk Supply Export	0.03
SSE Water Export	0.31

4.2.9 Re-basing the 2016/17 Figures

For both the Essex and Suffolk areas the normalised PCCs have been used to calculate measured consumption. PCCs have been calculated from the population and occupancy figures from the new forecast described below.

ESW's work planning database has been analysed to provide figures for the number of households internally and externally metered and for the sub-division into optants, selectives, new and pre-existing metered groups.

For the final submission of the NWL Business Plan in 2004, it was decided that the best way to forecast metered household consumption was to create a category of customers ESW calls "existing metered". To forecast metered consumption, base year consumptions had been derived from the billing database (ICIS) for recent new houses and for recent optants. In theory, the base year customer base could be divided into these broad categories, past metering policy had not been this simplistic – e.g. prior to free meters for all optants, ESW had a policy of metering sprinkler users – strictly an optant process in that the customer could choose whether to be metered or to discontinue using a sprinkler, but customers metered through this process would be expected to have different occupancy and consumption characteristics from other (financially driven) optants. Also ESW had compulsorily metered the Galleywood zone in 1993/4 and later introduced free meter optants for single occupant OAPs.

For these reasons, the base year consumptions for recently metered new and optant customers, if applied to the whole metered household base in 2002/3, did not give a total metered consumption matching that of the June Return reported total household metered consumption. It was therefore decided that all households metered up until the base year would be placed into a single category of known consumption – the existing metered, with the total base year metered household consumption. For these customers their consumption is known with confidence and so it makes sense to use this certainty in the forecast.

The existing metered customer base will not increase over time within the forecast, in that new customers will not be added until a new forecast is created every five years, but the number of households may be expected to change slightly due to voids, disconnections or demolitions. The customers metered by the 2016/17 base year have been moved into the existing metered base. Customers metered from 2017/18 onwards will join one of the following categories: new, options, selective.

ESW believes it is reasonable to regroup the customers every five years because changes in occupiers mean that a household metered through one particular metering process cannot be expected to keep those characteristics for all time – low occupier optants will be replaced by "average" occupiers, those whose behaviour may have changed through publicity surrounding a compulsory metering process may be replaced by occupiers who are ambivalent to the property being metered etc. Any attempt to forecast these uncertain changes could not be completed with reasonable accuracy and therefore such a process would not improve the accuracy of the demand forecast. A compromise position is therefore to re-base every five years.

To create the base year figures for the WRMP, the following processes took place:

1. The households in the 2016/17 Regulatory Report new, optant and selective groups were added to the existing metered group. This means for the WRMP, figures for 2016/17 have zero households in the new, optant and selective categories, but from 2017/18 households are added to these groups in line with the metering forecast.

2. For 2016/17 onwards the latest population forecast has been applied. This is the Edge Analytics forecast based on the plan based scenario. The overall occupancy forecast for 2016/17 onwards is derived from this population forecast and household forecast.

3. 64.67 Ml/d total leakage figure has been applied to 2016/17.

4. As a result of the changes in the base year a water balance has been produced to provide the post rebased MLE figures.

4.3 Populations

4.3.1 Background

The base building block for demand forecasting is the base year population served and the projected growth in population annually over the WRMP. This is a highly specialised area of the demand forecast, along with property growth numbers, and ESW employs specialist consultants to prepare the forecasts of population and property by each WRZ

However, whilst the consultants use official Office of National Statistics base year and projections for population and Local Authority data for property forecasting, both forecasts vary considerably when refreshed each five years. In addition the actual number of new properties built in Essex against those forecast to be built in the WRMPs invariably fall far short.

The graph below clearly demonstrates the dramatic changes in forecast numbers that have been experienced at each five yearly refresh of Essex WRMPs. The first WRMP (PR99) ESW had a population forecast for 2025, and each subsequent WRMP has had a new population forecast including a population for 2025. The 2025 population given in each WRMP is plotted below:

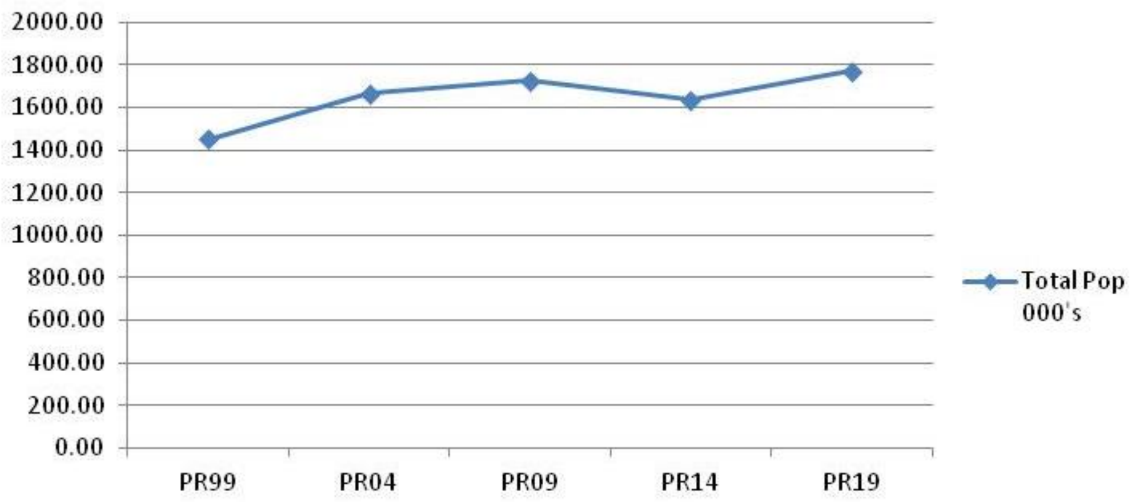


Figure 4.5: Essex population forecast for 2025

The large variance in population for 2025, which is a reflection of updated WRMP population figures for each year of each plan, clearly demonstrates the ethereal nature of any single year's forecast of future year's populations. Given that in Essex in 2025 only approximately 15% of DI will be non-household and 10% will be leakage, then 75% of demand will be from the domestic population. The difference in population estimates in 2025 between PR99 and PR19 is in the order of 317,000 people.

The population of Essex has grown as an overspill to London. Historically migrants settle in London for a period, when they begin families they then move out to surrounding counties, especially Essex. This has brought in young people with growing families whilst the older, retiring Essex people tend to move out to Suffolk and Norfolk. This gives a net increase in Essex population. Since the recession, the already below planned level of new homes, has fallen by over 50%. Equally the number of house moves has been a fraction of the pre-2007 levels. This has had the effect of nowhere for London migrants to go in Essex and a larger population remaining in London. This partially accounts for the much higher population growth forecast for London compared with Essex. The recent pickup in new home completions and secondary sales still falls far short of the historic numbers and it is difficult to see when in the future it will return to trend levels.

4.3.2 Overview

Population for the base year and forecasted years has been commissioned from Edge Analytics.

In line with the WRPG (Environment Agency, 2017) requirement, ESW has used local authority Plan housing growth evidence from all local authorities and has selected the Plan-based scenario. The detailed methodology used to determine household growth is provided in Population, Household and Property forecast technical report (Edge Analytics, 2017). A comparison between Trend and Plan-based scenario's is shown in the below graphs.

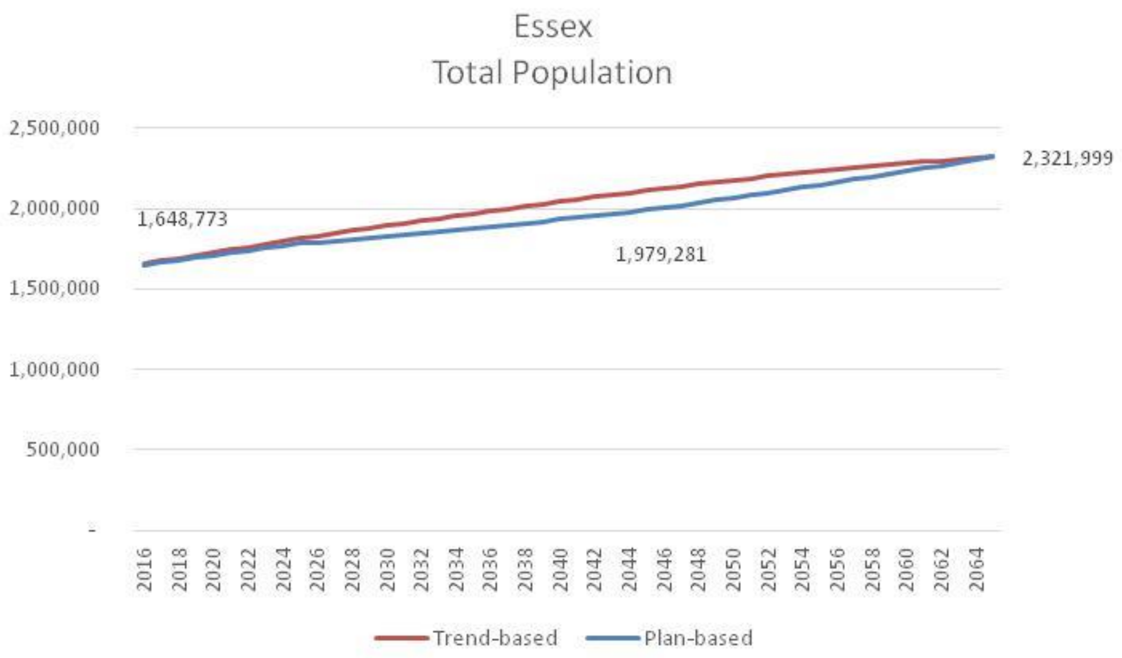


Figure 4.6: Essex trend and plan population scenarios

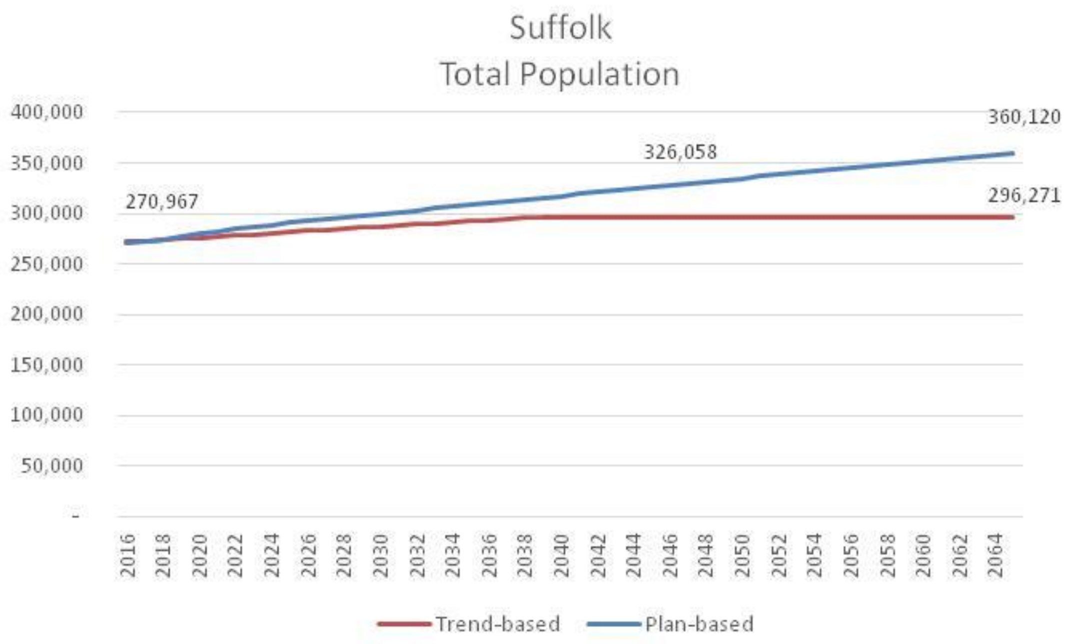


Figure 4.7: Suffolk trend and plan population scenarios

Edge Analytics used best practice methodology which follows the requirements of the WRPG.

Below is the supply demand balance for the local authority Plan growth projections for population and property, including a 20Ml/d supply to TWUL for 20 years.

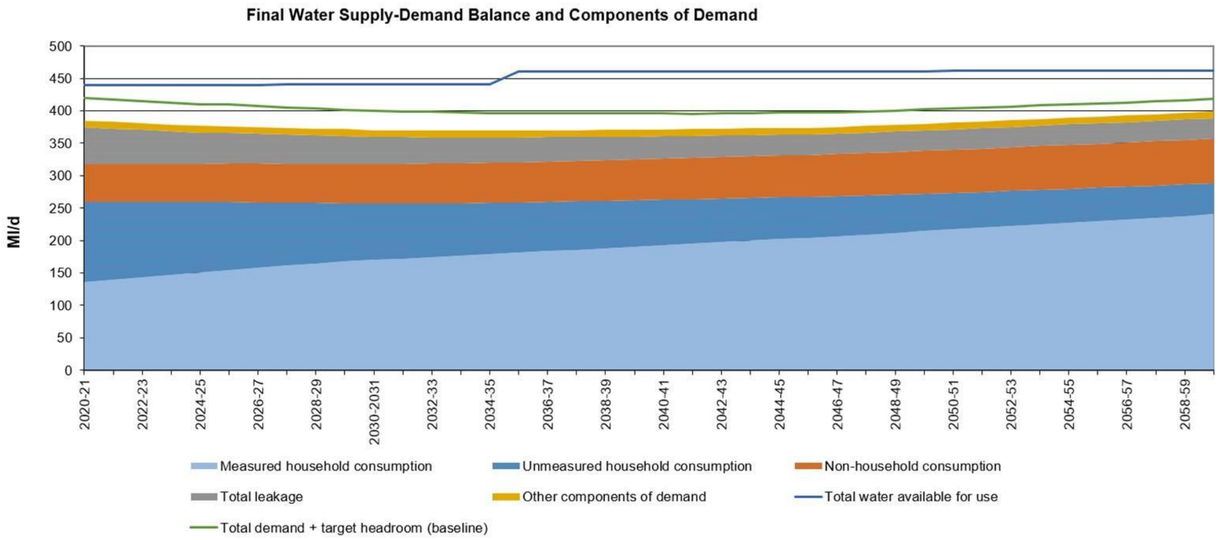


Figure 4.8: Supply demand balance for Local Plan growth projections

4.3.3 Edge analytics methodology summary

Edge Analytics was contracted to produce an update to the population and household forecasts by DMAs in the Essex and Suffolk areas. In line with the WRPG requirement, Edge Analytics has collected Local Plan housing growth evidence from all local authorities that are either wholly or partially included within the NWG operational boundary (Essex & Suffolk Water and Northumbrian Water).

Each of the 38 local authorities (plus 5 National Park Authorities) is at a different stage of Local Plan development. All have collated a variety of demographic and economic evidence to inform the plan-making process. Some plans have been adopted; others remain under development or open for consultation.

The information in the following table provides a summary of the current status of each Local Plan with an indication of the likely housing growth target over a designated plan period. These data are subject to change but provide a point-in-time perspective on likely housing growth outcomes that can be compared directly to existing 'trend' outcomes (on which the majority of the Local Plan evidence will have been based).

Table 4.5: Local Plan status, January 2017, NWG area (Source: Local Planning Inspectorate, Local Plans)

Area	Latest Local Plan Status[1]	Local Plan Period	Housing Target
Barking & Dagenham	Consultation	2015-2030	28,492

Area	Latest Local Plan Status[1]	Local Plan Period	Housing Target
Basildon	Draft	2014–2034	15,260
Braintree	Draft	2016–2033	14,365
Brentwood	Draft	2013-2033	7,240
Carlisle	Adopted	2015-2030	9,606
Castle Point	Adopted	2011-2031	2,140
Chelmsford	Consultation	2021–2036	11,625
Colchester	Emerging	2017-2032	18,400
County Durham UA	Consultation	2014-2033	29,127 - 32,623
Darlington UA	Emerging	2016-2036	10,000
Eden	Examination	2014-2032	3,600
Epping Forest	Consultation	2011-2033	11,400
Gateshead	Adopted	2010-2030	11,000
Great Yarmouth	Emerging	2020-2036	7,140
Hambleton	Consultation	2014-2035	5,400
Hartlepool UA	Consultation	2016-2031	6,135
Havering	Consultation	2017-2032	17,550
Lake District National Park	Adopted	2010-2025	900
Maldon	Examination	2014–2029	4,410
Mid Suffolk	Emerging	-	11,100 (2011-2031)
Middlesbrough UA	Consultation	-	6,970
Newcastle upon Tyne	Adopted	2010-2030	30,000 (Newcastle upon Tyne & Gateshead)
Newham	Emerging	-	-
North Tyneside	Examination	2011-2032	17,388
North York Moors	Consultation	2017-2035	522
Northumberland National Park	Emerging	-	-
Northumberland UA	Consultation	2011-2031	24,320
Redbridge	Draft	2015-2030	16,845
Redcar & Cleveland UA	Draft	2051-2032	3,978
Richmondshire	Adopted	2012-2028	2,880
Rochford	Emerging	-	4,800 (2011-2031)
Scarborough	Examination	2011-2032	9,450
South Norfolk	Emerging	Until 2036	15,516
South Tyneside	Consultation	2011-2036	-
Southend-on-Sea UA	Emerging	-	6500 (2011-2031)
Stockton-on-Tees UA	Consultation	2014-2032	11,061
Suffolk Coastal	Emerging	2010-2027	7,900

Area	Latest Local Plan Status[1]	Local Plan Period	Housing Target
Sunderland	Consultation	Until 2033	-
The Broads Authority	Consultation	2012-2036	320
Thurrock UA	Emerging	2014-2037	19,044
Uttlesford	Consultation	2011-2033	12,496
Waveney	Emerging	2011-2036	7,700 - 9,525
Yorkshire Dales National Park	Submission	2015-2030	825

Where available, the annual allocation of the overall housing target was taken from the information provided by each council. In cases where this information was not available, the overall housing target was distributed equally over the Local Plan period with adjustments made to take account of historical completions if available. These annual housing growth trajectories form the key input to the Plan-based forecast.

The methodology report has detailed the development of two key scenarios: a Trend-based scenario which replicates the 2014-based sub-national projection from ONS; and a Plan-based scenario which is driven by local authority Plan housing growth statistics. NWL's billing data has provided the basis for alignment of property numbers in the base year of the forecast period. A sensitivity analysis has been presented, to explore the uncertainty associated with forecast development.

Household and property forecasts at Census Output Area (OA) level

- Household forecasts at OA level have been calculated by applying household representative rates from the DCLG (Department for Communities and Local Government) household projection model at LADUA (Local Authority District & Unitary Authority) level to the OA level population, excluding population not in households.
- For the forecast years, OA level households have been reconciled to the trend in the LADUA level household totals derived at Step 3.
- The DCLG provides data for a forecast period that is shorter than the ESW forecast horizon. After the last year for which the DCLG data are available (2039), the household representative rates have been kept fixed for the remainder of the NWL forecast period.
- An OA-level vacancy rate has been calculated using statistics on households (occupied household spaces) and dwellings (shared and unshared) from the 2011 Census. This vacancy rate has been applied to the OA level households for each of the forecast years to create OA-level property figures.
- Property data from ESW's billing database has been used to provide an alternative property forecast that is more closely aligned to the number of NWL properties in 2016.

Sensitivity analysis -

- All demographic forecasts are subject to an element of uncertainty. Consideration of this uncertainty is an important element of the WRMP demographic evidence. The Edge Analytics approach includes a 'sensitivity' analysis, which considers the uncertainty associated with its forecasts in three ways: through the use of error distribution statistics recommended in the UKWIR guidance; through the development of both trend and plan-based scenarios; and through the application of variant assumptions to its scenarios.
- The Trend-based and Plan-based scenarios provide a range of growth outcomes, the first based on a continuation of historical trends, the second based on an expected trajectory of housing growth.
- In addition, the UKWIR guidance provides error distribution tables which have been applied to NWL growth forecasts, identifying broad upper and lower confidence percentiles for each year of the plan period. Furthermore, with international migration being a key area of uncertainty, the aggregate Trend-based scenario is presented alongside ONS high and low migration variants.
- Finally, the aggregate Plan-based forecasts have been derived using variant household growth assumptions, applying faster and slower rates of household formation from the DCLG's 2008-based (HH-08) and 2014-based (HH-14) models respectively. These alternatives consider variations in the rate at which household occupancy is expected to decline over the plan period.

Chosen population growth scenario

In the case of Essex and Suffolk supply areas, the population forecasts for PR19 using the Plan-based scenario shows a growth in population over the planning horizon. For Essex this has resulted in a 20.0% increase over 25 years and a 19.7% increase in Suffolk.

In the demand forecast overall occupancy reduces from 2.63 to 2.50 in Essex and reduces from 2.28 to 2.21 in Suffolk.

The detailed methodology used to determine population growth is provided in detail in the Population, Household and Property forecast technical report (2017).

Table 4.6: Population Growth for Essex and Suffolk

	2016/17	2044/45	Increase	% Increase
Essex	1,648,773	1,979,281	330,51	20.0%
Suffolk	270,967	324,349	53,382	19.7%

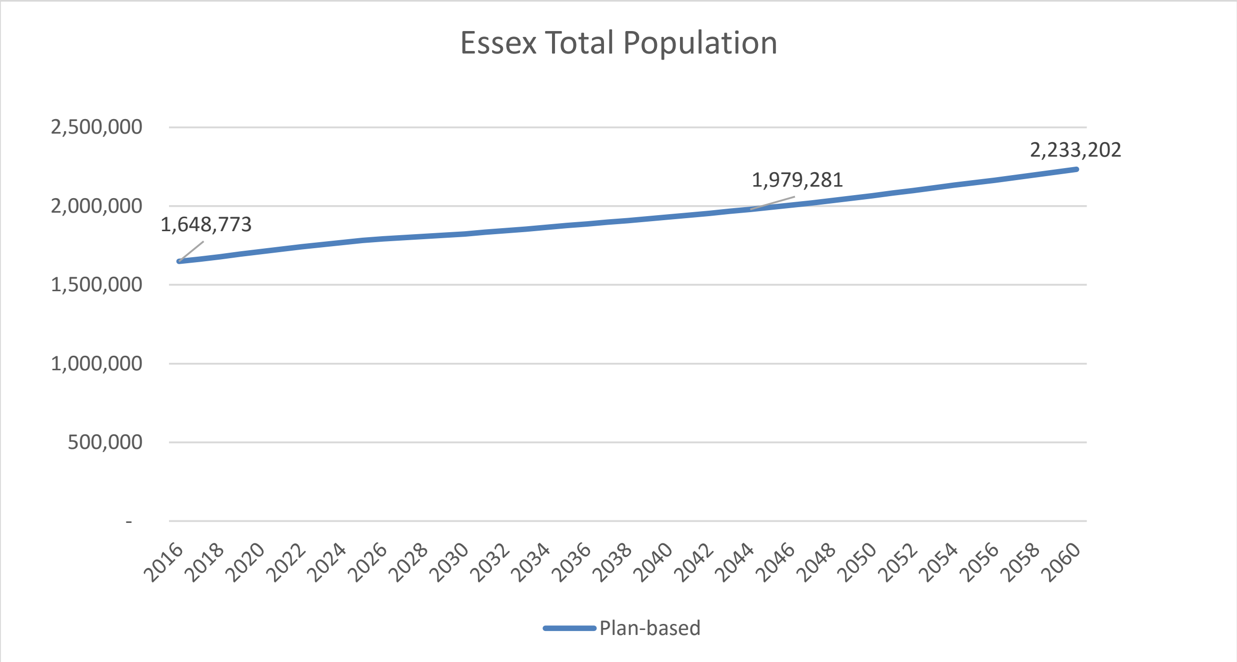


Figure 4.9: Essex population growth

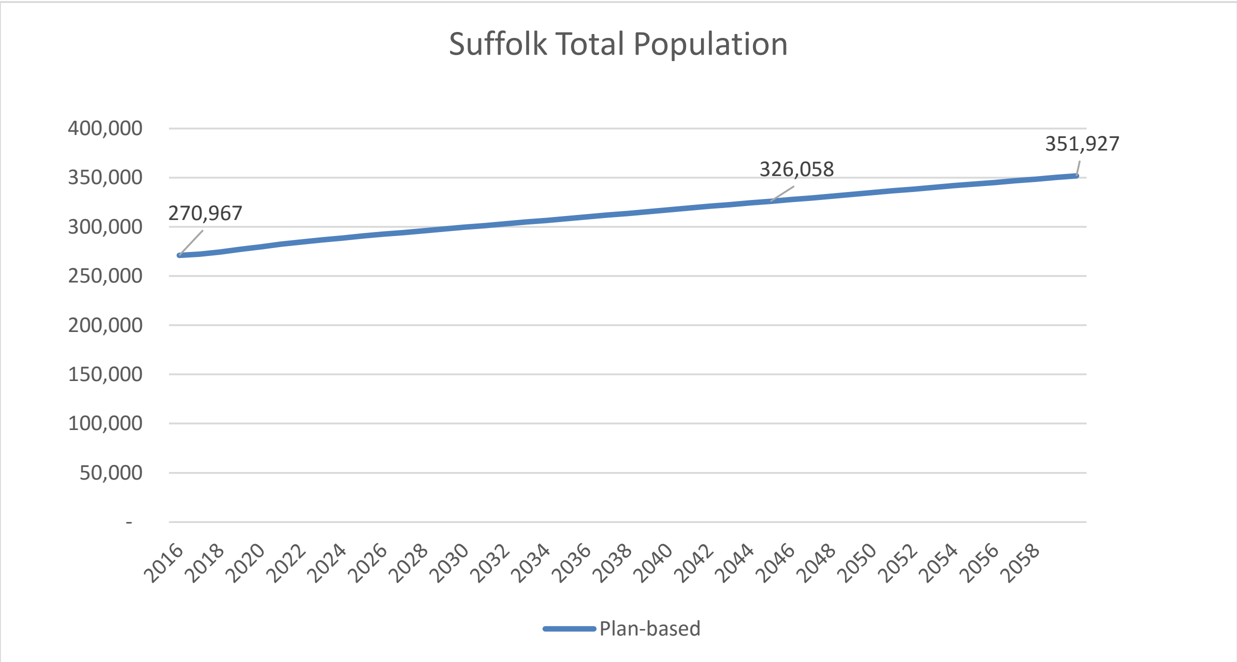


Figure 4.10: Suffolk population growth

4.4 Occupancy

Essex

The overall occupancy comes from the Edge Analytics domestic population figure. This total population is divided by the total number of billed households for the year to give an overall occupancy rate. However, whilst a total population figure is essential in the demand forecasts, an overall occupancy figure is at too high a level to be useful in the demand forecast directly. This is because the different housing categories of ESW's customers have different average occupancies. For example, unmeasured customers have a higher occupancy than that of the optant meter customers. This is due to low occupied properties where the customer gains financially by paying a measured charge whereas a high occupied property, if electing for a meter, would pay more for their water and sewage than if they remained unmeasured. It is therefore necessary to have a specific occupancy for different classes of customer.

The occupancies are set by various sources of information available to ESW, ranging from specific occupancy surveys sent to a random selection of customers, occupancy taken from meter optant applications, occupancy of customers on unmeasured consumption monitor 'The Study of Water Use', customer billing and professional judgement based on past occupancy and future forecasts of changes in the customer base.

The most recent survey data has come from the Micro-component Survey used to determine the ownership and frequency of use of water using appliances in the home. These surveys were carried out in January-March 2017 to populate the model for looking at future changes in PCC. For ESW a total of 10,714 responses were received. In the survey customers were asked to indicate the total number of people in the households and the breakdown of occupants for six different age groups as recommended in the UKWIR 'Integration of behavioural change into demand forecasting and water efficiency practices' report (UKWIR, 2016c). More information on these surveys is available in section 4.6.3.

Some customers left the 'total' box blank and entered the number of occupants within each age group. Where this was the case, the numbers were totalled to give an overall occupancy. On the contrary, several customers did the opposite, stating the total number of occupants but not stating the breakdown. In these cases, the breakdown could not be established and were therefore left blank.

Essex

Overall occupancy

The overall occupancy for all households steadily declines from 2.63 in 2016/17 down to 2.50 in 2059/60.

New homes

The occupancy for new homes in Essex is 2.26 to reflect the overall lower occupancy, the results from the micro-component survey and the fact that in the recent few years there has been a significant increase in the number of single bedroom apartments being built. The occupancy is forecast to increase gradually through to the end of the planning horizon in line with an increase in overall occupancy.

Table 4.7: Essex new homes occupancy

Year	2016/17	2020/21	2030/31	2040/41	2050/51	2059/60
Occupancy	2.26	2.29	2.34	2.39	2.44	2.48

New Optants

The Essex optant occupancy has been raised to 1.84 from the micro-component survey result of 1.84. The Company forecasts a modest increase in optant occupancy as there will always be changes to family occupancy that will result in the remaining occupier opting for a meter. While the occupancy rate of optants remains relatively steady over the 25 years, the actual number of properties opting for a meter decreases as increased metering removes eligible properties.

Table 4.8: Essex optant occupancy

Year	2016/17	2020/21	2030/31	2040/41	2050/51	2059/60
Occupancy	1.84	1.89	1.99	2.09	2.19	2.28

Existing metered

The base year for what becomes the existing measured is all the measured groups used in the reported outturn year, rebased to take account of changes in overall population and information from occupancy surveys. The figure of 2.20 has been used in the rebased numbers to account for the overall drop in total population. This figure then increases steadily over the whole of the planning horizon to 2.42 in 2059/60. In reality this occupancy is reset every five years when the new WRMP is produced.

Measured properties

The occupancy of the overall measured is calculated from all of the different metered components using their assigned occupancy and weighted by their forecast property numbers. Changes in this occupancy in the forecasts are influenced by the occupancy of the groups that dominate in future years e.g. new homes, optants, and selectives.

Table 4.9: Essex overall measured occupancy

Year	2016/17	2020/21	2030/31	2040/41	2050/51	2059/60
Occupancy	2.20	2.21	2.23	2.30	2.36	2.42

Unmeasured properties

The Essex unmeasured occupancy is calculated by subtracting the population assigned to all of the measured groups from the total household population and dividing this by the remaining number of billed unmeasured properties. This would always be expected to be the highest occupancy class but over time the overall measured occupancy and unmeasured occupancy converge towards each other.

Table 4.10: Essex unmeasured occupancy

Year	2016/17	2020/21	2030/31	2040/41	2050/51	2059/60
Occupancy	3.26	3.39	3.75	3.49	3.22	3.11

Suffolk

A number of sources of data on the occupancy of different property groups in Suffolk were used to inform the occupancy in the base year and future years for the Suffolk demand forecasts. The occupancy of the property groups is set for Suffolk as a whole and then the same occupancy used for each of the three Suffolk WRZs. It is not considered that any of the three WRZs have different occupancy characteristics nor is it considered viable to determine the three WRZ occupancies separately. Suffolk is likely to have different occupancies to Essex due to the high level of meter penetration that has been predominantly achieved by customers opting for a free meter. This suggests that Suffolk has a very high proportion of low occupancy housing compared to Essex. However, with an identical overall occupancy to Essex, this does mean that the unmeasured households in Suffolk will have a significantly higher occupancy. The higher number of low occupancy households in Suffolk is thought to be partially due to the touristic nature of the area, attracting a larger number of second home owners than Essex. If a property is a second, or weekend only home then it is usually more financially beneficial to have a measured, rather than an unmeasured, property.

Overall occupancy

The overall occupancy for all households steadily declines from 2.28 in 2016/17 down to 2.21 in 2059/60.

New homes

The occupancy of new homes has been decreased to 2.03 in 2016/17 to better reflect the survey information and the overall lower occupancy now occurring and the fact that in recent years there has been a significant increase in the number of single bedroom apartments being built. The occupancy is forecast to steadily increase until the end of the forecast.

Table 4.11: Suffolk new homes occupancy

Year	2016/17	2020/21	2030/31	2040/41	2050/51	2059/60
Occupancy	2.03	2.06	2.11	2.16	2.21	2.25

New Optants

The optant occupancy starts in the re-base year at 1.76, taken from the water use survey data and is forecast to steadily increase until the end of the planning horizon taking into account the current levels of meter penetration in Suffolk.

Table 4.12: Suffolk optant occupancy

Year	2016/17	2020/21	2030/31	2040/41	2050/51	2059/60
Occupancy	1.76	1.81	1.91	2.01	2.11	2.20

Existing Metered

The base year for what becomes the existing measured is all the measured groups used in the reported outturn year, rebased to take account of changes in overall population and information from occupancy surveys. The figure of 1.90 increasing to 2.12 by 2059/60 has been used in the rebased numbers. This occupancy is reset every five years when the new WRMP is produced.

Measured properties

The occupancy of the overall measured is calculated from all of the different metered components using their assigned occupancy and weighted by their forecast property numbers. Changes in this occupancy in the forecasts are influenced by the occupancy of the groups that dominate in future years e.g. new homes, optants or selective.

Table 4.13: Suffolk overall measured occupancy

Year	2016/17	2020/21	2030/31	2040/41	2050/51	2059/60
Occupancy	1.95	1.93	1.99	2.05	2.11	2.17

Unmeasured properties

The unmeasured occupancy is calculated by subtracting the population assigned to all of the measured groups from the total household population and dividing this by the remaining number of billed unmeasured properties. This would always be expected to be the highest occupancy class but over time the overall measured occupancy and unmeasured occupancy converge towards each other.

Table 4.14: Suffolk unmeasured occupancy

Year	2016/17	2020/21	2030/31	2040/41	2050/51	2059/60
Occupancy	3.03	3.06	3.00	2.78	2.58	2.38

4.5 Properties

Base year property figures are taken from the Company's billing database. The growth property figures for each of the forecasted years are provided by Edge Analytics. In line with the WRPG requirement, ESW is using Local Plan housing growth evidence from all local authorities that are either wholly or partially included within the ESW operational boundary.

4.6 Baseline Household Demand Forecasts

The household demand forecast has been developed by considering the population in groups as follows:

1. Unmeasured customers
2. Meter Optants
3. New Homes
4. Existing Metered

These groups have been chosen because ESW believes their consumption characteristics are noticeably different. However, households already metered cannot sensibly be assigned to the separate metered groups, as the consumption of this group is known, so it makes sense to regroup the metered customer base into a single category, which ESW calls "Existing Metered" every five years.

For the unmeasured, new homes and existing metered groups ESW has forecast PCCs using a new improved micro-component model, which has been populated for the base year using data collected from an appliance survey.

4.6.1 Meter Optants

For the meter optant group ESW has determined its future PCCs as a percentage reduction relative to the unmeasured PCC, maintaining the previously accepted and agreed assumptions.

Savings from the water efficiency target have been included in the baseline and final PCC forecasts. It has been assumed that the savings will be met equally by measured and unmeasured customers and by Essex and Suffolk area customers. Further details of these savings are provided in section 5 of the WRMP.

4.6.2 New Homes PCC

All new homes across the forecasted years have a PCC of 118 l/h/d. As a result of the introduction of water efficiency standards into Part G of the Building Regulations which came into force in April 2010, it is a requirement that all new homes are built to deliver consumption not exceeding 125 l/h/d. In 2017, ESW completed analysis of consumption in new homes built after 2012, the results showing that the PCC was lower than the 125 l/h/d standard.

4.6.3 Water Use Survey

To insure the latest source of information about our customers is included in the formation of a robust demand forecast a water use survey was created to collect occupancy, household appliance and water use information from ESW customers. An overview of the method is given below with detailed information available in the Micro-components Technical Report (ESW, 2017e).

Following the best practise for customer water use surveys in the UKWIR report (UKWIR, 2016), a stratified sampling method was selected where the customer base is split into sub-groups which are presumed to have distinctly different water consumption characteristics. Customers were split into the sub-groups of measured and unmeasured properties. The measured group was divided by meter status (e.g. optant, selective) and then all these groups were further divided into ACORN[1] categories. (Please refer to the Micro-components Technical Report (ESW, 2017e) for more detailed information on the sampling method).

1 ACORN is a consumer classification that segments the UK population created by CACI. By analysing demographic data, social factors, population and consumer behaviour, it provides precise information and an understanding of different types of people.

Table 4.15: Sub-group definitions

Sub-Group	Description
Unmeasured	Customers paying for their water by the rateable value of the property.
Measured	Customers paying for their water by water meter.
Existing	All properties that were metered before 2012.
Optant	Properties whose occupier opted to have a meter fitted after 2012.
Selective	Properties that had meters installed upon change of ownership (after 2012).
New	New-build properties built since 2012.
Acorn Cat 1	Wealthy Achievers
Acorn Cat 2	Urban Prosperity
Acorn Cat 3	Comfortably Off
Acorn Cat 4	Moderate Means
Acorn Cat 5	Hard-pressed

A postal and online survey method was employed to collect responses from customers. The survey design is based upon the 'long survey form' in the UKWIR (2016) report to a follow consistent approach to water use surveying with other water companies which in the future can develop nationally consistent datasets for comparison and pooling of data.

The survey consisted of 31 detailed questions which began with household type, age and occupancy questions, followed by household water using appliance ownership, frequency and duration of use questions, and finishing with questions on outdoor water use. An example of the survey and letter are shown in the Micro-components Technical Report.

Previous surveys of this nature have generated a 20% response rate in ESW and so based upon this expectation a total of 47,075 ESW customers were mailed in January 2017 with the water use survey. 6,206 of these customers also received an email version as they had already supplied ESW an email address.

A sum of 10,004 surveys was returned from this initial mailing. Although this is a 21% uptake a few sub-groups did not reach their specified quota and therefore a subsequent mailing was necessary. A totally different set of customers was randomly selected for the second mailing following the same sampling techniques as the first. 6,085 customers were sent the second mailing in February 2017 with 819 of these also receiving the email version. In total 10,714 surveys were returned. Survey answers were then split into different micro-components for analysis.

4.6.4 Integration of behavioural change

Water companies are increasingly interested in the way customers use water and the effect their behaviour and habits have on the total demand for water and how to forecast changes in behaviour. The UKWIR (2016)[2] project developed a framework for water companies to integrate behavioural change into demand forecasting.

The report looked at customer survey and consumption data and from this discovered it was possible to explain about 50% of the variation in household demand by a particular property type or garden size and dishwasher ownership (hence why these questions are included in the water use survey). Therefore, the remaining 50% of the variation might be attributable to additional 'human factors' but frequency of use information is able to explain a further 30% of the variation.

Following the framework of the UKWIR (2016) report a medium level of planning concern approach was followed for all WRZs. The framework recommends following the approach of the previous study's report UKWIR (2014)[3] with the inclusion of scenario analysis allowing the sensitivity of the central demand forecasts to be tested.

Therefore the framework from UKWIR (2014) uses the standard micro-component approach inferring consumption from self-reported survey data using micro-component assumptions. This is detailed in the following section on the Micro-component Model. A lowest tier has been selected for the level of detail for analysis where segmentation of customers is by unmeasured / measured status and a further split by metered status (optant, selective). Segmentation by acorn data has been collected for future analysis but has not been utilised in the micro-component model. This segmentation allows for sensitivity to external factors to be identified for each customer segment and included in the model to integrate behavioural change.

The information collected in the customer water use surveys helps understand the current behaviours and attitudes to water use of ESW customers and this is then reported and forecast through the micro-component model. For more information on the integration of behavioural change please refer to the Micro-component Technical report.

4.7 Micro-component Model

A micro-component model has been selected for estimating future household water consumption. This well-established model offers a more detailed logical approach as it quantifies the water used for specific activities (e.g. showering and toilet flushing) by combining values of ownership, volume per use and frequency of use to give a per capita consumption (PCC) figure (UKWIR, 2015) [4]. In the UKWIR (2012) report alternative approaches to household consumption forecasting were reviewed and this approach of using a micro-component model was recommended based upon the work of Paul Herrington (1996)[5]. From this report the highest tier for forecasting PCC

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[2] UKWIR (2016c) Integration of behavioural change into demand forecasting and water efficiency practices.
[3] UKWIR (2014) Understanding customer behaviour for water demand forecasting
[4] UKWIR (2015) WRMP19 Methods- Household consumption forecasting- Supporting guidance
[5] Paul Herrington (1996) Climate change and the demand for water, HMSO

has been selected for improved accuracy which forecasts trend using micro-components.

The model data sources are customer water-use surveys (please see section 4.6.3), Defra MTP reports[6] and the unmeasured individual household monitor (Study of Water Use, refer to section 4.2.1).

The model used for PR14 has been updated and the base year is now 2016/17 which projects forward annually to the end of the demand planning horizon. The micro-components are split into the following sections as recommended by the Environment Agency *et al* (2012):

- Toilet flushing
- Personal washing
- Clothes washing
- Dishwashing
- Outdoor use
- General use

These sections are subsequently split into sub-components to analyse ownership, frequency and duration of use in detail. Wherever possible ESW-specific data has been utilised and then reviewed alongside previous surveys and other available data sources to ensure that spurious results from small samples are identified and treated with caution.

For all micro-components the start position and rate of change is defined and applied to the duration of the planning horizon. For those components involving white goods, a range of models and their associated average volumes per use have been identified. Along with this are stated the assumed model lifespan and the dates when lower-volume technologies are expected to be introduced. There is a separate model for Essex and Suffolk.

In the tables the values for micro-components are the values detailed in this section (normal year values) with dry year uplift and meter under-registration added on. The valuesalso do not include any water efficiency savings. Metered values refer to metered existing properties only.

An overview of each of the micro-components is given below but for more detailed information please refer to the Micro-component Technical Report.

4.7.1 Toilet flushing

Toilet flushing was split into five separate groups to reflect the varying flush volumes. These include:

Dual flush pre 2001	9.25 litres
Full flush pre 2001	8.25 litres

[6] DEFRA (2012) MTP reports

Full flush post 2001	6 litres
Dual flush post 2001	4.7 litres

All households have at least one toilet therefore the ownership for all four types of WCs was portioned to equal 100%. Please refer to Table 4.16 for a summary of the toilet flushing base year and forecasting results.

Ownership of the different groups of toilets is based upon the results of the water use survey. Due to a toilet lifespan of 15 years[7] and an increase in the ownership of toilets which increases the replacement rate[8], ownership is forecast to decrease for pre 2001 installed toilets. Ownership of post 2001 installed toilets is forecast to grow by 30% (full flush) and 70% (dual flush) of the decreasing rate of the pre 2001 two types of toilet combined for the planning horizon.

The frequency of toilet flushing is taken from the answers in the water use survey and is calculated by averaging the number of flushes per person per day across the toilets owned for each household. Based on the extrapolation of Herrington (1996), frequency is set to increase at a rate of 0.0504 flushes per week per year across both Essex and Suffolk.

The respective volume for each of the toilet types is forecast to remain constant over the planning horizon.

[7] DEFRA (March 2011) MTP BNWAT01 WCs: market projections and product details version 1, pp7

[8] DEFRA (March 2011) MTP BNWAT01 WCs: market projections and product details version 1, pp7

Table 4.16: Summary of toilet flushing base year and forecasting

	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	
Dual flush pre 2001					
Essex Unmeasured	10.60	minus 1% p.a.	5.07	0.0504/7 p.a.	9.25
Essex Existing	11.72		4.29		
Suffolk Unmeasured	9.78		5.01		
Suffolk Existing	11.90		4.54		
Full flush pre 2001					
Essex Unmeasured	31.11	minus 1% p.a.	5.63	0.0504/7 p.a.	8.25
Essex Existing	30.68		4.57		
Suffolk Unmeasured	34.82		5.67		
Suffolk Existing	30.98		4.61		
Full flush post 2001					
Essex Unmeasured	19.96	+30% of the decreasing rate of dual flush pre 2001 and +30% of decreasing rate of full flush pre 2001	5.55	0.0504/7 p.a.	6.00
Essex Existing	15.84		4.80		
Suffolk Unmeasured	18.60		6.49		
Suffolk Existing	17.35		5.02		
Dual flush post 2001					
Essex Unmeasured	38.33	+70% of the decreasing rate of the dual flush pre 2001 and +70% of the decreasing rate of full flush pre 2001	5.65	0.0504/7 p.a.	4.7
Essex Existing	41.76		4.55		
Suffolk Unmeasured	36.80		5.84		
Suffolk Existing	39.77		4.87		

4.7.2 Personal Washing

The personal washing micro-component has been split into bathing, showering, hand washing / teeth cleaning and bidet use.

Bath

Ownership levels and frequency of use have been taken from the water use survey with ownership forecast to decrease by -0.73 per annum in measured properties to account for the increase in showers replacing baths particularly in smaller households[9]. In unmeasured categories it decreases at around half this rate. The frequency of baths is forecast to decrease until 2030 where it becomes level. Decreasing frequency of baths is primarily due to the shift from bathing to showering[10].

The volume of baths has been based upon the Waterwise average volume figure of 80 litres[11] and evidence from the Market Transformation Programme (MTP)[12]. Measured volumes use half this value for the proportion of baths that are shared. The respective volumes for all property groups can be seen in Table 4.17. These remain constant for the forecasting horizon.

Table 4.17: Summary of bath base year and forecasting

Bath	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	
Essex Unmeasured	68.43	-0.38 p.a. until 2040	0.3627	-0.5% p.a. until 2030	91.00
Suffolk Unmeasured	70.93	-0.39 p.a. until 2040	0.3840	-0.5% p.a. until 2030	91.00
Essex Existing	68.68	-0.73 p.a. until 2040	0.5238	-0.8% p.a. until 2030	51.26
Suffolk Existing	62.18	-0.73 p.a. until 2040	0.5199	-0.5% p.a. until 2030	50.08

Showers

Showers are split into three types; mixer, electric and power shower to account for the variance in flow rates.

[9] DEFRA (March 2011) MTP BNWAT08 Modelling projections of water using products, pp11.
[10] DEFRA (March 2011) MTP BNWAT08 Modelling projections of water using products, pp11.
[11] Waterwise (November 2011) Showers vs Baths: facts, figures and misconceptions "average bath's 80 litres" *http://www.waterwise.org.uk/news.php/11/showers-vs.-baths-facts-figures-and-misconceptions*
[12] DEFRA (March 2011) MTP BNWAT03 Baths -reference scenario average pp 9 and highest % of sales in 2010 were for medium sized baths (80-90 litres) pp10.

Ownership is taken from the water use survey with ownership of showers forecast to increase over the planning horizon with unmeasured properties increasing at a faster rate than measured. This is because it is assumed showers will have a higher take-up rate in unmeasured properties than measured. See Table 4.18 for details.

Table 4.18: Summary of showers base year and forecasting

	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	Base Year
Mixer Shower					
Essex Unmeasured	41.62	+0.2% p.a.	0.60	+0.6% p.a. until 2040	43.98
Suffolk Unmeasured	35.21		0.67		
Essex Existing	51.71	+0.1% p.a. until 2030	0.78	+0.005 p.a. until 2030	41.10
Suffolk Existing	43.80		0.89	+0.005 p.a. until 2040	36.65
Electric Shower					
Essex Unmeasured	30.33	+0.2% p.a.	0.66	+0.6% p.a. until 2030	38.78
Suffolk Unmeasured	33.05		0.67	+0.6% p.a. until 2040	
Essex Existing	25.82	+0.1% p.a. until 2030	0.78	+0.005 p.a. until 2030	34.27
Suffolk Existing	32.37		0.88	+0.005 p.a. until 2040	
Power Shower (>10l/min)					
Essex Unmeasured	15.57	+0.3% p.a.	0.59	+0.6% until 2040	76.14
Suffolk Unmeasured	10.96		0.64		
Essex Existing	21.21	+0.1% p.a.	0.72	+0.005 until 2030	67.28
Suffolk Existing	14.30		0.93	+0.005 until 2040	

The frequency of use was assumed to be the same for all types of showers and is taken from the water use survey. Shower frequencies are forecast to increase until 2030 as it is uncertain beyond this whether people would increase their shower use further.

To determine the respective volumes for each shower type results from the UK Water Industry Collaborative Fund project with Unilever R&D (Hendrickx et al, 2014) were used. An average of the various durations found in this research for different meter status and shower type were multiplied by the flow rate per shower type taken from this research as well. Shorter shower durations have been assumed for measured properties with power showers having the larger volumes per use. Shower duration is predicted to decrease across the planning horizon with a limit of five minutes as the minimum shower time.

Hand Washing / Teeth Cleaning

The ownership is set at 100% and remains constant. Frequency is set at seven times a day (five times after toilet use and two times brushing teeth) with this increased to eight for unmeasured properties. Frequency decreases over the planning horizon to account for assumed lower tap flow rates. The average tap flow rate of 6 l/min[13] is the bases for the volume of hand washing and teeth cleaning which has been multiplied by the estimated length of time each activity takes. The volume remains constant over the forecasting period.

Table 4.19: Summary of hand washing / teeth cleaning base year and forecasting

<table>
<tr><th rowspan="2">Hand washing / teeth cleaning</th><th>Ownership %</th><th></th><th>Frequency (/h/day)</th><th></th><th>Volume (l)</th></tr>
<tr><th>Base Year</th><th>Replacement Rate</th><th>Base Year</th><th>Growth Rate</th><th></th></tr>
<tr><td>Essex Unmeasured</td><td rowspan="4">100</td><td rowspan="4">Remains constant</td><td rowspan="2">8</td><td rowspan="4">((2060 freq – base year freq) / 44) + previous yr. freq</td><td>3.349</td></tr>
<tr><td>Suffolk Unmeasured</td><td>2.796</td></tr>
<tr><td>Essex Existing</td><td rowspan="2">7</td><td>2.512</td></tr>
<tr><td>Suffolk Existing</td><td>1.804</td></tr>
</table>

Bidet

Household ownership of a bidet has been taken from the water use survey results. In most cases, bidet use is considered too small to be included, therefore, in the forecast, frequency is assumed to remain at one use per day for the forecasting period. Volume per use also remains constant over the forecasting period at 1 litre in unmeasured properties and 1.2 litres in measured properties[14].

[13] Waterwise '6 litres / min' and DEFRA (March 2011) MTP BNWAT04 'washbasin tap flow rates range between 3.54-1.68', pp7.
[14] Scientific American (2017) *https://www.scientificamerican.com/article/earth-talks-bidets/* "1/8 gallon per use" (= 0.6litres per use, which has been increased to 1 for uncertainty).

4.7.3 Clothes Washing

The sections within the clothes washing micro-component are washing machine, washer-drier (drying part only) and washing clothes by hand.

Washing Machine

All washing machines have been split into four model groups with each model assigned an average volume use per load based upon the models currently available to customers.

It is assumed customers will buy from the most water efficient model on the market. Replacement rates of these models are applied to the forecast and fluctuate around double the assumed mean of 12.59 years[15]. As the ownership of washing machines increases and old models are replaced by new more water efficient models, the percentage ownership of model one decreases and models two, three and four are proportionally increased.

From the water use survey the total percentage ownership of all washing machines is calculated. The growth rate of washing machines is 0.25 per annum with total ownership capped at 99%. This allows for the total number of washing machines to be calculated based upon the total number of properties in the forecasting year.

The frequency of use for washing machines is taken from the survey. Baseline washing machine volume is the average of 30 models available on the market at the moment with the higher tertile used for unmeasured properties and the lower tertile for measured with an assumption that measured properties will purchase more efficient models. The volume for each forecasted year is based upon the percentage of each model owned multiplied by the total litres per use.

[15] DEFRA (March 2011) MTP BNWO01 Combined Laundry 'washing machines and washer drier lifespan is assumed to be 12.59 years', pp13. Waterwise report prepared for DEFRA (September 2008) Water and energy consumptions of Dishwashers and Washing Machines, 'on average a clothes washing machine is replaced once every 12 years', pp 9.

Table 4.20: Summary of washing machine base year ownership and frequency

		Frequency		
	Base Year Ownership	Base Year (property / week)	Growth Rate	Base Year Volume (litres)
Essex Unmeasured	97.68	3.72	+0.02 p.a.	57.77
Suffolk Unmeasured	93.95	3.80	((2060 freq – base year freq) / 44) + previous yr. freq	57.77
Essex Existing	93.46	3.51	remains constant	43.97
Suffolk Existing	93.35	3.14		43.97

Washer Driers (drying part only)

Washer driers use similar amounts of water in the washing phase as washing machines; however the drying phase also uses significant amounts of water as most operate by a process of condensation that removes humidity but consumes water[16].

The ownership of washer driers for each customer group is taken from water use survey results. Ownership is forecast to increase by 0.8% of the base year ownership. Penetration of washer-driers is thought to increase as single-occupancy households and confined living spaces make washer driers more practical than separate washers and driers[17].

Base year frequency of use is the same as washing machines and increases by around 1% per annum over the planning horizon with the assumption that they will be used more frequently. Similar to washing machines, the baseline washer dryer volume is the average volume (drying part only) of 30 models available on the market at the moment, with the higher tertile used for unmeasured properties and the lower tertile for measured with an assumption that measured properties will purchase more efficient models.

[16] Waterwise report prepared for DEFRA (September 2008) Water and energy consumptions of Dishwashers and Washing Machines, pp 21.
[17] Waterwise report prepared for DEFRA (September 2008) Water and energy consumptions of Dishwashers and Washing Machines, pp 21.

Table 4.21: Summary of washer drier base year ownership and frequency

Washer Dryer (drying part only)	Ownership %		Frequency (l/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	
Essex Unmeasured	97.68	+0.8% p.a.	3.7222	+0.02 p.a.	81.50
Suffolk Unmeasured	93.95	+1% p.a.	3.8026		
Essex Existing	93.46	+0.8* p.a.	3.5094	+1% p.a.	64.45
Suffolk Existing	93.35	+1% p.a.	3.1384	remains constant	

Washing clothes by hand

The ownership values determined for washing clothes and frequency of use are taken from the water use survey. Unmeasured household ownership remains constant throughout the forecasting horizon, whereas measured households decrease by 0.2% per annum over the horizon.

Volume per use is based upon the average washing up bowl volume of ten litres with the assumption measured households wash by hand 3-4 times per week and measured 1-2 times a week. The volume is assumed to decrease over the forecast to account for the increase in water efficient behaviours.

4.7.4 Dishwashers

The dishwashing micro-component has been split into four sections; dishwasher, washing up, waste disposal and recycling.

Dishwashers

The forecast model for dishwashers is based on the same approach as that used for washing machines. All dishwashers have been split into three models with each of these models assigned an average volume per load based upon the models currently available to customers[18]. It is assumed customers will buy from the most water efficient model on the market. Replacement rates of these models applied in

[18] Waterwise report prepared for DEFRA (September 2008) Water and energy consumptions of Dishwashers and Washing Machines, pp 10. Which? (September 2012) *http://www.which.co.uk/energy/creating-an-energy-saving-home/reviews-ns/water-saving-products/water-efficient-dishwashers/*.

the forecast vary around the assumed mean of 14.5 years[19]. As the percentage ownership of model one decreases, models two and three proportionally increased.

The baseline ownership of dishwashers is taken from results of the water use survey. Ownership is forecast to increase for all households, with total ownership capped at 99%. This allows the total number of dishwashers to be calculated based on the total number of properties.

The frequency value assigned to dishwashers has been taken from the water use survey. The forecast of frequency of use is related to the number of people living in a property, so as the average occupancy increases over the forecast the dishwasher frequency increases at the same rate.

Similar to washing machine, baseline dishwasher volumes are the average of the 30 models available on the market at the moment with the higher tertile used for unmeasured properties and the lower tertile for measured with an assumption that measured properties will purchase more efficient models. The volume for each forecasted year is based upon the percentage of each model owned multiplied by the total litres per use.

Table 4.22: Summary of dishwasher base year ownership and frequency and volume.

		Frequency		
	Base Year Ownership	Base Year (property / week)	Growth Rate	Base Year Volume (litres)
Essex Unmeasured	43.38	4.32	base year freq multiplied by 1.5 x change in occupancy	12.57
Suffolk Unmeasured	36.27	4.72		10.35
Essex Existing	50.22	4.25		9.24
Suffolk Existing	39.59	4.12		9.24

Washing Up

It is assumed that all homes that do not own a dishwasher will wash up. It is also assumed that 60% of households with a dishwasher will also do some washing up as well. Therefore the total percentage of customers who wash up is dependent upon the growth rate of dishwashers.

The frequency consists of a two part calculation based upon people without a dishwasher wash up more times than people with a dishwasher. It is presumed that

[19] DEFRA (March 2011) MTP BNDW01, ‘13 years’, pp11. Waterwise report prepared for DEFRA (September 2008) Water and energy consumptions of Dishwashers and Washing Machines, ’16 years’ pp 10. Mean of both these values is 14.5 years lifespan.

properties without a dishwasher wash up 18 times a week and those with a dishwasher are assumed to wash up at the same frequency as dishwashers. The forecasted frequency is therefore also dependant on the growth rate of dishwashers. Volume per use is based on the average washing up bowl size of ten litres.

Table 4.23: Summary of washing up base year ownership and frequency

Washing up	Ownership %	Frequency (/h/day)	Base year volume (l)
	Base Year	Base Year	
Essex Unmeasured	82.65	13.69	20.00
Suffolk Unmeasured	84.16	14.62	12.00
Essex Existing	79.91	12.82	8.00
Suffolk Existing	84.16	14.08	6.00

Waste Disposal Units

The ownership and frequency of use for waste disposal units is taken from the water use survey and remains constant over the forecast. From Waterwise's components of demand figures (Sep 2008)[20] the volume of 25 litres per use has been assumed for unmeasured properties and six litres per use for measured properties. Volume of use also remains constant over the planning horizon.

Recycling

Ownership and frequency for recycling is based on the water use survey. Volume per use is calculated by using the average tap flow rate of 6 litres per minute with the assumption each item is rinsed for 10-15 seconds.

Table 4.24: Recycling ownership, frequency and consumption.

Recycling	Ownership %	Frequency (/h/day)	Total consumption (l/h/d)
	Base Year	Base Year	
Essex Unmeasured	40.26	6.86	1.45
Suffolk Unmeasured	39.02	7.67	1.78
Essex Existing	43.24	7.28	2.23
Suffolk Existing	38.20	7.34	0.77

4.7.5 Outdoor Use

The micro-component section outdoor use has been split into the following sections:

[20] Waterwise (Sep 2008) Water consumption of components of domestic demand 'waste disposal unit (used with running water) 9 litres per min, can range between 6-25 litres / min'.

- pressure washer
- lawn sprinkling
- hose for watering garden
- watering can
- bucket for car wash and rinse
- hose for car rinse
- paddling pool
- large paddling pool (12-15ft +/or temp swimming pool)
- pond filling
- and swimming pool filling

Pressure washer

The ownership and frequency of use for pressure washer (power washers) is taken from the survey results. Ownership is expected to continue to increase over the next few years before stabilising with measured properties increasing at a slower rate than unmeasured properties.

A typical pressure washer volume ranges between 350-500 litres per hour with Waterwise stating the average is 400 litres / hour[21]. Base year volume is calculated from the average of the 30 models available on the market at the moment with the higher tertile used for unmeasured properties and the lower tertile for measured with an assumption that measured properties will purchase more efficient models.

Table 4.25: Summary of pressure washer base year and forecast

<table>
<tr><th rowspan="2">Pressure Washer</th><th>Ownership %</th><th></th><th>Frequency (/h/day)</th><th></th><th>Volume (l)</th></tr>
<tr><th>Base Year</th><th>Replacement Rate</th><th>Base Year</th><th>Growth Rate</th><th>Base Year</th></tr>
<tr><td>Essex Unmeasured</td><td>19.97</td><td rowspan="2">+0.25 p.a. until 2040</td><td>0.03</td><td rowspan="4">Remains constant</td><td rowspan="2">420.60</td></tr>
<tr><td>Suffolk Unmeasured</td><td>19.00</td><td>0.05</td></tr>
<tr><td>Essex Existing</td><td>19.99</td><td rowspan="2">+0.025 p.a.</td><td>0.04</td><td rowspan="2">189.45</td></tr>
<tr><td>Suffolk Existing</td><td>18.96</td><td>0.04</td></tr>
</table>

Lawn sprinkling

The ownership and frequency of lawn sprinkling has been determined from the survey as well. Across all the property areas the average time sprinklers were used

[21] Argos products available (September 2012) range from between 350-500 litres per hour, Waterwise estimate average is 400 litres / hour.

during the summer six months was between 21-27 hours. Similar to pressure washers, the frequencies are set to remain constant in measured properties.

The Defra MTP report states that ‘sprinklers typically use 540-1000 litres per hour (9-16 litres per minute)’. [22] Customers were asked in the water use survey to indicate the size of their garden. Large gardens were assigned a higher volume of 1000 l/hr and small gardens were assigned the lower volume of 770 l/hr for unmeasured and 540 l/hr for measured. Medium gardens were given the midpoint volume of between the higher and lower assigned volumes. Volumes were then weighted based upon the proportion of garden size of customers. Volumes remain constant until 2035 and then decrease for the remainder of the forecast. See Table 4.26 for details.

Table 4.26: Summary of base year and forecast for lawn sprinkling

Lawn Sprinkling	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	Base Year
Essex Unmeasured	5.28	Remains constant	22.15	Remains constant until 2040 then -5% p.a.	743.97
Suffolk Unmeasured	3.39		21.25	Remains constant until 2040 then -2% p.a.	720.92
Essex Existing	4.05	-0.01 p.a.	22.00	Remains constant	189.45
Suffolk Existing	1.90		26.67		

Garden Watering using hose or watering can

The percentage of people who water their garden using a hose or watering can is taken from the water use survey answers along with the frequency of use. For unmeasured properties hose watering is assumed to increase over the forecasting period and existing properties are assumed to decrease over the forecasting period due to expected difference in water efficient behaviours.

The volume for watering cans used is based upon the Defra MTP report[23] of an average of ten litres per fill along with 4-8 fills per use. Volumes per use for hoses

[22] DEFRA (March 2011) MTP BNWAT06 Domestic water use in new and existing buildings, ‘Sprinklers typically use 540-1000 litres per hour (9-16 litres per minute)’, pp 9.
[23] DEFRA (March 2011) MTP BNWAT06 Domestic water use in existing buildings, ‘Watering cans come in a variety of volumes typically between 7-13 litres’, pp 9.

are estimated by Waterwise of between 600-1000 l/hr. It has been assumed for this model that that the volume of a hose used to water the garden will be 770l/hr and if a trigger hose gun is attached 540 l/hr. From the water use survey the percentage of customers who did or did not own a trigger hose gun were used to calculate the average volume per use for each group.

Table 4.27: Summary of base year and forecast for hose used for garden watering.

Hose used for watering garden	Ownership %		Freq. (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	Base Year
Essex Unmeasured	38.18	+0.5% p.a. until 2040, -0.3% for remainder	30.41	Remain constant	653.30
Suffolk Unmeasured	25.73	+0.5% p.a. until 2040, -0.5% for remainder	28.25		676.46
Essex Existing	29.31	-0.5% p.a.	28.36		666.02
Suffolk Existing	20.82		25.96		679.53

Table 4.28: Summary of base year and forecast for watering cans

Watering can	Ownership %		Frequency (/h/day)		Volume (l)
	Base Year	Replacement Rate	Base Year	Growth Rate	Base Year
Essex Unmeasured	28.57	Remain constant	25.21	Remain constant	80.00
Suffolk Unmeasured	30.72		22.08		60.00
Essex Existing	23.89		21.63		60.00
Suffolk Existing	29.40		21.27		40.00

Car Washing

Car washing has been split into three activities:

- using a bucket for both washing and rinsing
- using a bucket for washing
- using a hose for rinsing only

The ownership and frequency of all three of these activities comes from the water use survey and these remain constant through-out the planning period. The volume for a bucket used for car washing is based on an assumption of two buckets per wash and six buckets per rinse, with the volume of one bucket as an average of seven litres[24]. The volume per use of 90 litres is used for a hose for rinsing[25]. These remain constant over the forecasting horizon.

Table 4.29: Summary of base year and frequency for car washing

Car Wash	Bucket for both washing and rinsing			Bucket just for washing litres			Hose for rinsing only litres		
	Vol (l)	Ownership (%)	Freq. (H/wk.)	Vol (l)	Ownership (%)	Freq. (H/wk.)	Vol (l)	Ownership (%)	Freq. (H/wk.)
Unmeasured Essex	80.00	18.73	18.17	28.00	7.08	18.17	90.00	9.68	18.25
Unmeasured Suffolk		22.77	20.40		9.73	22.10		12.82	22.59
Existing Essex	60.00	17.90	13.37	14.00	8.58	17.09		11.52	17.57
Existing Suffolk	40.00	23.48	13.86		9.08	16.77		11.80	16.66

Paddling Pool, Large paddling pool (12-15ft), Pond and Swimming Pools

Ownership of a paddling pools, large paddling pools / temporary swimming pools, ponds and swimming pools is taken from the water use survey. Households are assumed to use or refill these 10-15 times a year which converts to 0.02-0.04 times per household per day. Measured properties frequency has been lowered to reflect the water conserving awareness of these customers. A range of 30 advertised products currently available provides the basis for the volumes with the higher tertile used for unmeasured properties and the lower tertile for measured with an assumption that measured properties will purchase more efficient models. The daily water use of swimming pool filling has been taken from the Market Transformation Programme report evidence as 271 litres for all households[26]. Ownership, frequency and volume remain constant over the forecasting period.

[24] Most buckets on sale in B&Q (Sep 2017) average at 10 litres, assumed not to be filled to full capacity so a volume of 7 litres has been assigned.
[25] DEFRA (March 2011) MTP BNWAT06 Domestic water use in existing buildings, 'Hoses can use upwards of 540 litres of water per hour depending on the pressure and hose size', pp9. Therefore assuming 540 litres / hour which is gives 9 litres / min flow rate for 10 minutes to give 90 litres per use.
[26] DEFRA (March 2011) MTP BNWAT06 Domestic water use in new and existing buildings pp9-10. BSPF response to DEFRA's consultation on proposed changes to powers to restrict non-essential uses of water.

Table 4.30: Summary of base year and forecast for paddling pools

<table>
<tr><th rowspan="2">Paddling Pool</th><th>Ownership %</th><th></th><th>Frequency (/h/day)</th><th></th><th>Volume (l)</th></tr>
<tr><th>Base Year</th><th>Replacement Rate</th><th>Base Year</th><th>Growth Rate</th><th>Base Year</th></tr>
<tr><td>Essex Unmeasured</td><td>4.84</td><td rowspan="4">Remain Constant</td><td>0.04</td><td rowspan="4">Remain Constant</td><td rowspan="2">383.10</td></tr>
<tr><td>Suffolk Unmeasured</td><td>5.63</td><td>0.03</td></tr>
<tr><td>Essex Existing</td><td>4.16</td><td rowspan="2">0.02</td><td rowspan="2">196.40</td></tr>
<tr><td>Suffolk Existing</td><td>3.01</td></tr>
</table>

Table 4.31: Summary of base year and forecast for large paddling pools

<table>
<tr><th rowspan="2">Large Paddling Pool</th><th colspan="2">Ownership %</th><th colspan="2">Frequency (/h/day)</th><th>Volume (l)</th></tr>
<tr><th>Base Year</th><th>Replacement Rate</th><th>Base Year</th><th>Growth Rate</th><th>Base Year</th></tr>
<tr><td>Essex Unmeasured</td><td>2.28</td><td rowspan="4">Remain Constant</td><td>0.03</td><td rowspan="4">Remain Constant</td><td rowspan="2">8109.00</td></tr>
<tr><td>Suffolk Unmeasured</td><td>2.37</td><td>0.01</td></tr>
<tr><td>Essex Existing</td><td>2.79</td><td>0.02</td><td rowspan="2">3408.90</td></tr>
<tr><td>Suffolk Existing</td><td>2.41</td><td>0.01</td></tr>
</table>

Table 4.32: Summary of base year and forecast for pond filling

<table>
<tr><th rowspan="2">Pond filling</th><th>Ownership %</th><th></th><th>Frequency (/h/day)</th><th></th><th>Volume (l)</th></tr>
<tr><th>Base Year</th><th>Replacement Rate</th><th>Base Year</th><th>Growth Rate</th><th>Base Year</th></tr>
<tr><td>Essex Unmeasured</td><td>6.88</td><td rowspan="4">Remain Constant</td><td rowspan="3">0.03</td><td rowspan="4">Remain Constant</td><td rowspan="2">800.00</td></tr>
<tr><td>Suffolk Unmeasured</td><td>7.19</td></tr>
<tr><td>Essex Existing</td><td>6.13</td><td rowspan="2">381.67</td></tr>
<tr><td>Suffolk Existing</td><td>5.32</td><td>0.01</td></tr>
</table>

Table 4.33: Summary of base year and forecast for swimming pool filling

<table>
<tr><th rowspan="2">Swimming Pool filling</th><th colspan="2">Ownership %</th><th colspan="2">Frequency (/h/day)</th><th>Volume (l)</th></tr>
<tr><th>Base Year</th><th>Replacement Rate</th><th>Base Year</th><th>Growth Rate</th><th>Base Year</th></tr>
<tr><td>Essex Unmeasured</td><td>2.28</td><td rowspan="4">Remain Constant</td><td>0.03</td><td rowspan="4">Remain Constant</td><td rowspan="4">271</td></tr>
<tr><td>Suffolk Unmeasured</td><td>2.37</td><td rowspan="3">0.01</td></tr>
<tr><td>Essex Existing</td><td>2.79</td></tr>
<tr><td>Suffolk Existing</td><td>2.41</td></tr>
</table>

4.7.6 General Use

The general use category takes into account all other areas of water use within the home and garden. For each household group a constant figure has been used over the planning horizon. General use has been split into the following areas of water use:

- Plumbing losses
- Other internal use (DIY, children's play, steam irons, house plants, washing paint brushes etc.)
- Animals (Water used for drinking, washing and cleaning cages etc.)
- Cleaning
- Drinking (Including filling kettles)
- Food prep / cooking
- Running tap (Running tap till hot/cold)
- Hot tubs and water softeners

For each component the assumptions have been built up from ownership, frequency of use and volume assumptions. The resulting figures are shown in

Table 4.34. In determining these figures the normalised base year total PCCs to achieve a balance was taken into account. No additional allowance has been made for new appliances or for activities not mentioned above. It is assumed that these are accommodated within the uncertainty of the above assumptions.

Table 4.34: Summary of base year and forecast for general use

General Use	Unmeasured Essex l/hd/d	Unmeasured Suffolk l/hd/d	Existing Essex l/hd/d	Existing Suffolk l/hd/d
Plumbing losses	0.98	1.02	1.64	1.80
Other internal use	3.00	1.30	1.50	0.65
Animals	0.28	0.30	0.30	0.35
Cleaning	1.84	1.98	1.95	1.58
Drinking	2.00	2.00	2.00	2.00
Food preparation and cooking	3.07	1.32	1.82	2.11
Running taps	1.63	1.47	0.49	0.42
Water Softeners	1.38	1.79	0.33	0.58
Hot Tubs	0.23	0.21	0.12	0.13
Total	14.41	11.38	10.14	9.62

4.7.7 Overall Household Demand

The resulting PCC forecasts show an overall household PCC, for the normal year, reducing steadily over the planning horizon from 149.86 l/h/d in 2016/17 to 123.79 l/h/d in 2059/60.

4.8 Non-Household Demand Forecasts

This section sets out the non-household demand forecasts for 2017/18 to 2059/60 for ESW. These forecasts show actual volumes up to 2016/17 and use ESW's own non-household demand forecast methodology for 2017/18 and beyond.

The methodology used for forecasting non-household demand is set out and then the forecast results are discussed.

In April 2017 there was a major change to the water industry with the creation of a new non-household water market. This saw the separation of retail activities and the creation of wholesale companies and retail companies. This means that going forward for the non-household water market the primary 'customers' of the Company are the retail companies, who then in turn bill the end user or non-household customer. For simplicity, through this report the term ‘customer’ will still refer to the end user rather than retail companies.

While these changes to the industry will not affect the demand of water from non-households it does mean that, as a wholesaler, ESW will not have responsibility for the primary direct contact with end customers in the same way that it did in the past and that the only information held by ESW about end users will be the data that is available within the Central Market Operating System (CMOS).

4.8.1 Methodology

ESW has developed its own methodology forecast for non-household demand for the 2020 WRMP and for use in Ofwat’s PR19 price control process. This methodology uses trend data based on past actual use by customers to predict a profile of future demand.

4.8.2 Approach

The demand forecast methodology is based on a number of assumptions and a formula built on three elements. The customer base is split into two groups:

- Identified customers who use more than 10,000 cubic metres of water per year and for whom an individual forecast has been generated for each customer;
- Non-identified customers who use less than 10,000 cubic metres per year for whom an average volume per property is forecast, and their total demand is calculated by multiplying this average by the forecast number of properties.

The key assumptions made are:

- No new identified customers will open during the forecast period, and no closures will be forecast, unless robust, public domain information is available. Any new customers will fall into the non-identified group of customers;
- In general, demand for individual customers remains relatively stable unless there is an expansion or reduction on the customer’s site, or if they fundamentally change how they use water. These events cannot be predicted and so it cannot be assumed that these events will happen unless they are already in progress;
- Demand will trend to a flat line over time if there are no changes to water use on site. Recent past data may show a decreasing trend due, for example, to water efficiency measures. However forecasting that reduction to continue at the same rate for 40 years is unrealistic. Therefore a forecast calculation that trends demand to a flat line over time has been used;
- It is extremely difficult to robustly forecast the economic climate 40 years in advance. Therefore the non-household demand forecast is not modified for the behaviour of the economy.

Taking into account these key assumptions a formula was developed that uses a logarithmic trend as a base to forecast demand. This forecast is based on three sections:

- Trend data
- Step change adjustment
- Economic adjustment

Demand components used in the calculation of household demand are all weighted to average demand.

4.8.3 Trend forecast

The past ten years of actual demand is used to develop a profile of demand based on a logarithmic trend. Using trend data provides a more average look at demand over time, and should provide a central forecast of demand out to the future. Any abnormal demand, such as a single year of high demand caused by leakage, or abnormally low demand as caused by a partial closure, will be smoothed out and will not overly influence the forecasts.

4.8.4 Step change adjustment

Over the past ten years, some customers may have made a step change in their demand, which means that demand in recent years should have more influence over demand than the demand from ten years ago. A pure trend analysis will not take full account of this step change, and therefore a calculation has been included that looks at the difference between demand early in the series of data and demand in the most recent years. The forecast based on the trend is adjusted by this difference, called the “step change adjustment”, to bring the forecast into line with actual demand experienced in the recent past.

4.8.5 Economic adjustment

This is a percentage multiplier to be factored in to the trend forecast, which is an assumption that allows for an adjustment to make future demand more or less positive than experienced in the past.

No adjustment has currently been made to this element of the formula because ESW does not believe there is sufficiently robust data available to forecast the economy out into the future. At the most it may be possible to indicate that the next few years may show lower demand than past trend data may indicate, however it is difficult to say by how much. In addition the various forecasts of the economy, for example from HM Treasury, change on a regular basis. ESW also believes that it is difficult to tie demand for water use to the strength of the economy. Implementation of water efficiency measures can offset any growth, and the opening or closure of one large customer can throw any forecast out of line with expectations. Therefore it is preferred not to use this adjustment on this basis at this time. This position may be reviewed.

Example

The graph below illustrates how this demand methodology would predict demand for a customer.

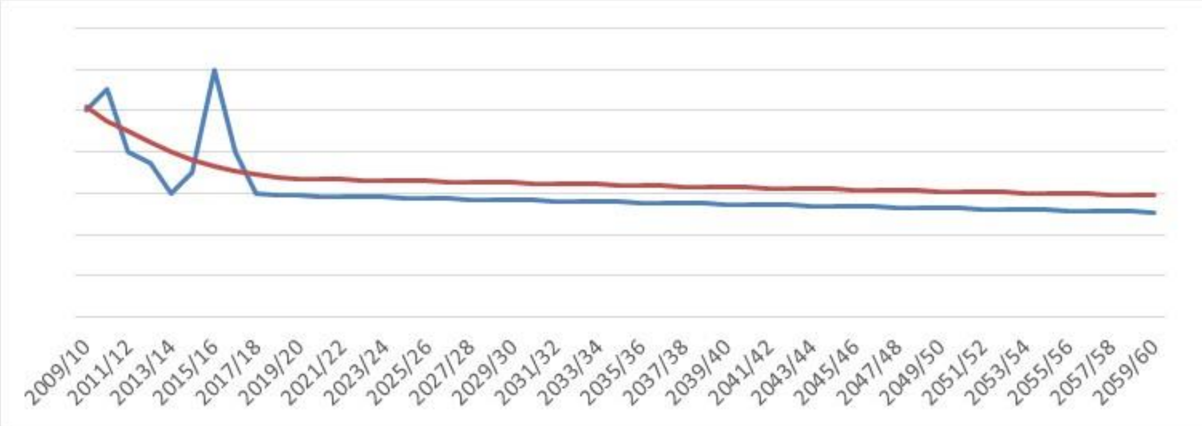


Figure 4.11: Example of demand forecast (orange line would be used in the Company's forecast)

This customer clearly had some abnormal demand in 2015/16. This influences the trend and so purely using the trend forecast would over forecast (for this particular customer). The most recent demand has been lower than the trend would indicate, and so the step change adjustment modifies the forecast downwards for this example customer, although not to the lowest ever demand, but to a position in line with recent demand. The "step change adjustment" would adjust upwards, should recent demand be higher than the trend data indicates.

4.8.6 Application of the methodology

The demand forecast applied an individual trend line for each identified customer. For all of the remaining non-identified customers an average demand per property has been derived and the same trend approach had been applied using the average demand per property. The forecast average per property is then multiplied by the forecast number of non-identified properties to generate a total forecast demand for the non-identified customers.

4.8.7 Non-Household Forecasting

4.8.7.1 Uncertainty

It is not possible to predict exactly what will happen in the future, as has been demonstrated with the change to the economic climate over the past five years and the uncertainty around the potential impact of Brexit on British industry. Customers can close at a moments notice and, as there are no contracts with water customers, they can increase or decrease demand at any time. While good contact with customers can keep track of general changes, frequently significant changes are commercially sensitive, and are not communicated in advance within ESW in question, let alone with external suppliers, such as water companies.

The methodology used for ESW's non-household demand forecast uses the real data available, and combines this with an overall view to result in a reasonable looking forecast. If there has been decreasing demand in recent years, and the economic climate seems to remain generally pessimistic, it seems reasonable to forecast decreasing demand in the next few years. It is unlikely that demand may suddenly surge, unless there is major growth in industry, but it is possible that a slight increase could occur, should the economy recover. On the other hand demand could collapse should current trends continue into the long term. Using a flat trend gives a forecast that arrives somewhere between these two scenarios. In reality, some customers will increase their demand and other will decrease, which in many cases will offset one another.

4.8.7.2 Sensitivity

Different ways of forecasting will produce different forecast volumes. The demand forecast based on individual trend forecasts for individual customers was tested against what the forecast would look like if trends based on sector or size were used instead.

These forecasts do not pick up step changes in single customer behaviour, they tend to be smooth. They also incorporate data for properties that have closed, therefore a sector or size trend tends to be lower than one based on individual trends. Such a trend could be viewed as valid, however it is counter to the starting assumption that all existing identified non-household customers will remain open, unless otherwise publicised.

The non-household demand forecast is most sensitive to assumptions in demand of the largest contributors to demand. These are the assumptions applied to the group of non-identified customers, and the demand profiles of the largest customers. The forecasts for the largest non-household customers have been reviewed individually to ensure that they take account of the latest information available, and that their forecast consumption is based on a centrally reasonable estimate. The following graph shows how demand for a large customer can be volatile year on year. Using the trend based approach ensures that the forecast demand is not based on the peak or lowest demand. In this case recent demand is slightly higher than the trend would indicate so the forecast used is adjusted slightly upwards by the "step change adjustment" as previously described.

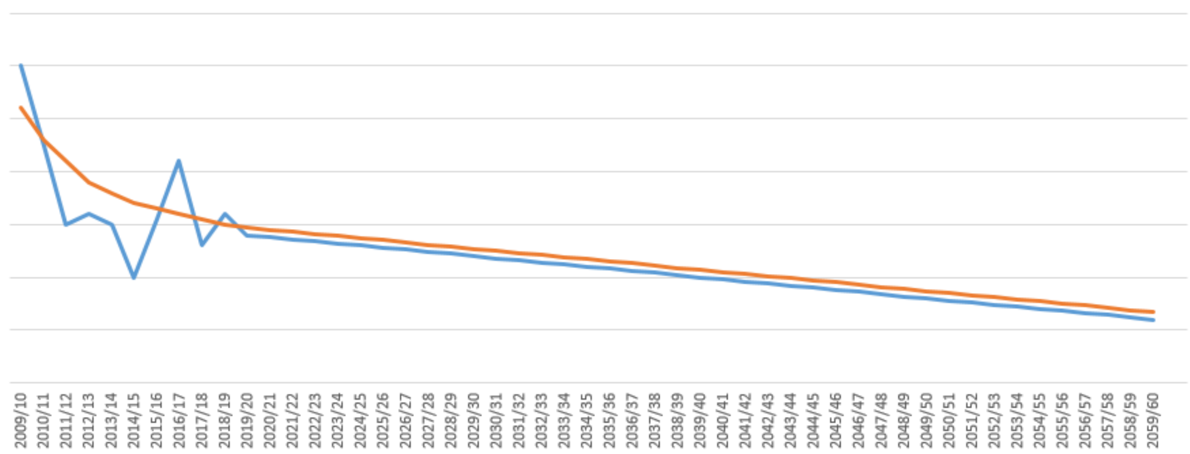


Figure 4.12: Example demand forecast for variable demand at anonymous larger customer.

The forecast would be sensitive to demand for this customer if either the 2016/17 peak demand or the lower demand of 2014/15 were used. The trend gives a clear way to make a decision on where to pitch demand, and one that can be consistently applied across all customers.

Should information become available that this particular customer is making a step change to their demand, for example by a partial closure in the next year, or maybe that they intend increasing their production line which will increase their demand, this information can then be built into the forecast, by either reducing demand in the year stated for the partial closure, or by increasing demand by overwriting the “step change adjustment” to reflect the expected increase.

Having tested the forecast methodology in several ways, ESW feels confident that it provides a reasonable forecast that is based on sensible assumptions.

4.8.8 Non-Household Potable Water Demand by Sector

At this stage demand has not been analysed by Standard Industrial Classification (SIC). This is because the methodology of looking at smaller customers as a group means it is not necessary to look at different types of smaller customers. Small customer demand is discussed in more detail below.

Each of the larger customers have been allocated to one of ten broad sectors, which have been aimed at grouping their demand into a small set of groups for which drivers of demand should be fairly similar.

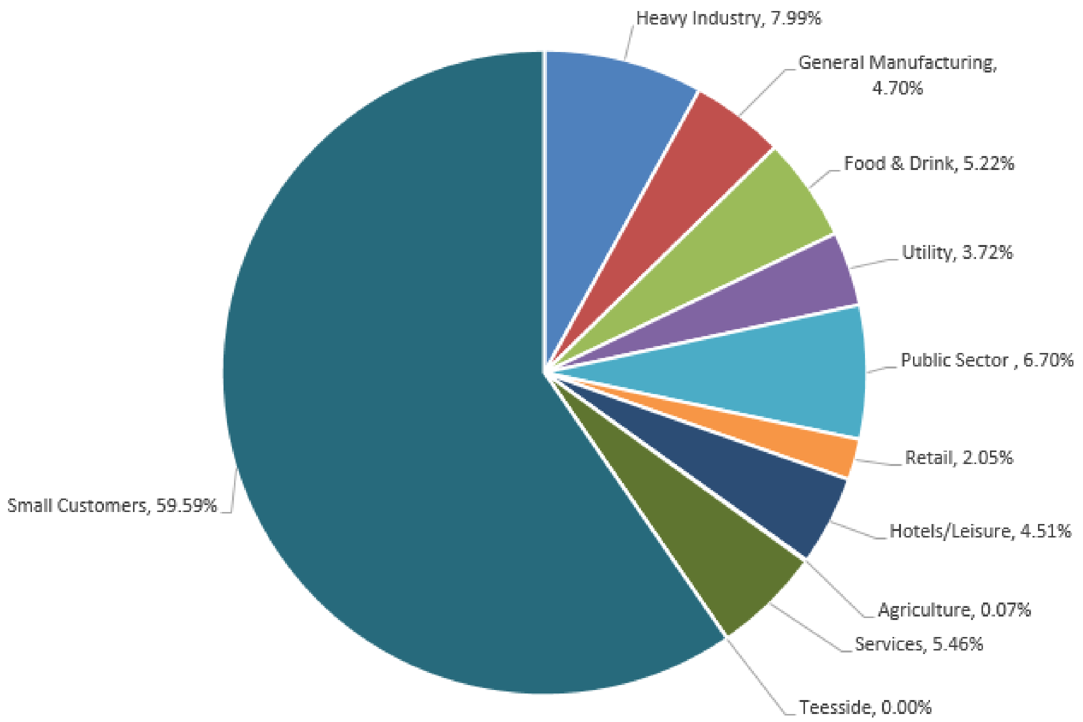
Table 4.35: Non Household Customer sectors

	Title	Description	Examples
Small Customers	Non-Identified Customers	All customers who use less than 10,000 cubic meters of water per year.	
Large Customers	Heavy Industry		Mining, oil refinery, car manufacturers
	General Manufacturing	All industry that produces something physical	
	Food and Drink	Food and drink manufacturers	
	Utility	All utilities	Power stations, water services, water and sewerage companies.
	Public Sector	Organisations which are mostly funded by government and will be affected by the public finances.	Hospitals, schools, councils, prisons, police, fire services etc.
	Retail	Anything that sells to the general public.	Shopping centres and supermarkets.
	Leisure	All customers who are part of providing leisure and holiday activities to the general public.	Hotels, holiday parks, sports clubs.
	Agriculture		Farms, dairies, etc.
	Services	General service industries.	Finance, insurance etc.
	Teesside	A small group of large customers on Teesside in the North East.	Not relevant for Essex & Suffolk. Included to show consistency in the approach for the North East and Essex & Suffolk regions.

4.8.9 Defined industrial sectors

The graphs below illustrate the proportion of demand in each region from each of the sectors defined above. Small customers who use less than 10,000 cubic meters per year make up approximately 60% of measured non-household demand.

2016/17 Essex Volumes (Mld)



2016/17 Suffolk Volume (Mld)

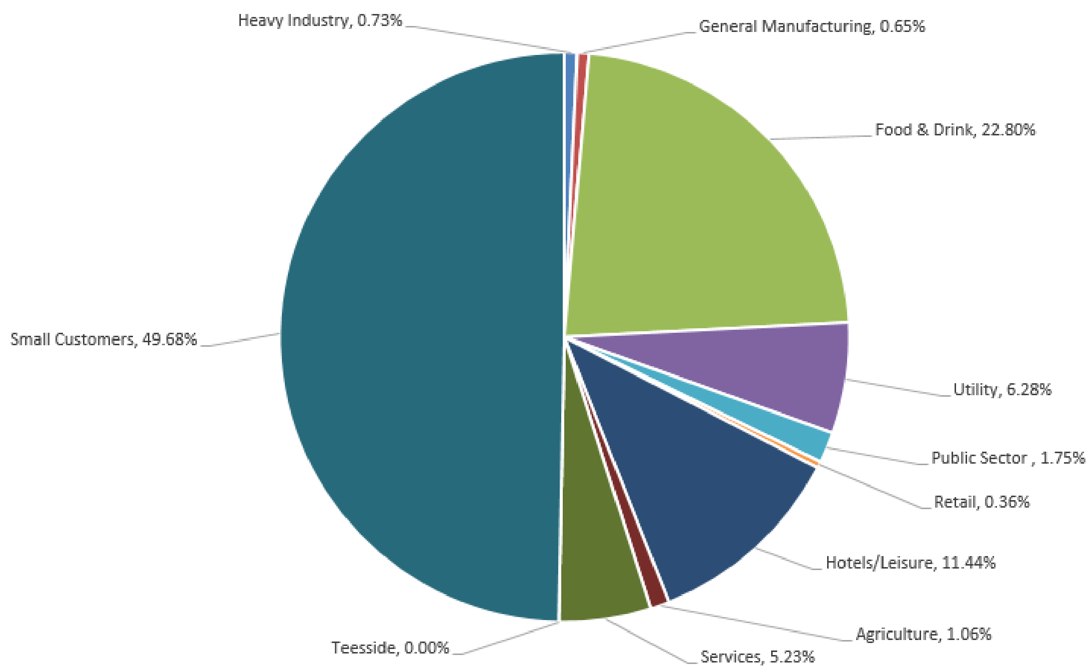


Figure 4.13: Make-up of non-household demand in the Essex and Suffolk regions in 2016/17.

Heavy industry is the largest area of identified customer use in Essex, being dominated by a few larger customers, one of whom has changed operation since PR14 and is using much smaller volumes of water than they had been historically. Food and drink and leisure are the largest areas of demand in the Suffolk region.

2016/17 Essex Volume (Mld)

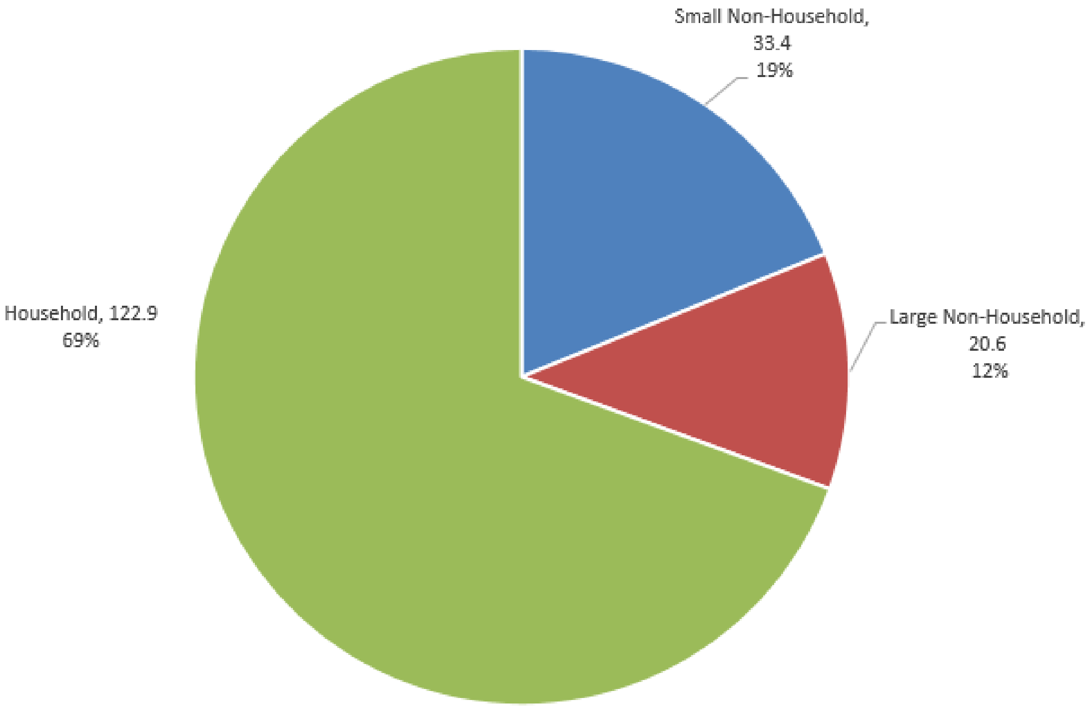


Figure 4.14: Breakdown of demand in the Essex Water Resource Zone for 2016/17.

Proportionally, demand in Essex is driven by households, with only 31% of demand coming from non-households.

4.8.10 Large Customer Historical Demand

Since 2009/10 non-household demand has been quite stable in most sectors, and the changes in demand, particularly in the heavy industry category, as shown in Figure 4.15 are due to closures or changes in operations of specific properties.

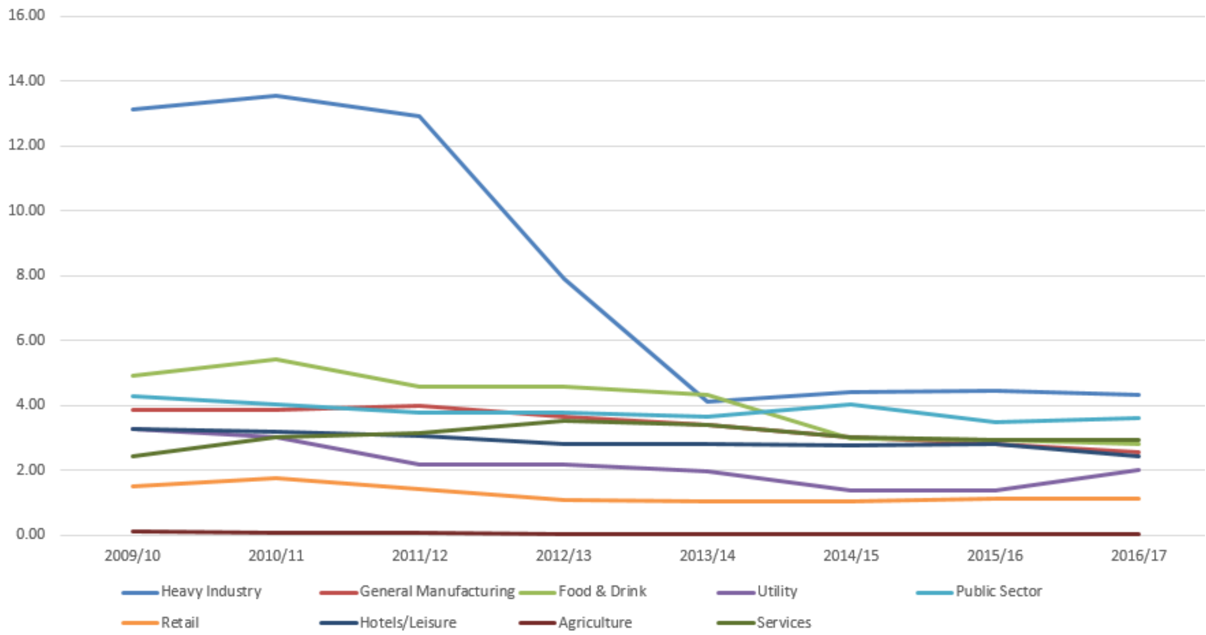


Figure 4.15: Large non-household demand in Essex 2009/10 – 2016/17 – change in volumes.

Demand in all sectors is now lower than it was in 2009/10. Whilst the largest proportional reductions in demand are in heavy industry and agriculture, the changes in agriculture are against relatively small volumes. Non-household demand in Essex has been significantly affected by the closures or changes in operations of a few large customers in the heavy industry sector.

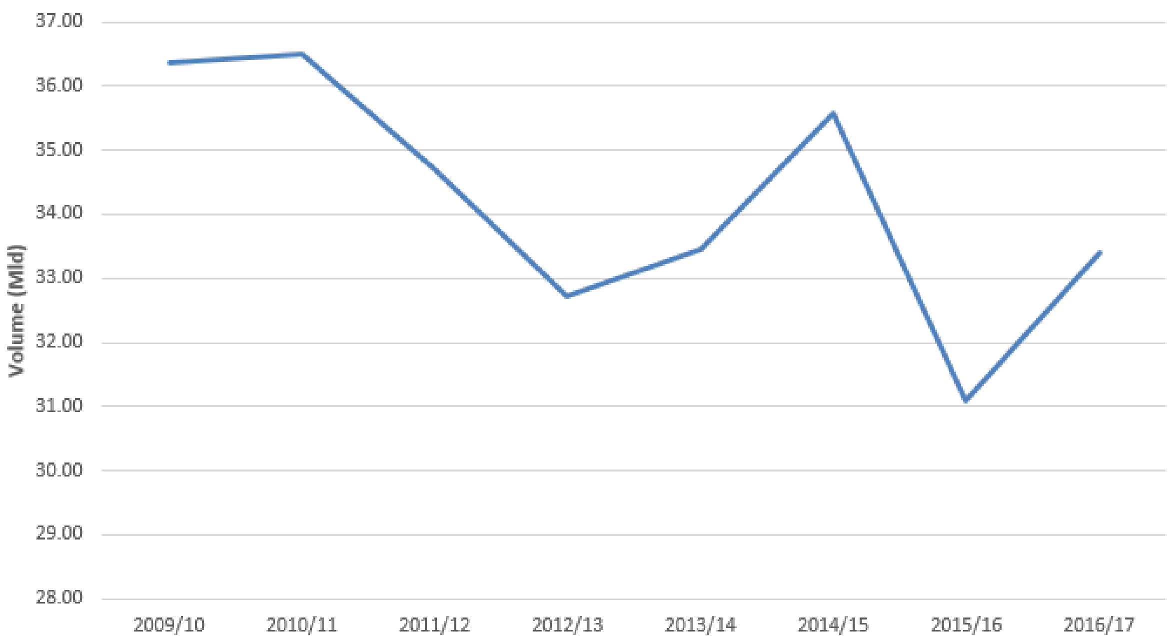


Figure 4.16: Small Customer historic demand

Figure 4.16 above shows how demand from small non-households has changed year on year between 2009/10 and 2016/17 however, with a general decline over time. The step change seen in 2010/11 is partly due to the changes in reporting from systems.

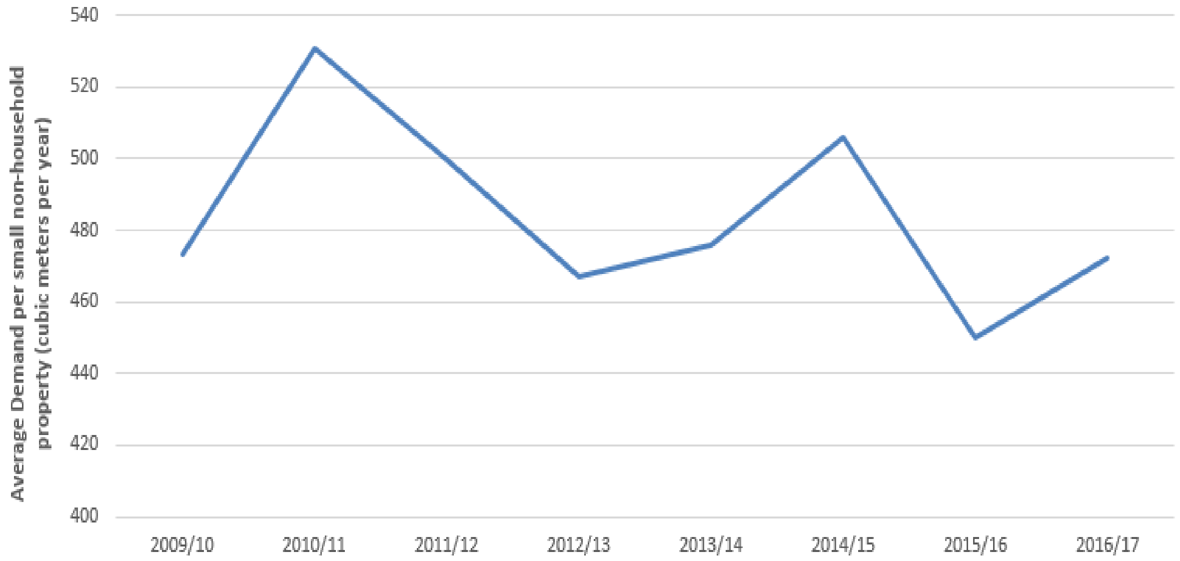


Figure 4.17: Historic small non-household demand average per property in Essex

It is not possible to exactly determine the cause of the changes in demand however the higher consumption in 2010/11 and the subsequent reduction is a combination of leaks occurring during the harsh winter in 2010, subsequently finding and repairing these leaks and more attention being paid to water usage.

While these variations in average demand per property seem relatively small, accumulated over all small non-household properties this can add up to a significant change in total demand.

4.8.11 Forecast Demand

Overall measured non-household forecast demand to 2060 is relatively flat, with a gradual increase over time to account for growth of non-household property numbers. This is due to the assumption built into the forecast methodology that individual customer demand will trend to a flat line over time. In the short term there is some uncertainty in the views from the government and HM Treasury on what the impact of Brexit will be on the UK economy in the coming years, and so the flattening of demand within this timescale seems reasonable.

It is unlikely that large increases in demand will be experienced, unless new large water users open. The forecasts do not assume that this will happen because assuming new demand is uncertain until the new site actually starts operation.

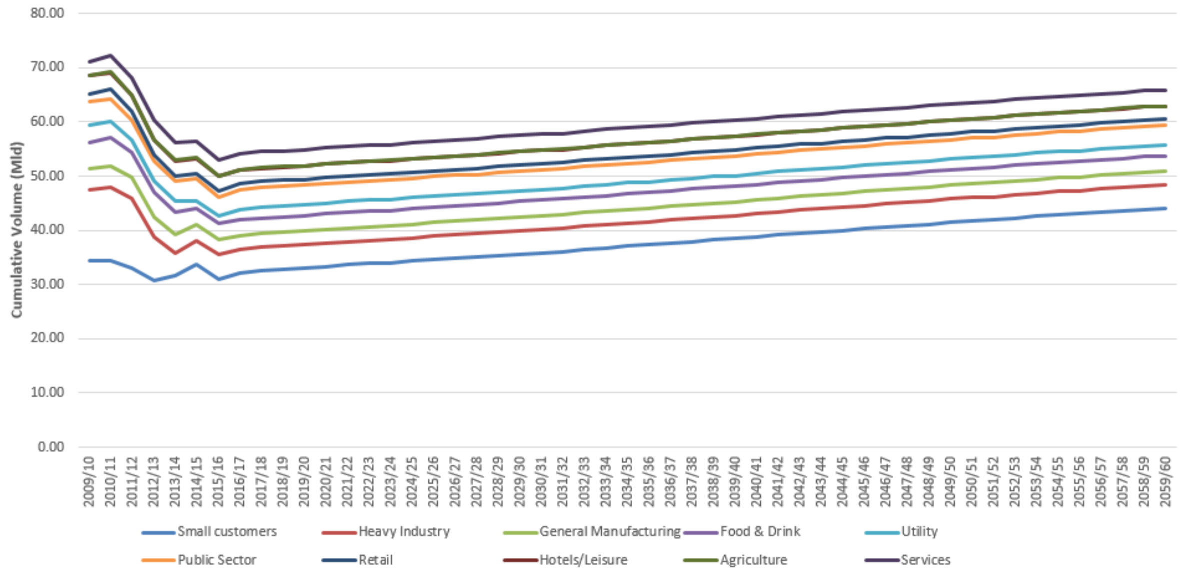


Figure 4.18: Forecast demand in Essex by sector – volumes are cumulative, so the gap between each line is the size of each sector.

Table 4.36: Change in measured non-household demand in Essex by sector between 2016/17 and 2059/60

Sector	Demand (Mld)		Change (Mld)	% Change	Notes
	2016/17	2059/60			
Small Customers	32.20	44.08	11.88	36.89%	Increase due to anticipated growth in small non-household customers, rather than increased demand from the current customer base.
Heavy Industry	4.32	4.30	-0.02	-0.27%	
General Manufacturing	2.54	2.53	-0.01	-0.27%	
Food and Drink	2.82	2.81	-0.01	-0.27%	
Utility	2.01	2.01	0	0%	
Public Sector	3.62	3.61	-0.01	-0.27%	
Retail	1.11	1.10	-0.01	-0.27%	
Hotels/Leisure	2.44	2.43	-0.01	-0.27%	
Agriculture	0.04	0.04	0	0%	
Services	2.95	2.94	-0.01	-0.27%	
Total	54.05	65.86	11.82	21.87%	

The largest change in the forecast is for small non-household customers, with the demand increasing due to anticipated growth in property numbers rather than an increase in average demand per customer.

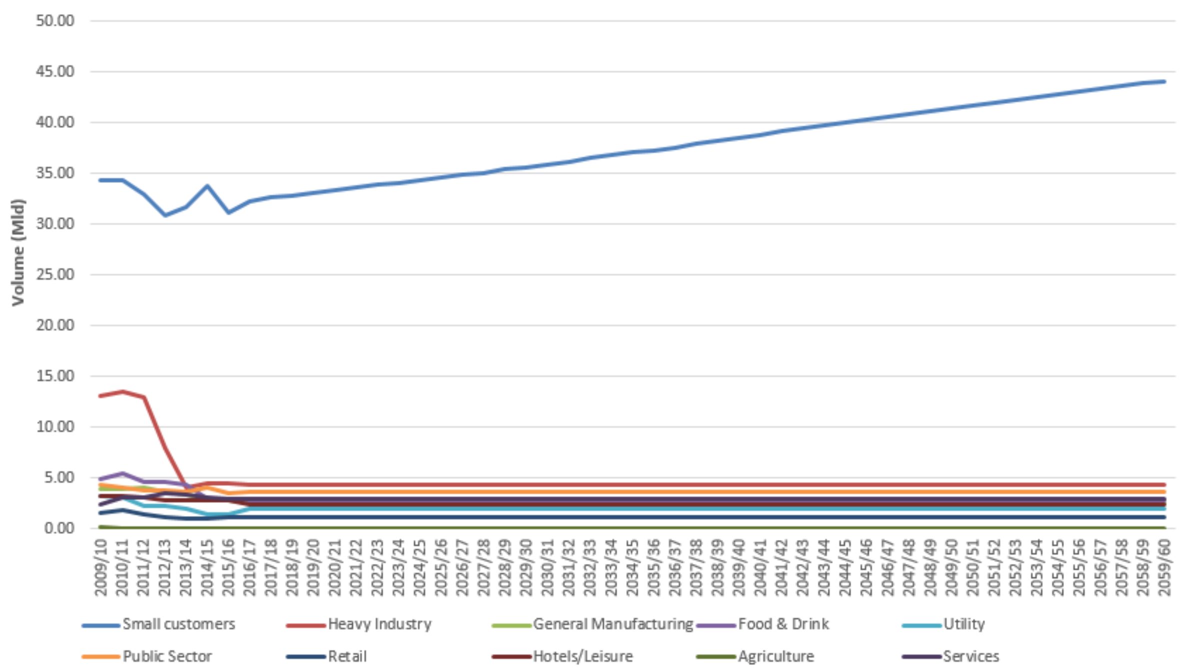


Figure 4.19: Forecast demand in Essex – by sector

4.8.12 Suffolk Demand by Water Resource Zone (WRZ)

Overall household demand is 53% of demand in Suffolk. Demand from small non-households and large non-households are evenly split, however due to the relatively small size of the Company's Suffolk region, that large non-household demand is dominated by a few large customers.

2016/17 Suffolk Volume (Mld)

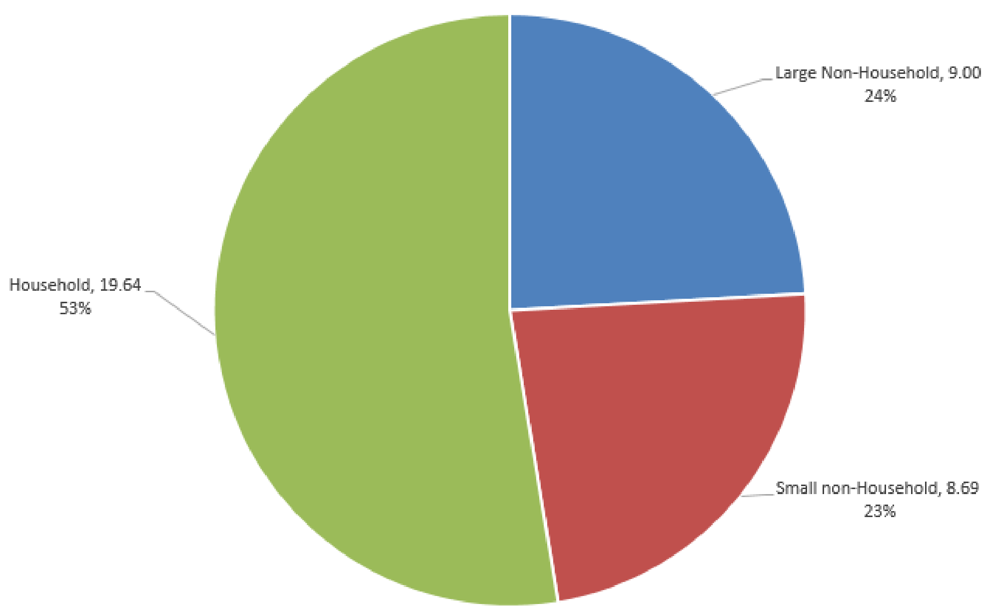


Figure 4.20: Breakdown of demand in Suffolk Total 2016/17

As the graphs in the figure below show, demand in Hartismere is dominated by several large customers, whereas the proportion of household and non-household demand is comparable between the Central and Blyth WRZs.

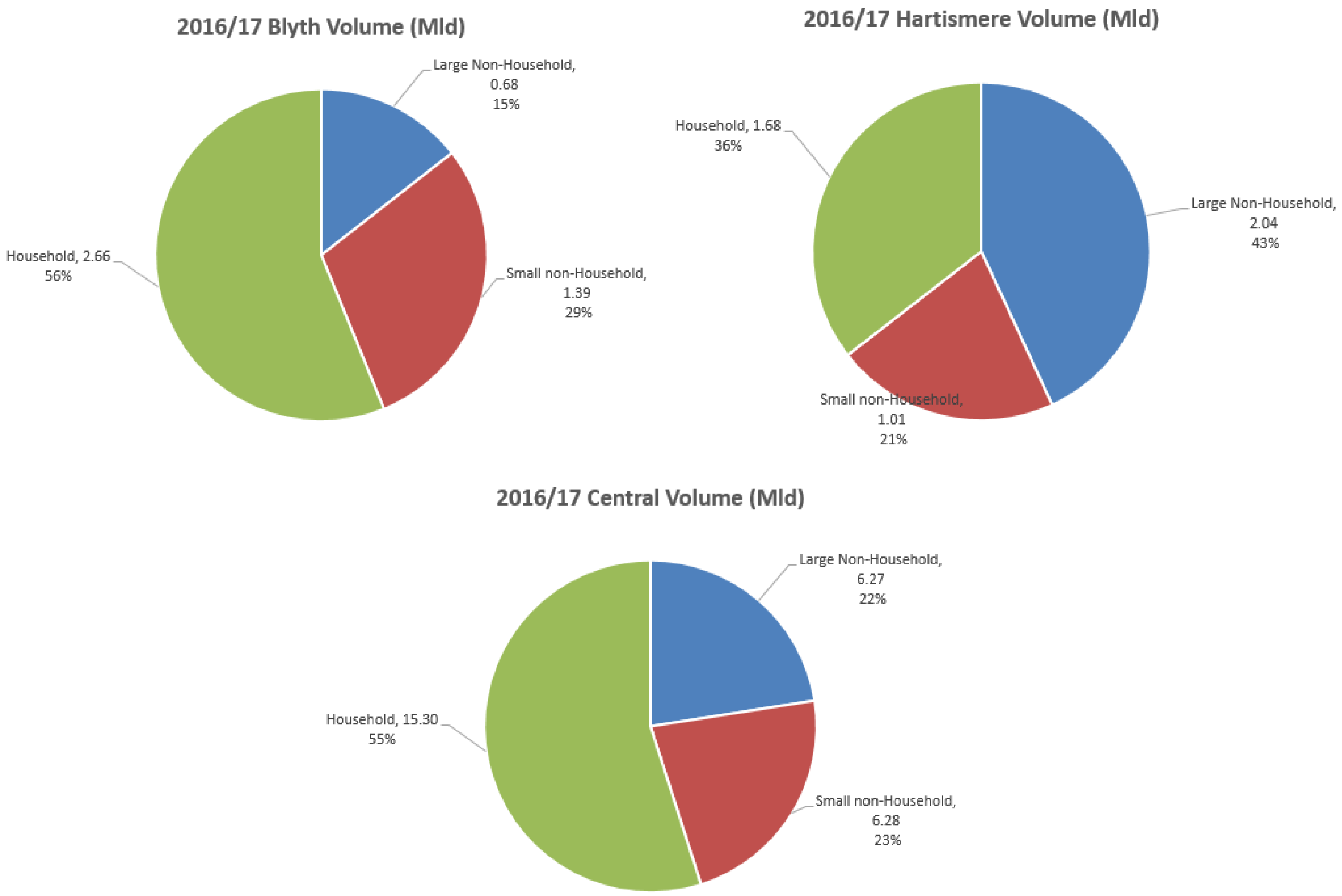


Figure 4.21: Breakdown of demand in Suffolk Water Resource Zones for 2016/17

4.8.13 Large Customer Historical Demand

Since 2009/10 non-household demand has been quite stable in most sectors, with no major decreases in demand.

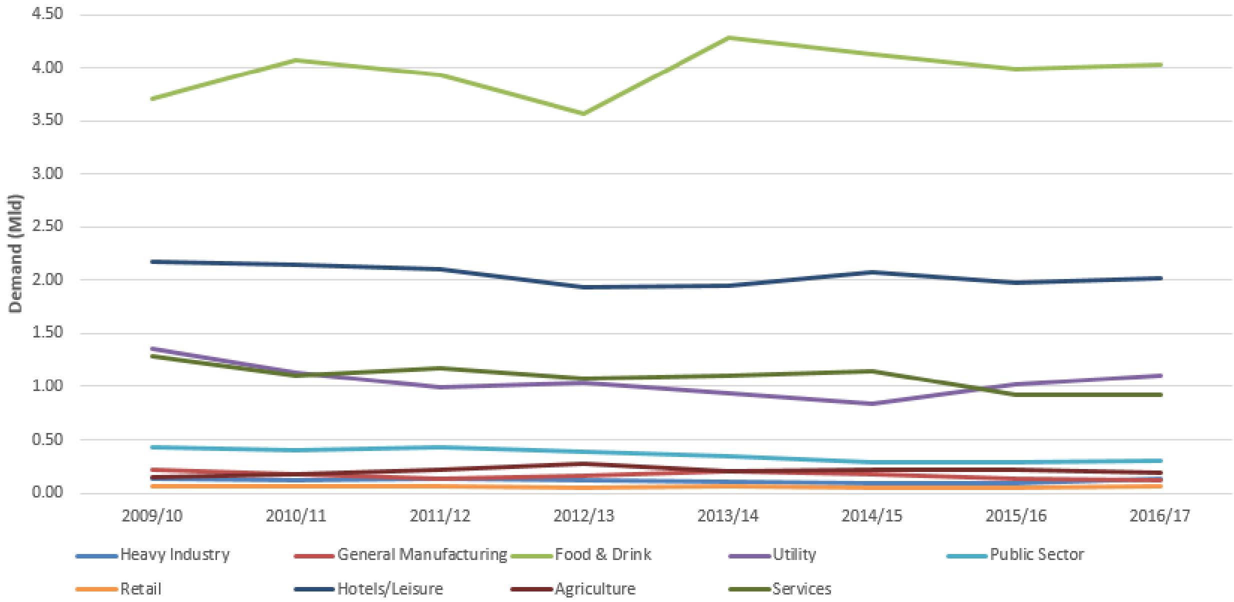


Figure 4.22: Large non-household demand in Suffolk 2009/10 – 2016/17 change in volumes.

Demand in all sectors is now lower than it was in 2009/10, with the exception of food and Drink and Agriculture, which have seen slight increases in demand. Agriculture is a change on very small volumes, however the impact on food and drink is mainly due to an increase for one large customer.

4.8.14 Small customer historic demand

Figure 4.23 shows how demand from small non-households has seen a general reduction between 2010/11 and 2015/16, however in 2010/11 some changes to how data is reported from systems were made, which may have affected the increase in 2010/11.

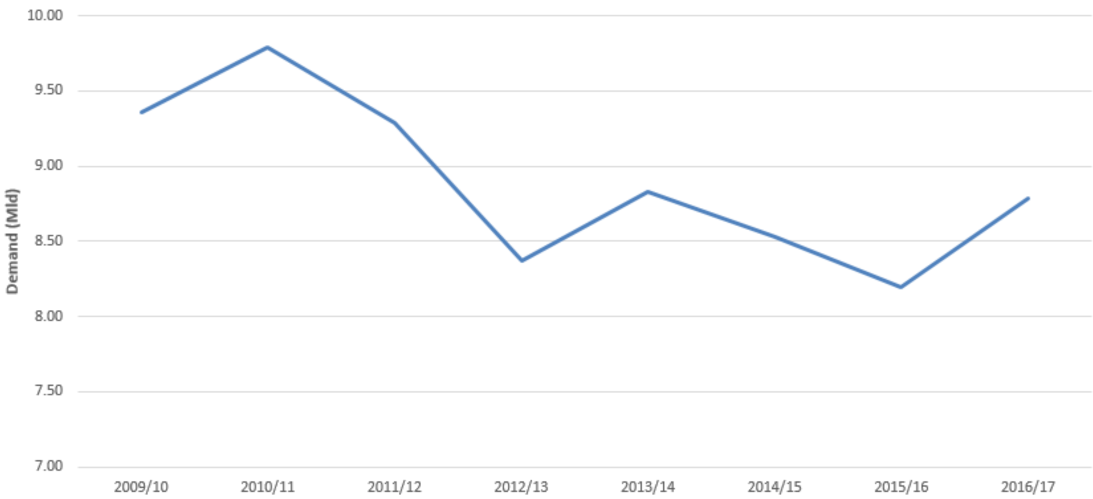


Figure 4.23: Historic small non-household demand

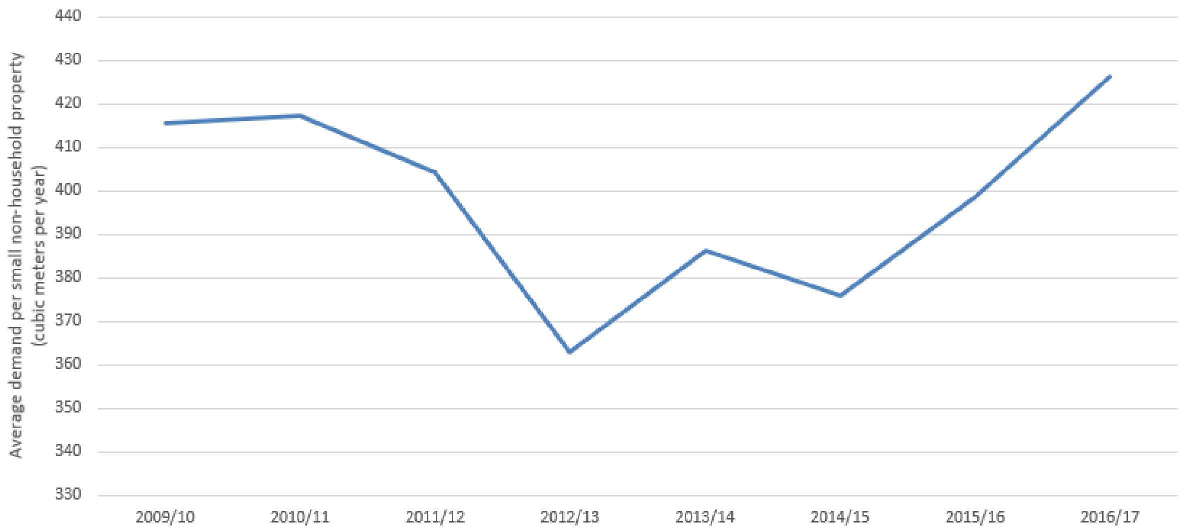


Figure 4.24: Historic small non-household demand average per property

4.8.15 Forecast Demand

Demand in Suffolk is driven primarily by small non-household customers and the food and drink sector. The trends in these sectors will have a significant impact on the overall forecast.

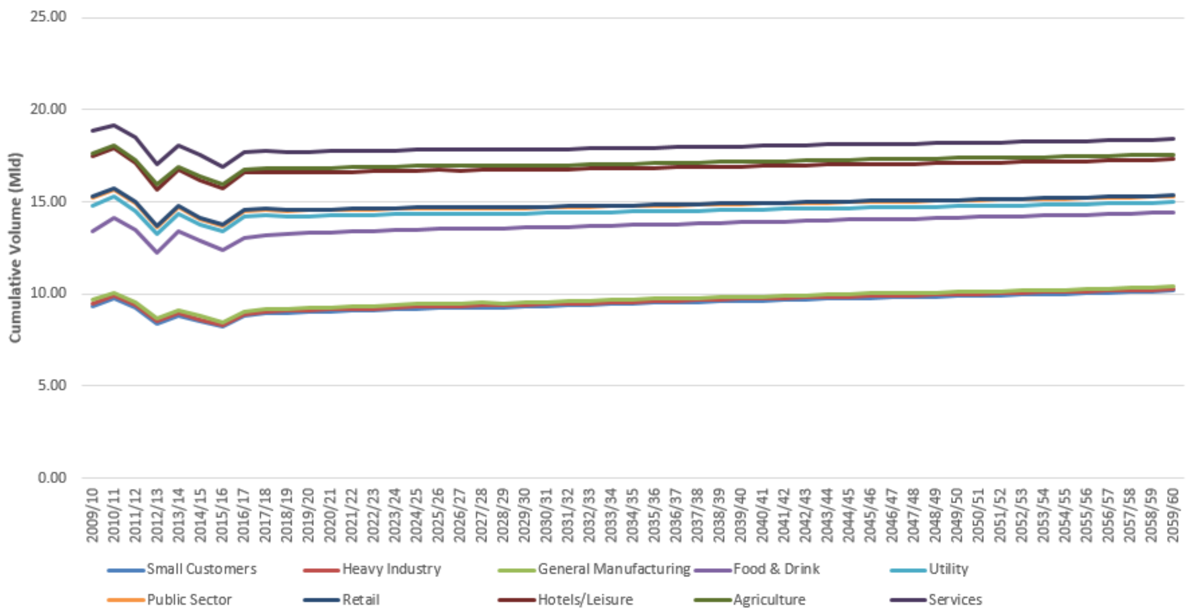


Figure 4.25: Forecast demand in Suffolk by sector – volumes are cumulative, so the gap between each line is the size of each sector.

Overall demand has been reducing slightly since 2009/10, however has flattened somewhat in recent years.

Table 4.37: Change in measured non-household demand in Suffolk by sector between 2016/17 and 2059/60

Sector	Demand (Mld)		Change (Mld)	% Change	Notes
	2016/17	2059/60			
Small customers	8.79	10.17	1.38	15.74%	
Heavy Industrial	0.13	0.10	-0.03	-19.27%	
General Manufacturing	0.12	0.11	-0.01	-3.32%	
Food and Drink	4.03	4.03	0	-0.05%	
Utility	1.11	0.56	-0.55	-50.45%	
Public Sector	0.31	0.31	0	0	
Retail	0.06	0.04	-0.02	-33.09%	
Hotels/Leisure	2.02	1.97	-0.05	-2.43%	
Agriculture	0.19	0.26	0.07	39.07%	
Services	0.93	0.83	-0.10	-10.55%	
Total	17.69	20.38	2.71	15.32%	

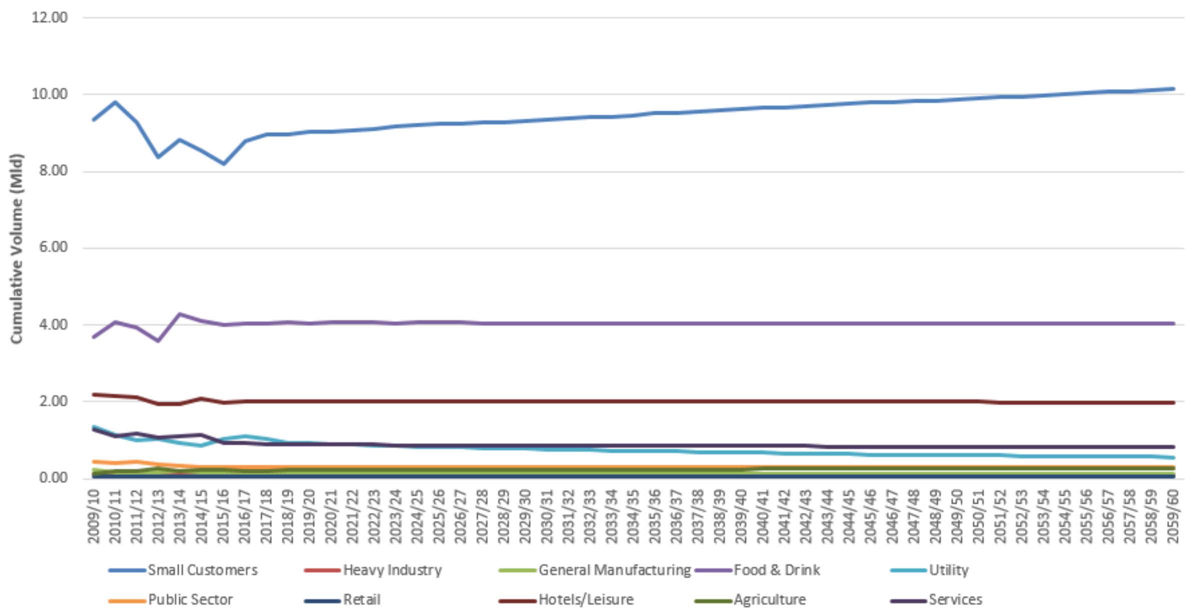


Figure 4.26: Forecast demand in Suffolk – by sector.

4.9 Total Normal Year Baseline Demand Forecasts

The total baseline demand forecast is comprised of the elements described in the preceding sections and the demand management described in section five.

4.10 Defining Dry Year Factors

4.10.1 Introduction

The historic record of weather versus demand has been examined to identify conditions of a dry year and the weighted average number of dry years expected has been calculated for ESW.

4.10.2 Background Information

A dry year definition is required when a company decision is to be made for the June Return submission to Ofwat stating that the weather experienced during the period of the return has been a dry year or not. Simple criteria will be selected based on average maximum temperature and total rainfall for the return year. The supply and demand should be forecast under a dry year scenario reassuring people and organisations that the actions they will take under a dry year scenario will meet their level of service.

Guidelines from the Agency, Ofwat and NERA state that a dry year should be the basis of the demand planning process, however there appears to be no distinct, precise definition of the characteristics of a dry year. This definition is problematic to apply as the introduction of demand restrictions is more commonly linked to water resource availability resulting from weather conditions over a prolonged period, usually a previous year.

A weighted average demand forecast is required as the basis of the companies revenue forecast[27]. In the planning horizon not all years will turn out to be 'dry'. Typically the demand a Company is most likely to be faced with will be a combination of demand from 'normal' years, 'dry' years or 'wet' years[27]. The frequency of each type of year in the planning horizon and the demand associated with these types of years will be reflected in the weighted average forecast.

4.10.3 Objectives

- To review the dry year definitions available.
- To examine the relationship between weather and demand and identify years of specific interest due to unusual weather and demand patterns with the peak summer period (June-September) being examined in greater detail.

[27] Water Resource Planning Guideline, (2012), EA, OFWAT, DEFRA, welsh government.

- To compare rainfall with the 10 year long-term average and maximum temperature compared to the 10 year and 30 year long-term averages for the identified years of specific interest.
- To identify the dry years that have occurred in the Essex and Suffolk supply regions in the past 25 years as determined by the annual number of days greater than 25^{o}c and yearly cumulative rainfall.
- To determine the weighted average number of dry years which may occur in a 10 year period for Essex and Suffolk areas.

4.10.4 Dry Year Definitions

Environment Agency

The Agency states the definition of a dry year (household) is, “a period of low rainfall and unconstrained demand” (Environment Agency, 2013). In the Agency report ‘A scenario approach to demand forecasting’ (Environment Agency, 2001), 1995 is assumed to represent a dry year.

The WRPG states that a water company should analyse historical supply and climate data to set out the dry year demand as a continuous profile over a year at monthly or weekly intervals. The term ‘dry year’ is defined as a period of unconstrained demand and low rainfall.

Ofwat

Ofwat stated in their Business Plan Guidelines (Ofwat, 1998) that, “companies should describe in the commentary of their business plan the relationship between expected demand in a year with normal weather and expected demand in a dry year. Where a company has provided the Environment Agency with a demand and supply forecast based on its critical period (assumed to be peak week unless otherwise stated), they should focus on key milestone planning years e.g. 2002-2003 and 2007-2008.” (Part D, D8, Business Plan Guidelines)

NERA

NERA (UKWIR/Environment Agency, 2002) states, “there is no universally accepted standard specifying the increase and decreases in demand associated with dry and wet conditions. In the absence of a standard, forecasts of weather related variations in demand should have an empirical justification, for example, they might be based on an historical analysis of demand and relevant weather variables, or demand given weather conditions that occur ‘1 in x’ years.”

The WRPG states, “the characterisation of supply e.g. during a wet/dry/normal year, is a simplification of reality. The distribution of supply is not necessarily such that a dry year implies the lowest DO. Instead, there could be effects that carry over from one year to a next, so that DO in a normal year could be low as a result of the preceding year being dry, or it could be reduced in an extremely wet year due to turbidity disabling sources.”

NERA (UKWIR/Environment Agency, 2002) also states, "Any given year could be categorised as wet, normal or dry, although there is an infinite number of possibilities ranging from the very wettest to the very driest years possible. For any given 'type' of year, say a dry year, there is a distribution of possible yields around the expected value. Thus, it would be possible to say that dry year yield is 120Ml/d with 95% confidence, but only 110Ml/d with 98% confidence, for example. Furthermore, for each 'type' of year, normal, wet or dry, there is a distribution of possible demand outcomes around the expected value, with this distribution driven by stochastic processes. In addition, over a number of years climate change will also influence demand."

Stage 1 of the NERA guidelines suggests that, "planners collect supply and demand detail for a range of weather conditions and for a number of critical periods. Critical periods are when there is the greatest stress on the ability of the water supply system to meet demands. Critical periods may be driven by peaks in demand, by troughs in DO, or by a combination of the two."

Temporary Restrictions on Water Consumption

As the definitions above state, dry years should be based on a year of unconstrained demand, therefore years with periods of temporary restrictions on use or 'temporary use bans' need to be noted.

A temporary use ban was brought into operation in Essex at midnight on 12th June 1997 after a long period of exceptionally dry weather, which started in April 1995. By February 1997 the previous 21 months had been the driest of the 20th century with combined storage at Hanningfield and Abberton reservoirs only 55% compared to the previous year's figure of 70.3%. In addition many pipes burst as a result of the ground thawing and freezing at the beginning of the year resulting in a large increase in demand. The freezing weather also caused problems with the transfer of water into the reservoirs so that valuable recharge time was lost.

In the years 2006 and 2012 temporary restrictions on water use did occur in the majority of the water supply companies surrounding ESW. Although ESW did not impose a temporary restriction on water use, the effect of the drought message was seen to decrease demand across the Company's supply area as well.

4.10.5 Methodology and limitations

Weather data was obtained from the MET Office Writtle College weather station in Essex, Lowestoft weather station in Suffolk and Lingwood weather station in Norfolk. The use of different sources of information over the years would be the main limitation due to the lack of consistency. It must be assumed that these measurements are representative of the region as a whole although there will be small regional differences.

Demand information, in the form of daily distribution input for both Essex and Suffolk supply areas was obtained from MIPS archived data, [Management Information Presentation System] and imported into spreadsheets for analysis.

The period of analysis chosen was 1987-2016. This period would be affected by changes in conditions that have occurred over the last 10 years, such as increases in metering and improved leakage controls and provides an analysis period of 25 years. Key years of interest that comprise of dry year conditions were identified from analysis of weather data. The summaries of weather data for these years of specific interest were collated and a number of graphs were prepared as a basis for identifying patterns in demand and weather.

Specific Years of Interest

The weather and demand data for the period 1987-2016 was carefully studied and a number of years identified for further comparisons. The weather summaries for these years are shown below as taken from the Met Office. Figure 4.27: A comparison of daily total demand (black), daily maximum temperature (red) and daily total rainfall (blue) from 1987 until 2016 for the Essex supply area. Figure 4.27 and Figure 4.28 compare the daily total demand, maximum temperature and rainfall totals for the years 1995-2016.

Weather Summaries

1990: A very warm and dry year. Rainfall totals from the period since early March being one third of the average. The first four days in August saw a degree of high temperatures that exceeded any other hot spell in the 20th Century with 3rd August seeing the hottest temperatures on record.

1995: The hottest summer since 1976, one of the warmest years on record and one of the driest years since 1976.

1996: The driest year on record since records began in 1943. Rainfall deficit was 31.7% of the 1958-87 average and 32.4% of the 1987-2012 average.

2003: Very warm year with a mean air temperature of 10.7^{o}C, 0.7^{o}C above the 1971-2000 average for Writtle weather station. The mean maximum air temperature was 15.6^{o}C, 0.63^{o}C above the 1995-2012 average. August saw the highest maximum temperature of 35.7^{o}C of 1995-2012 records.

2005: Warm and very dry year. This year was at the midpoint of the dry-year spell of 2004-06 where from November 2004 to July 2006, 17 of the 21 months showed below-average rainfall for the Essex and Suffolk regions.

2006: A warm and dry year with July 2006 as the warmest month on record and 10% less rainfall than the 30 year mean.

2010: The driest year since 2003. The period between January and June was particularly dry generally the driest period since 1953. However rainfall deficits were reduced by a very wet August in the south and east of England.

2011: A very warm April and October with record temperatures widely exceeding 25^{o}C during the heat wave in October. Much of eastern and southern England had a persistent rainfall deficiency causing concerns for water resources, agriculture and the environment.

2012: A year of 'dramatic contrast' as described by the Met Office. The first three months were warm and dry but were then followed by an exceptionally wet period from April lasting most of the summer. The UK annual rainfall total was 116% of average, the second highest in the series from 1910, narrowly beaten by 2000.

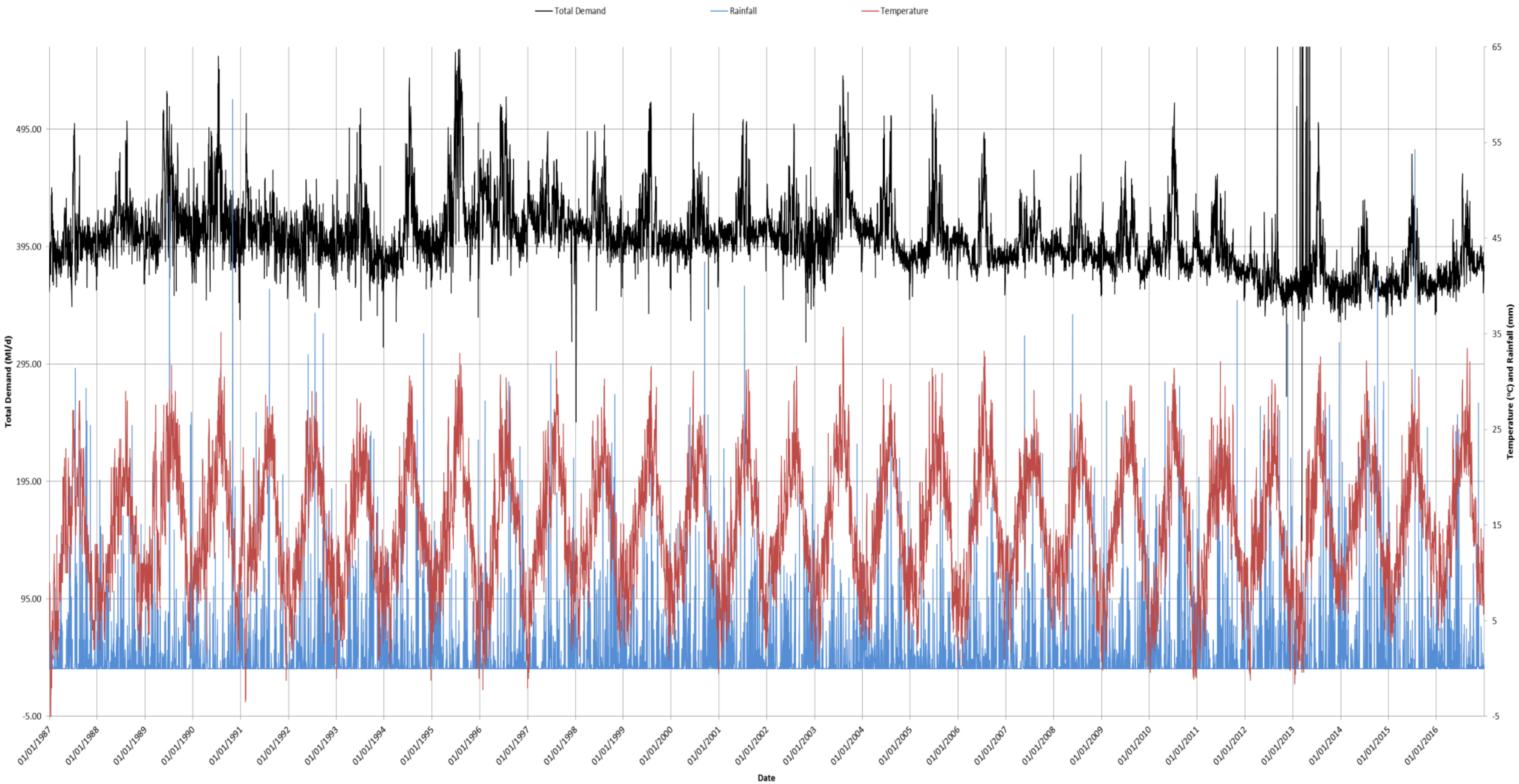


Figure 4.27: A comparison of daily total demand (black), daily maximum temperature (red) and daily total rainfall (blue) from 1987 until 2016 for the Essex supply area.

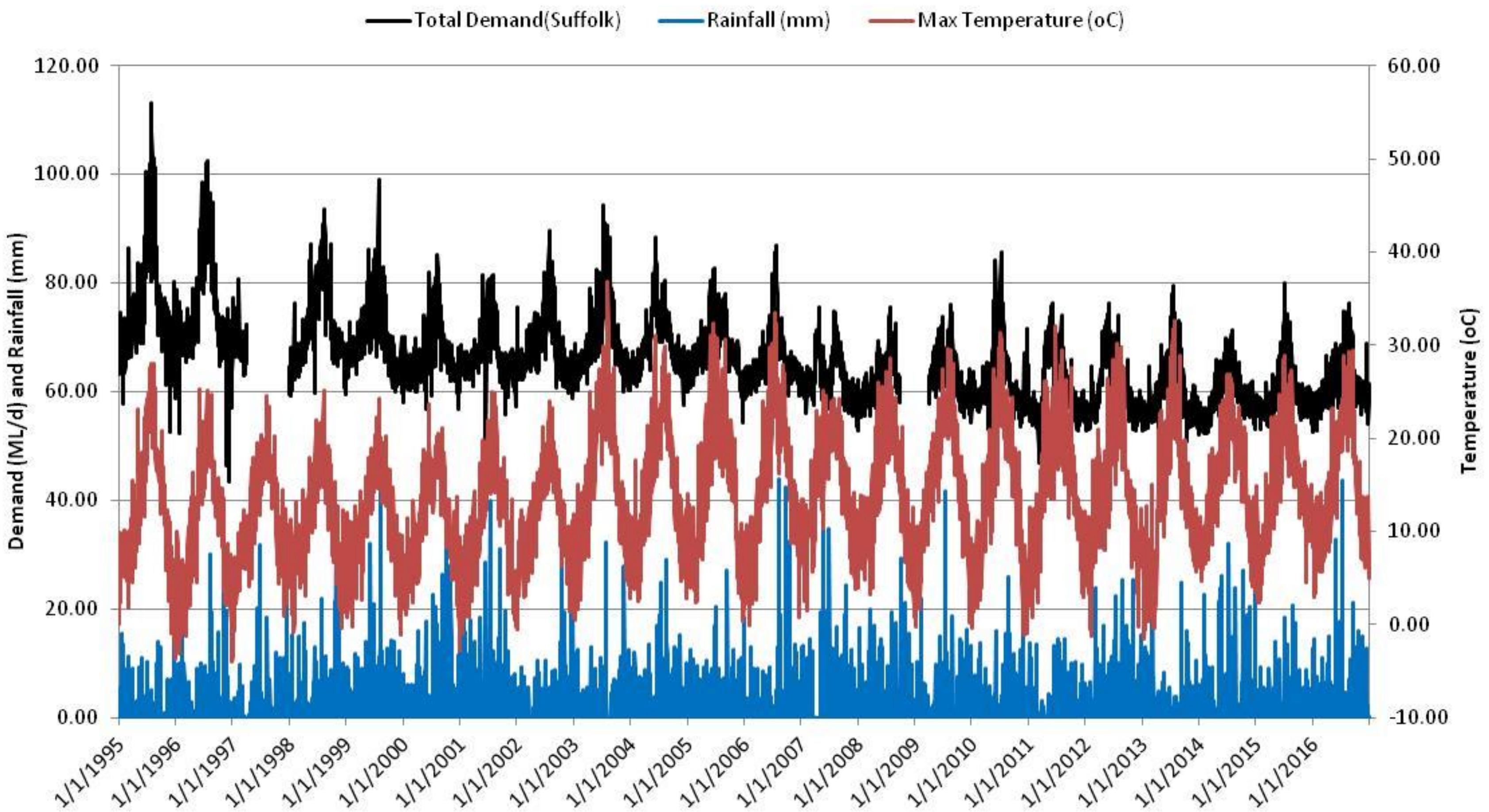


Figure 4.28: A comparison of daily total demand (black), daily maximum temperature (red) and daily total rainfall (blue) from 1995 until 2016 for the Suffolk supply area.

Figure 4.29 to Figure 4.40 summarise the relationships between demand and weather for three of the key specific years of interest.

<u>1990:</u>

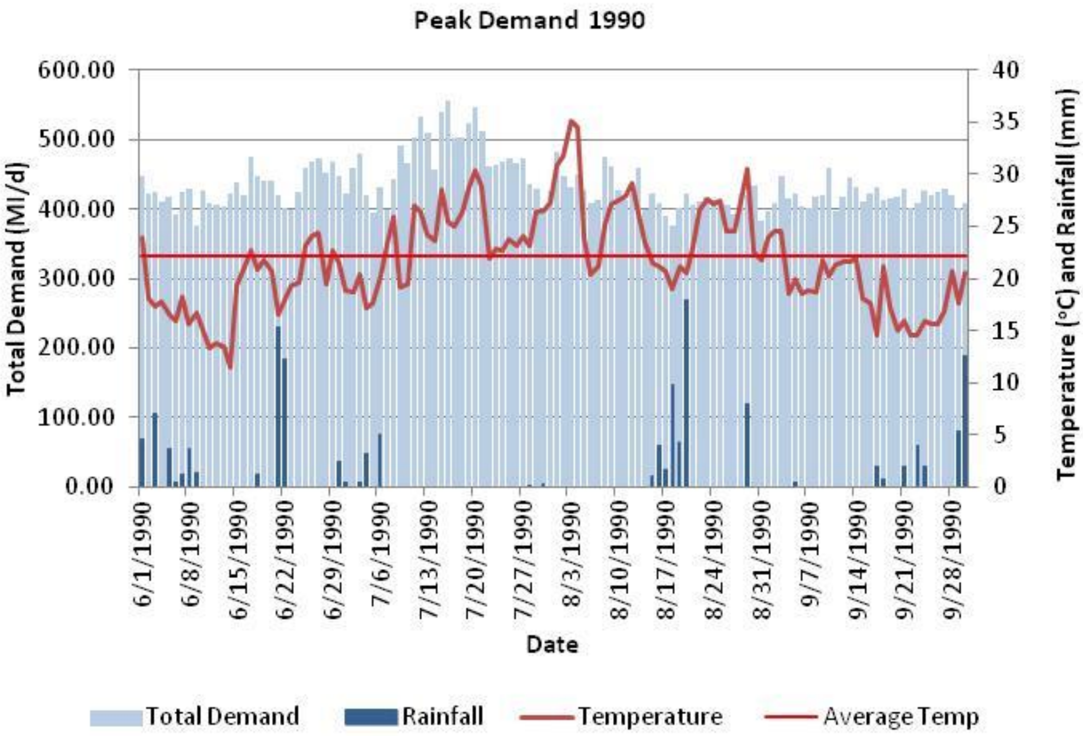


Figure 4.29: Peak period demand compared to maximum daily temperature and total daily rainfall for 1990.

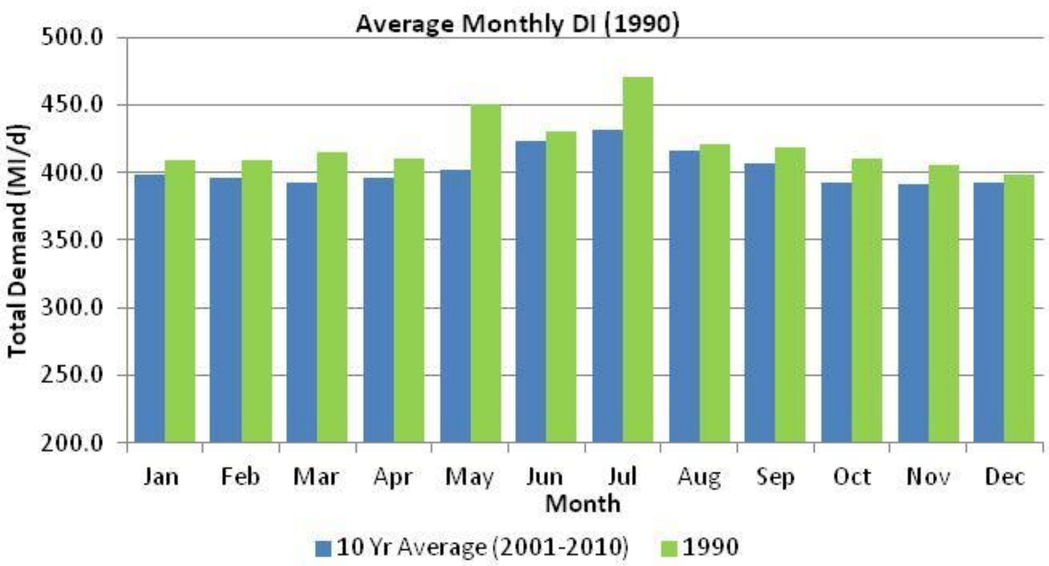


Figure 4.30: 1990 total demand compared to 10 year average total demand, clearly showing that the demand in 1990 is above average demand, particularly in the months of May and July.

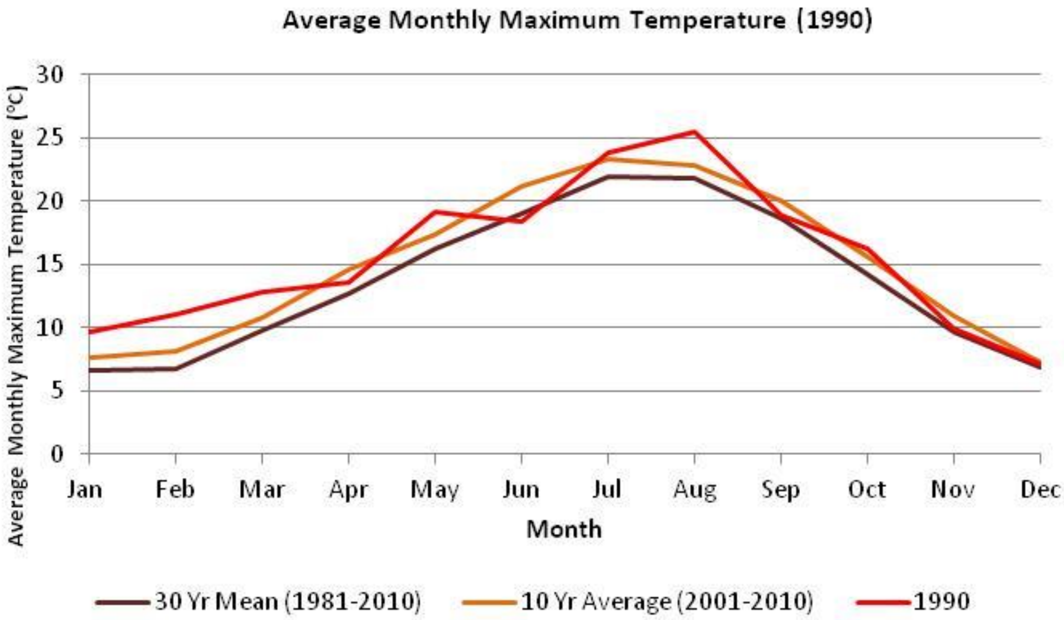


Figure 4.31: The average monthly temperature for 1990 compared to the 30 year and 10 year means. It shows 1990 temperature was higher than average for the majority of the year, particularly at the beginning of the year and the months of July and August.

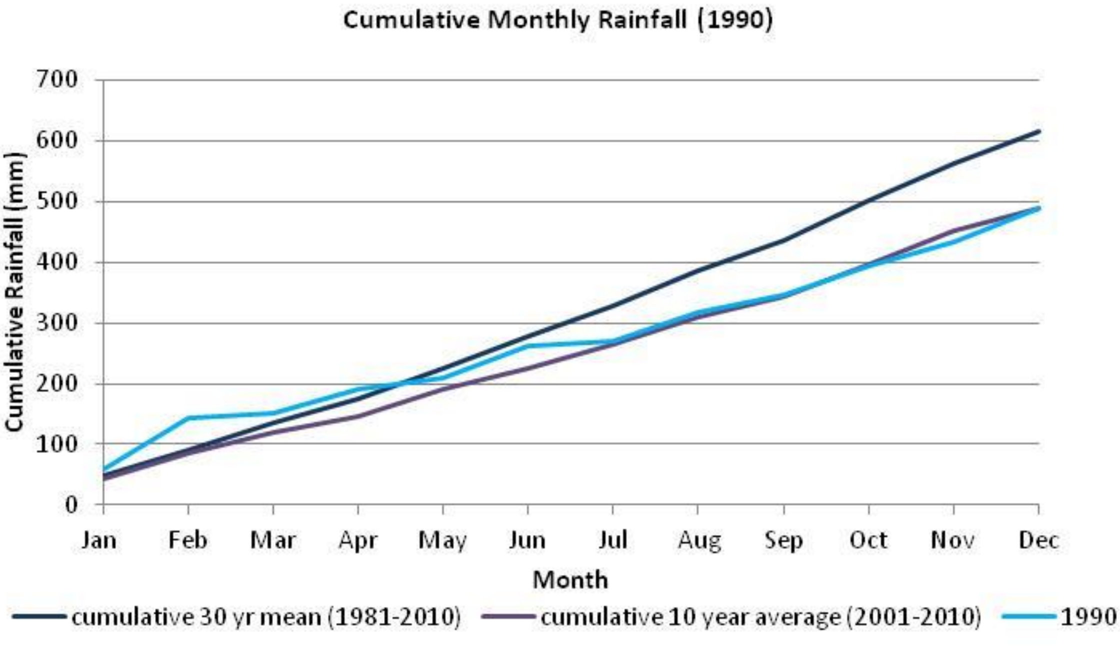


Figure 4.32: The cumulative monthly rainfall for 1990 compared to the 30 year and 10 year means. The graph demonstrates that 1990's monthly rainfall is slightly greater than or nearly equal to the 10 year mean.

1995:

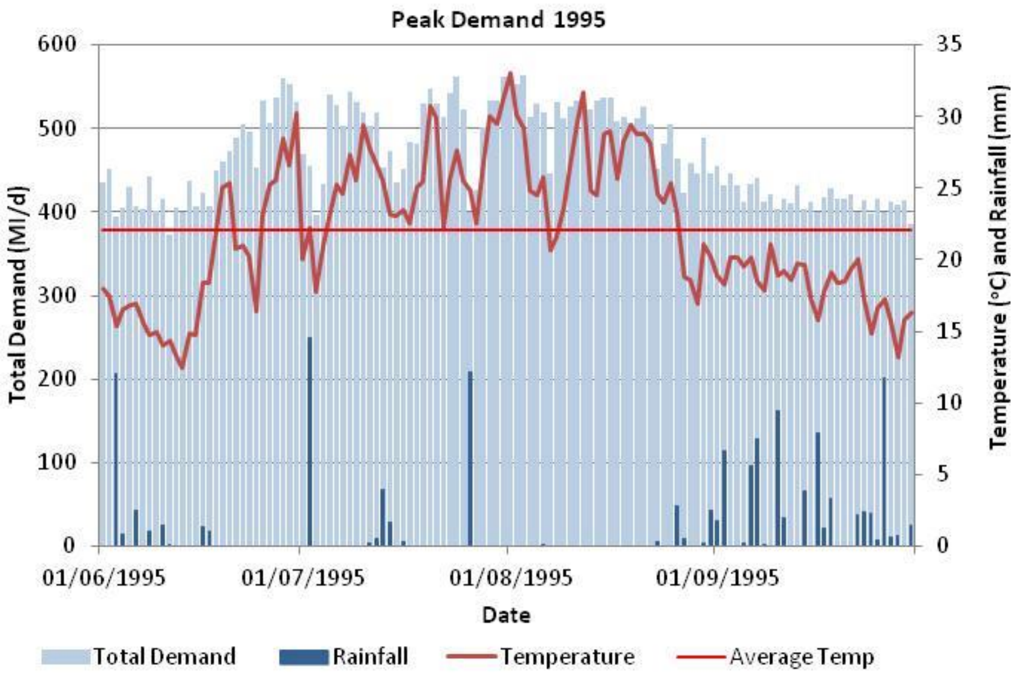


Figure 4.33: Peak period demand compared to maximum daily temperature and total daily rainfall for 1995.

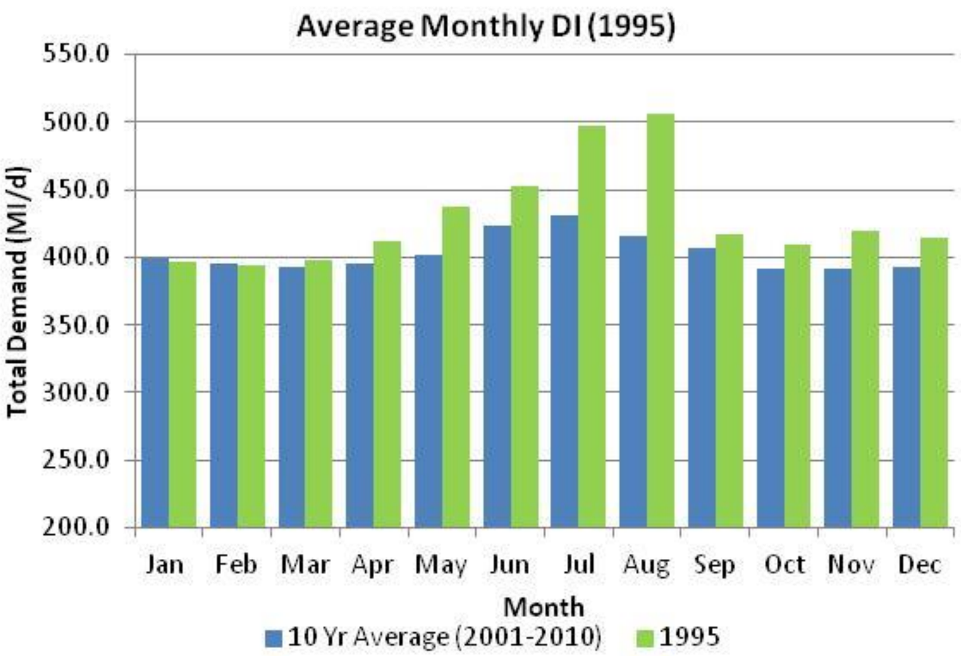


Figure 4.34: 1995 total demand compared to 10 yr average total demand, clearly showing that the demand in 1995 is above average for all months ESW has total demand data for.

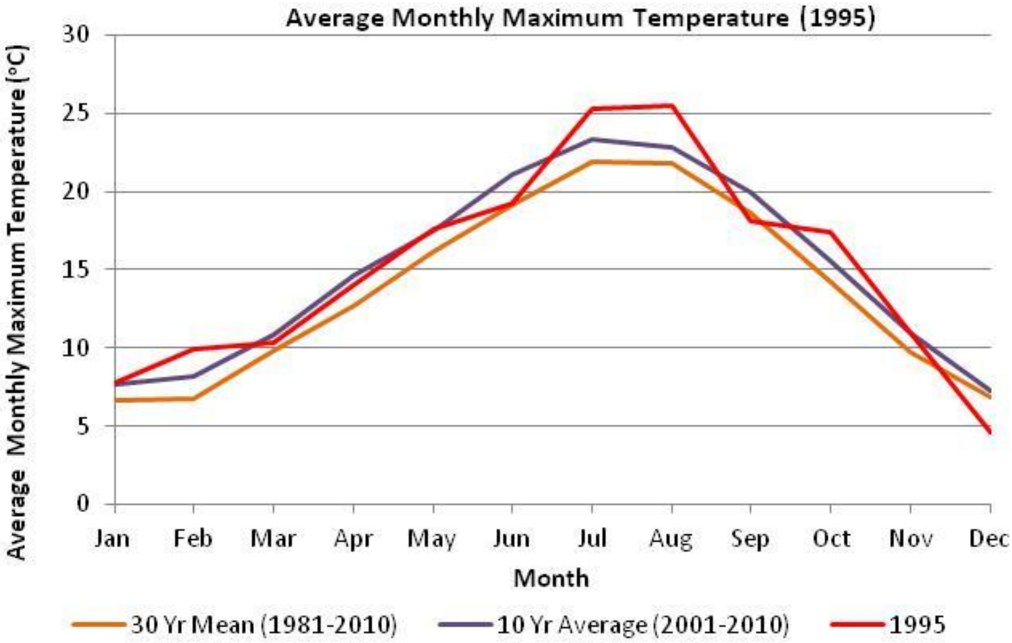


Figure 4.35: The average monthly temperature for 1995 compared to the 30 year and 10 year means. It shows 1995 temperatures where higher than average for the summer peak period.

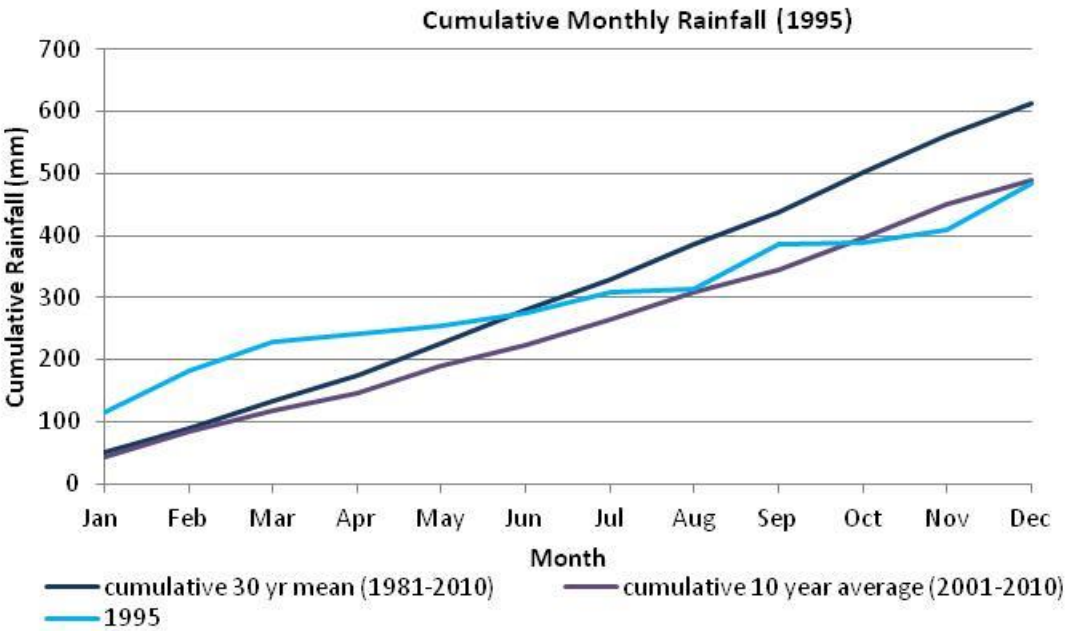


Figure 4.36: The cumulative monthly rainfall for 1995 compared to the 30 year and 10 year means. The graph demonstrates that the rainfall for 1995 is greater than the mean at the beginning of the year and close to the average monthly rainfall for the remainder of the year.

2006:

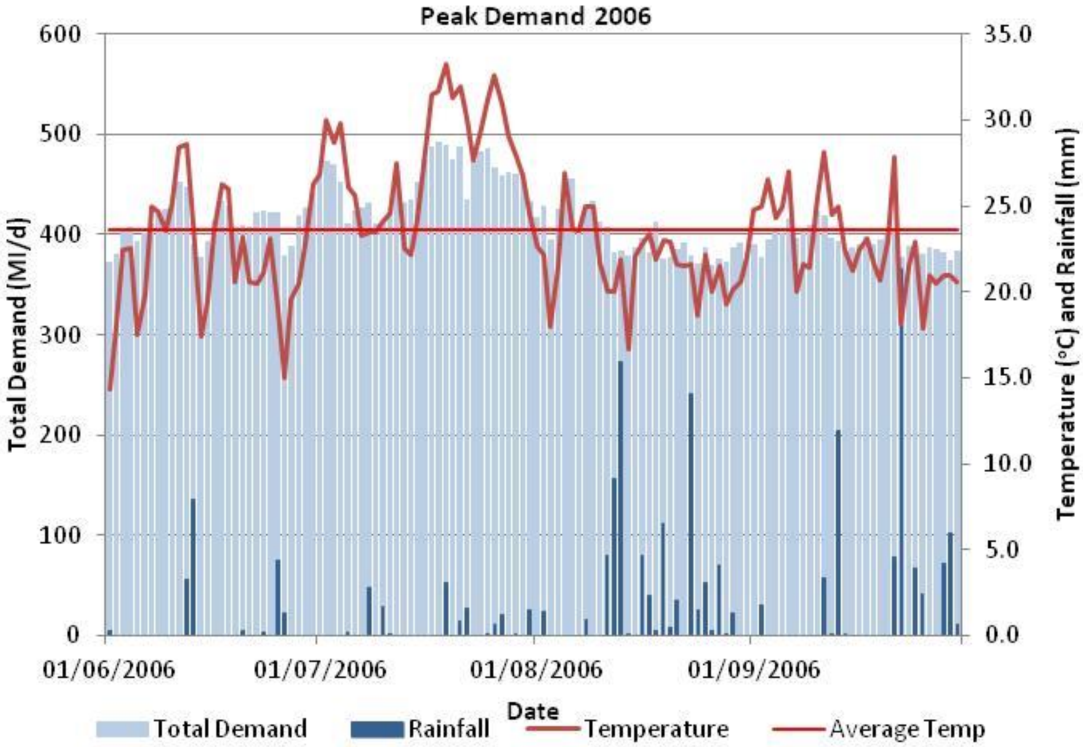


Figure 4.37: Peak period demand compared to maximum daily temperature and total daily rainfall for 2006.

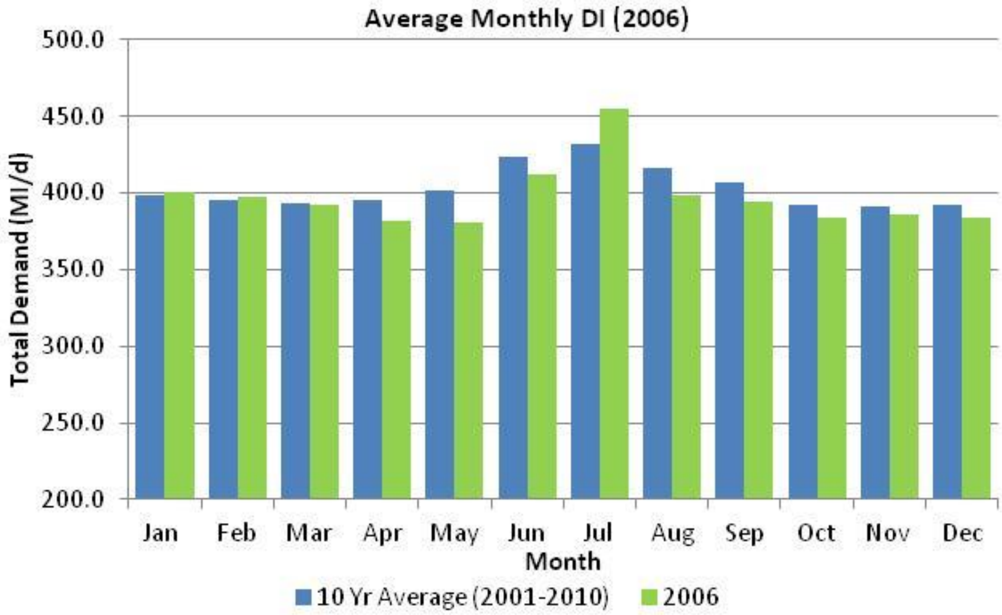


Figure 4.38: 2006 total demand compared to the 10 year average whereby 2006 demand tends to be slightly lower than the 10 year average demand apart from the month of July where demand is much higher.

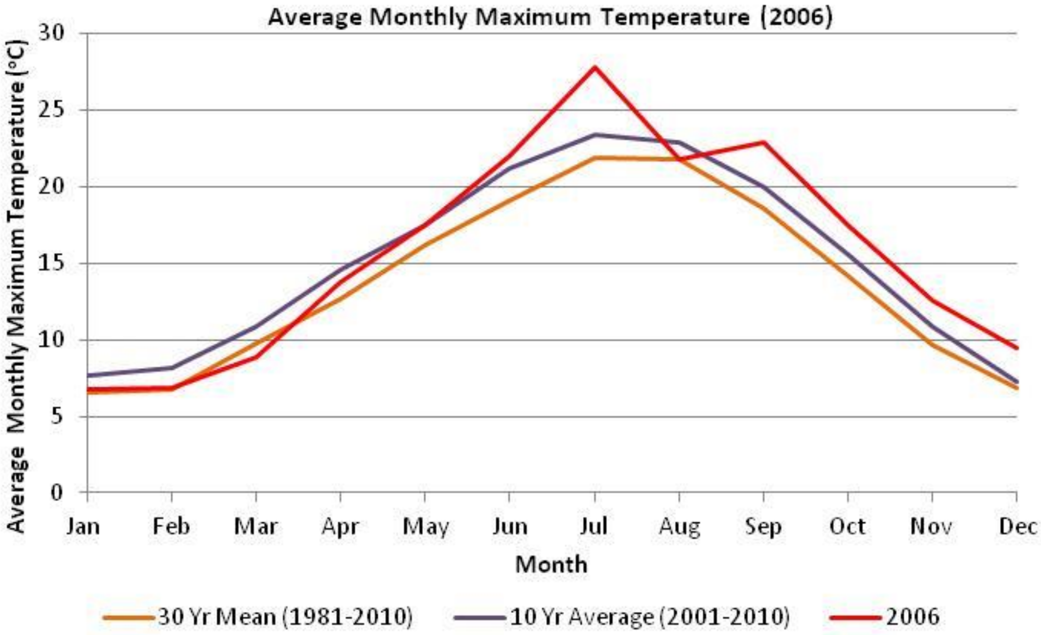


Figure 4.39: The average monthly temperature for 2006 compared to the 30 year and 10 year means. Average monthly temperature increases considerably in the months of June and July and stays above the 30 year mean for the rest of the year.

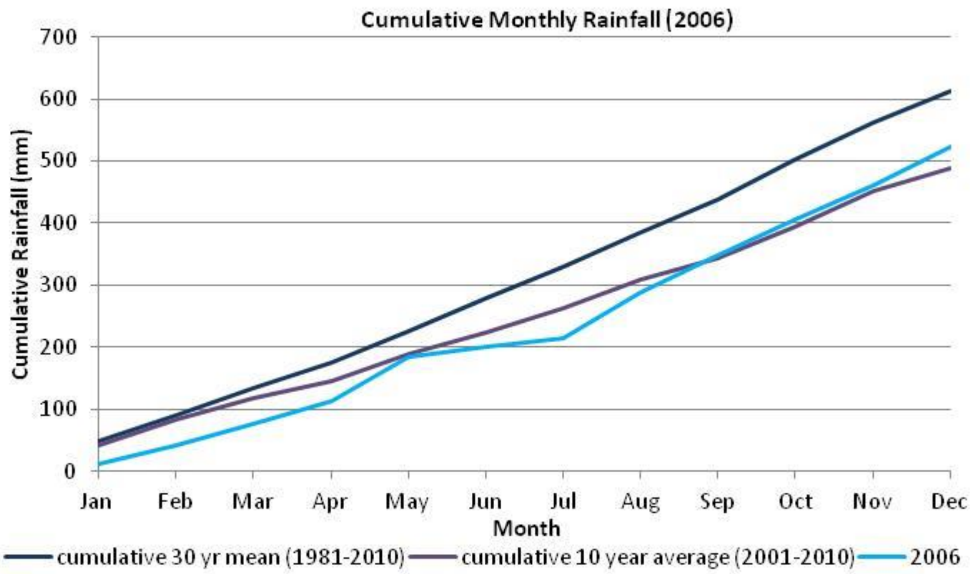


Figure 4.40: The cumulative monthly rainfall for 2006 compared to the 30 year and 10 year means. For eight months of the year cumulative rainfall stays below both 30 year and 10 year means.

Storage Levels for Specific Years of Interest:

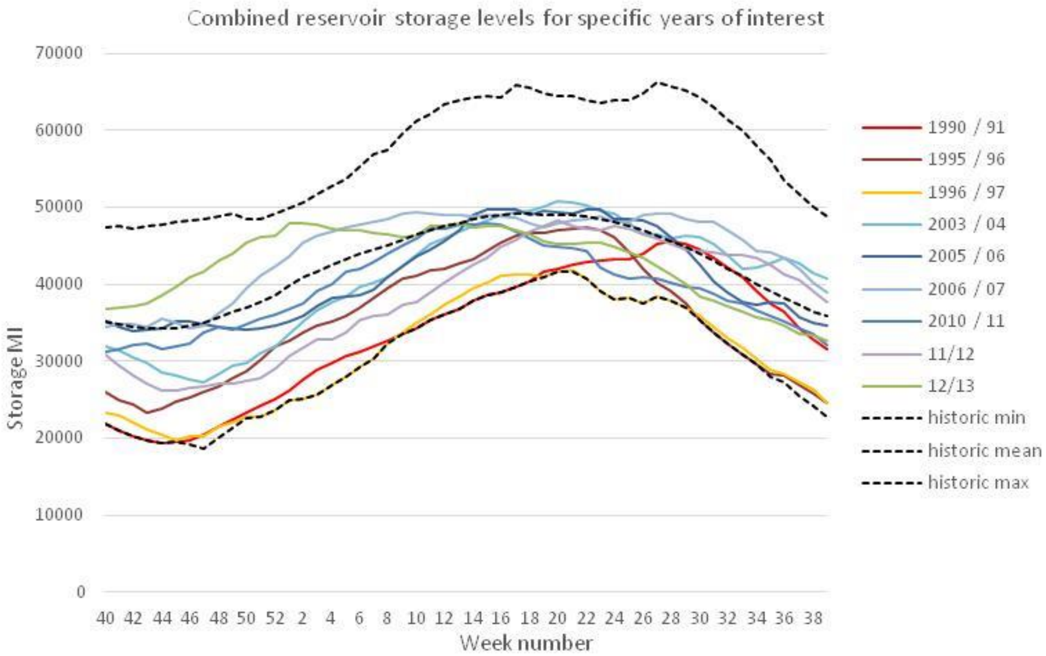


Figure 4.41: Hanningfield and Abberton combined storage levels for the specific years of interest. The years of 1990, 1995 and 1996 hit the historic minimum storage levels.

4.10.6 Data Results

By undertaking analysis of the patterns in weather and demand data for the specific years of interest in Essex and Suffolk, the following summary of the results for each of these years are given.

1990: Record temperatures at the beginning of August demonstrate 1990 as a very warm year with temperatures for the majority of the year higher than the 30 year average (1981-2010). Cumulative monthly rainfall was close to the 10 year mean (2001-2010) for this year but less than the 30 year mean. Abberton and Hanningfield combined reservoir storage levels were below historic average for most of 1990, with storage at times hitting the historic minimum level. Average DI was above the 10 year mean for all months in 1990 with the months of May and July being significantly higher than the mean.

1995: In 1995 a sustained high demand was experienced over the summer period, much greater than the 10 year average (2001-2010) for the same period. 1995 total demand was larger than the 10 year average for 10 months in the year. Average total demand over the summer peak period was 468.9Ml/d and weekend peaks rose to an average 530Ml/d with the top demand at 563.1Ml/d. Low rainfall and high temperatures over the summer peak period greatly influenced this high demand. Summer temperatures were on average 1.7^{o}C higher than the 30 year mean (1981-2010) and cumulative rainfall for 1995 was 130mm less than the 30 year cumulative average. In 1995 Hanningfield reservoir storage levels were low and below the historic mean for the entire year. Across the country 1995 was classed as one of the warmest and driest years since 1976.

1996: Combined storage levels from Abberton and Hanningfield reservoirs hit the historic minimum storage level for most of 1996. Cumulative rainfall was 138mm lower than the 30 year cumulative mean (1981-2010). Out of the eight specific years of interest, 1996 is classed as the second driest. Total demand in 1996 was above average for all months in the year and much higher at the start of the year and during the summer peak period. Temperatures for this year were close to the 10 and 30 year means.

2003: The rainfall for the period April to July closely followed the long-term average, with the annual cumulative rainfall measured at 479.3mm. High summer temperatures were only experienced for a short period of time, where August saw the maximum temperature of 35.7°C. The high demand of 1995 did not occur to the same extent in 2003, with a slightly higher total demand seen only for the second half of the year. Combined reservoir storage levels over the summer period were greater than the historic mean and at one time reach the historic maximum level.

2005: This year was at the mid-point of the dry-year spell of 2004-06 where from November 2004 to July 2006, 85% of the 21 months showed below-average rainfall for the Essex and Suffolk regions. Temperature in 2005 was 1.54°C greater than the 30 year average for the year. It was the driest year out of all the specific years of interest, with a cumulative rainfall of 427.2mm, 187mm less than the 30 year cumulative rainfall average. Total demand for 2005 is shown to match closely with the 10 year average demand with a slightly higher demand in June for this year and combined reservoir storage levels for 2005 matched closely to the historic mean.

2006: July 2006 was the warmest month on record with the average maximum temperature reaching 27.5°C for the month, 5.9°C higher than the 30 year mean (1981-2010). Total rainfall for the month was 13.9mm, 27% of the 30 year mean. Average total demand peaked this month for the year and was 5% higher than the 10 year average (2001-2010). However the rest of the peak demand period saw an average total demand that was less than the 10 year average. Combined reservoir storage levels for the most part of the year remained higher than the historic mean and for 6 weeks of the year are aligned with the historic maximum storage levels.

2010: The period between January and July was particularly dry and cumulated in a high average maximum temperature of 25.1°C, high demand and low total rainfall in July. However rainfall deficits were reduced by a very wet August and combined storage levels remain close to the historic mean.

2011: A persistent rainfall deficiency occurred across much of eastern and southern England this year creating concern for water resources. In Essex, April and October saw very low total rainfall in 2011. April’s total rainfall was just 2mm, 5% of the 30 year average total rainfall for this month and October’s total rainfall was ¼ of the 30 year average. Temperatures were also above the mean in the spring and autumn with the average maximum temperature in April 49% higher than the 30 year mean. 2011 total demand was below average for most of the year with the exception of May which was 4% higher than the 10 year average for that month. Combined reservoir storage levels were below the historic mean at the beginning of the year with the remainder of the year lying close to the historic mean.

2012: After the first three months of warm and dry weather it was followed by a period of exceptionally wet weather lasting through the summer. 2012 has been included because of the temporary use bans that occurred neighbouring water companies at the beginning of the year but as the year progressed it became one of the wettest years with rainfall total at 116% of average. Combined reservoir storage levels lay close to or above the mean for this year.

4.10.7 Data Analysis

In developing a dry year definition it is important that the approach should combine the summer demands with the all year round weather conditions. A simple approach was decided upon where the number of days in a year where the temperature rose above 25ºC was compared to the cumulative rainfall for that year.

Table 4.38: The number of days greater than 25oC and the annual cumulative rainfall for the years 1987-2016 in Essex and Suffolk.

Graphic representation of this data shows that the position of the year in a specific quadrant defines the year as either a wet, normal or dry year. Please refer to Figure 4.42 and Figure 4.43. The quadrants for the graph were drawn where the number of days greater than 25ºC equalled 30, as this would loosely represent one month, and secondly that cumulative rainfall equalled 635mm, as rainfall less than 635mm would be classified by Met Office Writtle Weather Station as on the dry side of the average year in Essex. Thus the ‘dry’ quadrant would be where the number of days greater than 25ºC exceeded 30 and the cumulative rainfall was below 635mm and years placed within this quadrant would be defined as ‘dry years’.

The results from this graphic representation approach show that three years defined as dry years In Essex (1990, 1995 and 2006) and one year (1995) in Suffolk.

Table 4.38: The number of days greater than 25ºC and the annual cumulative rainfall for the years 1987-2016 in Essex and Suffolk.

Essex			Suffolk		
Year	No. of days > 25oC	Cumulative Rainfall Jan-Dec (mm)	Year	No. of days > 25oC	Total Rainfall Jan-Dec (mm)
(1976)	45	470			
1987	7	837.8	1987	6	646.6
1988	5	739.3	1988	3	572.8
1989	29	609.6	1989	26	455.6
1990	31	498.01	1990	25	564.3
1991	17	496.2	1991	10	385.4
1992	18	661.9	1992	10	637.1
1993	9	646	1993	3	780.8
1994	17	626.13	1994	17	561.7
1995	41	484	1995	38	540.2
1996	18	396.6	1996	15	497.5
1997	26	488.25	1997	21	522.5
1998	11	658.16	1998	9	716.1
1999	23	562.7	1999	14	671.5
2000	8	743.4	2000	4	721.4
2001	18	804.6	2001	11	797.1
2002	14	715.6	2002	13	509.4
2003	26	464.8	2003	16	548.6
2004	19	626.6	2004	12	693.8
2005	26	427.2	2005	15	624.4
2006	34	523.7	2006	27	681.8
2007	4	563	2007	2	732.9
2008	13	566.9	2008	6	707.8
2009	14	611.8	2009	11	581.2
2010	27	534.7	2010	18	683.6
2011	17	527.5	2011	11	445
2012	15	950.9	2012	12	778.5
2013	28	674.3	2013	22	541.7
2014	26	797	2014	8	808.7
2015	23	538.9	2015	12	516.7
2016	27	534.2	2016	17	456

As a comparison, data for the year 1976 is shown for Essex as this is a recognised year of severe drought in the UK. Highlighted values in red show those rainfall and temperature values that are above the thresholds for dry year (>30 days above 25ºC and <635mm rainfall). Dry years are highlighted in yellow.

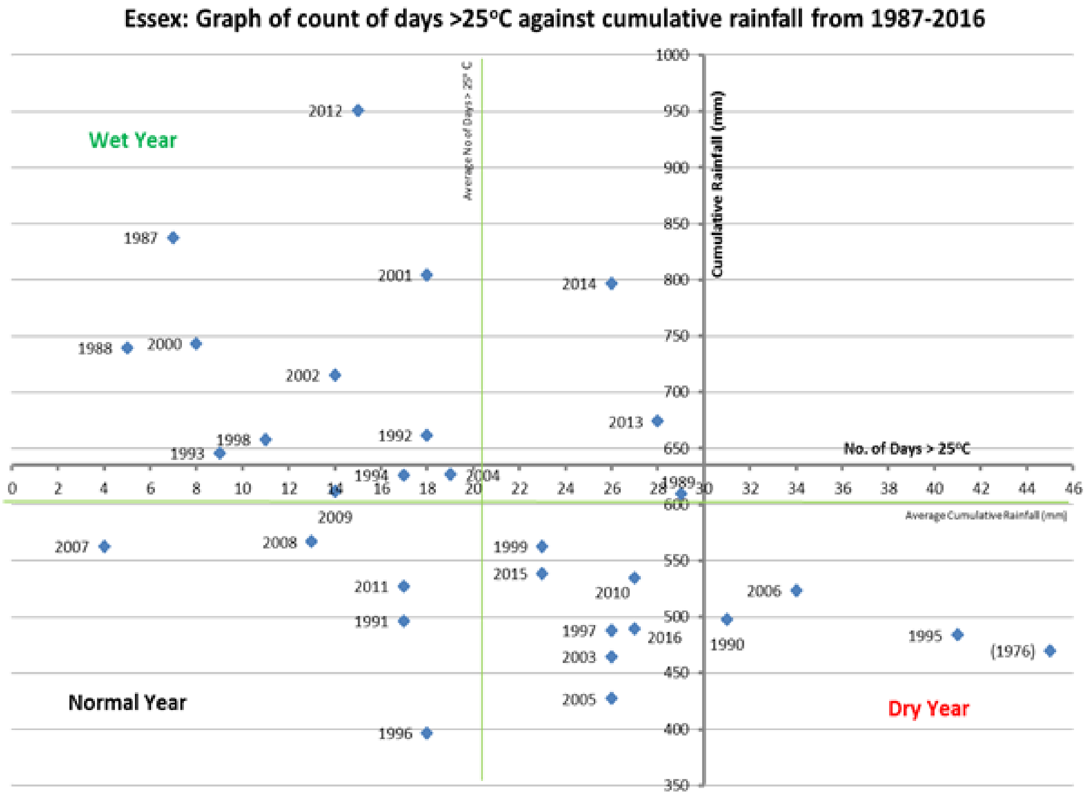


Figure 4.42: The annual number of days greater than 25°C and the annual cumulative rainfall for the years 1987-2016 in the Essex region.

The green lines indicate the average temperature and cumulative rainfall for the period 1987-2016 in Essex. The axes indicate the split in quadrants which are named either ‘wet’, ‘normal’ or ‘dry’ according to the likely conditions experienced. The graph shows that the years 1976, 1990, 1995 and 2006 are classed as dry years under this approach.

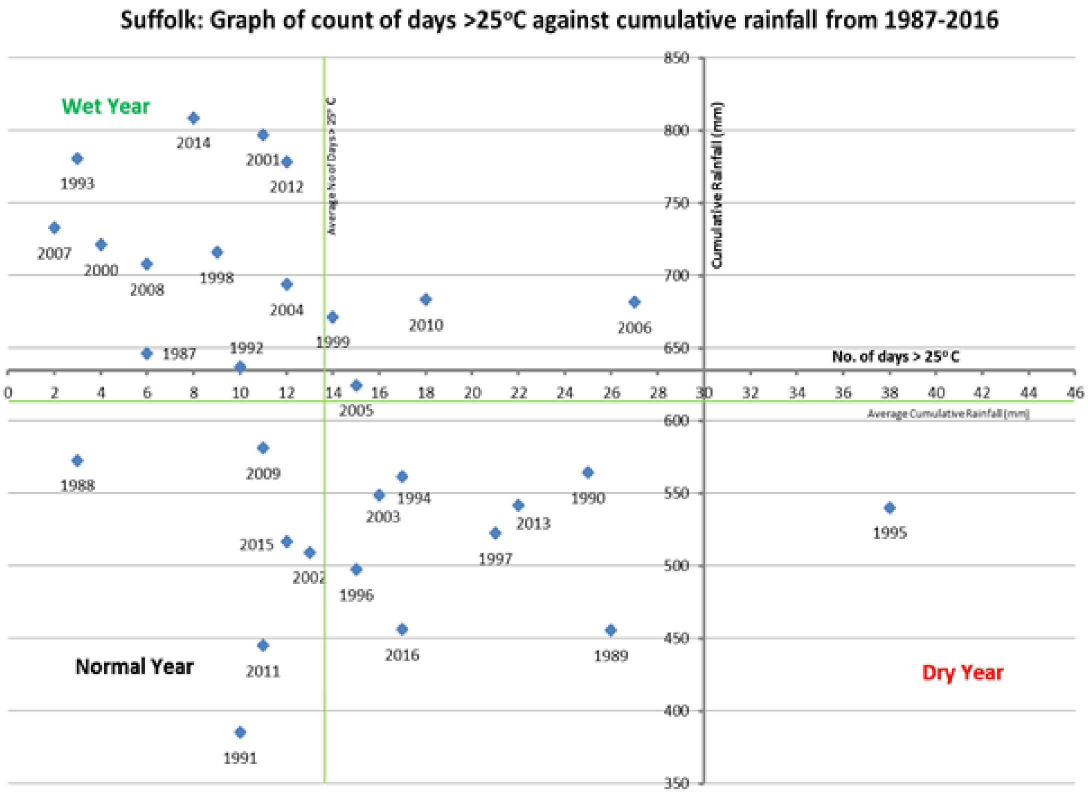


Figure 4.43: The annual number of days greater than 25°C and the annual cumulative rainfall for the years 1987-2016 in the Suffolk region.

The green lines indicate the average temperature and cumulative rainfall for the period 1987-2016 in Suffolk. The axes indicate the split of quadrants which are named either ‘wet’, ‘normal’ or ‘dry’ according to the likely conditions experienced. The graph shows that the year 1995 is classed as a dry year under this approach.

4.10.8 Summary

Various statistical analyses are available to apply to weather data to clearly define the weather conditions for a particular year or seasons of that year but there seems to be no universally accepted method to employ.

The decision to take into account the two variables of cumulative rainfall and number of days with maximum temperatures greater than 25°C offers a very simplistic but effective approach for the definition of a dry year.

4.11 Dry Year Baseline Forecasts

The increases (from normal year to dry year) assumed for a dry year were applied to unmeasured and measured per capita consumptions, plus an increase for non-household consumption and leakage. These increases were reviewed in 2008 and it is now considered that only household demand is likely to increase in a dry year.

The household increases were based on analysis of the demands in 1995/96 and were modified for PR19 to take account of the changes to the base demands arising from metering.

The previous additional PCC has been applied to the 2006/7 populations to provide an estimate of the 1995/96 based dry year forecast for 2006/7. This methodology is still used for PR19 as there have been no further dry years since 2006/7. It is expected that as metering has increased, the current and future dry year impact on unmeasured households will have increased and the impact on measured households will have decreased. This is because the measured households are increasingly composed on meter optants, who are low users of water and selectively metered customers who will be seeking to restrain their bills. The remaining unmeasured households will have a strong element of customers who have deliberately chosen not to opt for a meter, and are high users.

The increases have been calculated as follows:

- Previous increase in measured PCC x 2006/7 measured population = 95/96 based additional dry year measured consumption for 2006/7
- Previous increase in unmeasured PCC x 2006/7 unmeasured population = 95/96 based additional dry year unmeasured consumption for 2006/7
- Sum the above to give total 95/96 based additional dry year consumption for 2006/7.
- Unmeasured population x revised PCC increase = 2006/7 rebased Dry Year unmeasured consumption
- 2006/7 rebased dry year unmeasured consumption - Total 95/96 based additional dry year consumption for 2006/7, divided by measured population gives 2006/7 rebased dry year measured consumption

The increases are as follows:

Table 4.39: Increases in PCC

	Unmeasured PCC l/hd/d	Measured PCC l/hd/d
Essex	7.3	1.26
Suffolk	2.1	0.84

5.0 BASELINE WATER EFFICIENCY, METERING & LEAKAGE CONTROL

5.1 Water Efficiency

5.1.1 Water Efficiency Overview

Water efficiency has remained a key strand of ESW's demand management undertakings throughout AMP6. Having initiated the first water efficiency retrofit programme in 1997, ESW is able to demonstrate the successful delivery of industry-leading projects, schemes and initiatives spanning over twenty years. These activities have resulted in quantifiable water savings, unrivalled customer experiences and a significant contribution to the water efficiency evidence base.

The strategy has, and continues to be, designed to create water efficiency programmes that make genuine savings in water as cost effectively as possible. A critical part of the programme is the monitoring of results to find out what the actual savings in water are and how sustainable they are, and customer surveys to gauge the effectiveness of the approach. Whilst this benefits ESW's water efficiency planning and ultimately the high levels of demonstrable water savings achieved, it has and will continue to contribute significantly to the Industry's water efficiency evidence base, in turn aiding others in developing demand management and water efficiency strategies.

Particular achievements have been the increase in effectiveness of ESW's water efficiency retrofit projects, the strong emphasis on the measurement of water savings (at more detailed levels than household meter readings which can easily mislead), interest in the sustainability of savings, a determined focus on the delivery of sustained behaviour change and proactive attempts to share and disseminate the results, experience and learning. ESW has also received recognition for its innovative and creative approach to delivering its wide range of initiatives via a whole-town approach. Every Drop Counts is ESW's largest ever water saving programme taking a wide-reaching and community-focused approach. It was awarded Water Resources Initiative of the Year in the 2017 Water Industry Achievement Awards and a The Green Apple Award for Environmental Best Practice in 2017.

5.1.2 Progress in AMP6 and Current Strategy

Following Ofwat's water efficiency targets in AMP5, ESW designed its water efficiency strategy in AMP6 based on the direction set out in Defra's Water for Life (precursor to the Water White Paper) and its Statement of Obligations for PR14, which emphasised the Government's expectation that water companies will deliver overall demand reductions via demand management measures, including water efficiency. Defra also clearly stated that it expected companies to show in their WRMP how they will reduce per capita consumption.

The Agency and Defra accepted ESW's water efficiency proposals to annually reduce per capita consumption (PCC) by 0.26 l/head/day (equating to 0.49 Ml/day) by delivering water efficiency activities in AMP6; a target that it is on track to meet. Water savings have been achieved primarily through the delivery of household water efficiency activity, applied equally to unmeasured and measured customers. Water efficiency programmes were delivered to non-households prior to retail separation in April 2017, following which it has been deemed the responsibility of retailers.

The following section will highlight the key water efficiency activities that have been undertaken in order to deliver the water efficiency strategy in AMP6, in turn giving a background to some of the activities that will form the strategy in AMP7.

5.1.3 Every Drop Counts

Every Drop Counts is ESW's largest ever water saving campaign, taking a truly innovative and wide-reaching approach by offering customers the chance to participate in a range of initiatives that are usually delivered at different times and places throughout the year.

EVERY DROP COUNTS

It uses a combination of targeted advertising and community-based marketing to maximise participation in the wide range of water efficiency projects to help communities not only save water, but energy and money too. Since the initial trial of the whole-town approach in 2014, ESW has completed 12,365 home retrofit audits and 64 business audits in four towns. The culmination of refining and improving the process annually has seen success in terms of customer participation increase each year.

Every Drop Counts offers water savings schemes, initiatives and solutions to households and schools within the targeted town. A key component of the campaign is the offer to householders of a free plumber-led home retrofit visit worth over £130. The water and energy saving visit includes the installation of a wide range of retrofit products alongside effective engagement with the householder to enact long-term behaviour change. The water efficiency retrofit project has formed a key component to ESW's water efficiency strategy since 1997. A retrofit audit involves a plumber attending an appointment at a customer's property with a view to fitting and/or delivering a wide range of water saving products to ensure the household is water efficient. The customer is engaged in conversation and encouraged to spend time with the plumber whilst fitting the devices, to ensure that behaviour change messages are conveyed effectively.

Participating customers that have received an Every Drop Counts water efficiency retrofit visit are each saving on average 21.3 litres per day. This equates to an annual saving of 7,775 litres which in turn results in monetary savings of approximately £21 on each participating customer's water and sewerage bills. Each participating customer received a comprehensive plumber-led home water audit including water and energy saving products such as aerated or regulated showerheads, tap inserts, leaking toilet repairs, dripping tap repairs, water butts and dual-flush retrofit devices. The project to date is now saving 263,375 litres of water per day.

On an annual basis, ESW delivers the Every Drop Counts whole-town approach in a specific town selected for varying reasons. Each annual campaign is launched with a stakeholder engagement event in May, following which the home retrofits and school educational programmes are delivered throughout the summer. Activity concludes in October, following which the autumn sees a period of customer research and data analysis, and throughout the winter the identification of recommendations and planning for the subsequent year.

A key component of Every Drop Counts is an overarching innovative marketing campaign. The campaign aims to generate a buzz around the community using bill boards, electronic panels, stunt marketing and newspaper/radio advertisements to raise awareness. ESW also worked with the environmental charity ‘Groundwork’ to deliver a series of customer engagement events that were tailored to provide opportunities for our customers to sign-up for a water saving retrofit in the local high street, at supermarkets, shows and festivals. By working in partnership with the community and environmental charities, ESW is also able to engage community champions to deliver a series of customer engagement stands, utilising their understanding of the community to encourage wider participation.

5.1.4 Behaviour Change and Education

ESW fully understands the importance of engaging with customers to influence water using behaviour. The distribution and fitting of water saving products forms only part of the story. Influencing customer behaviour, through informing customers of how much water they use, how they use water and challenging the habitual nature in which they use water, in turn delivers quantifiable and sustainable water savings. The Company has understood this for many years and therefore behaviour change underpins all projects and initiatives.

Through each of ESW’s home retrofit projects, whether delivered internally, using contractors or trusted third-parties, the customer is fully engaged about their consumption, the links to energy and monetary savings and how the devices installed work. In 2015, ESW delivered a piece of research that aimed to establish the proportion of water savings achieved through the installation of products compared to those achieved through effective behaviour change engagement. The research was conducted in conjunction with a phase of home retrofits audits undertaken during the summer of 2015 in which 1,495 properties participated. The properties were randomly assigned to two groups; one receiving the full audit (product installation and customer engagement) and the other receiving a product-only audit (product installation but no engagement). Customers that received a full audit saved on average 24.9 l/prop/day. Customers that received a product-only audit saved on average 18 l/prop/day, suggesting that behaviour change accounts for between a quarter and a third of water savings achieved through home retrofit projects.

ESW also recognise the importance of educating the younger generations, and in turn has implemented two highly energetic, engaging and creative programmes delivered to primary and secondary schools respectively:

- Super Splash Heroes

  Between 2010 and 2015, ESW delivered an educational play and workshop named Little Green Riding Hood. Working with a local theatre company, the programme was delivered to 119,552 pupils through 619 performances in 456 schools. It was a successful project that resulted in sustained behaviour change in primary school aged children.

  In 2016 Water Saving Week, ESW launched a refreshed programme named Super Splash Heroes. Based on the concept that the pupils themselves could become Super Splash Heroes, an educational play and workshop was created in collaboration with a national theatre company. An engaging, fast-paced and drama-based play is delivered to all pupils at participating primary schools. This is then followed by an educational workshop, led by the actors, with the aim of reinforcing the messages the pupils learnt during the play.

  Super Splash Heroes visit 100 schools in the ESW supply area on an annual basis, engaging approximately 200 pupils at each play/workshop. The offering takes an entire morning or afternoon and leaves the pupils fully engaged about water conservation and why water is important. A full day workshop with additional activities is offered to schools within the Every Drop Counts target towns.

  Alongside the primary school play and workshop, which forms the core of Super Splash Heroes, ESW created a picture book, smartphone/tablet based app game, trump cards, a children's kit and a social media marketing toolkit, all of which support the programme and are used at events throughout the year.

- #WATERSAVINGSELFIE

  The #WATERSAVINGSELFIE project is a result of collaborative working with teenagers to identify a problem, create an innovative solution and then make it a reality. The project is a 'first of its kind', blending water efficiency with social media. Using the platforms of Twitter, Facebook and Instagram, 1,690 students at The Gable Hall School in Corringham were encouraged to wear a t-shirt provided by ESW, take a creative selfie and post their picture along with a water saving hint, tip or pledge on their preferred social media site.

On 4th September 2015, the project was launched at The Gable Hall School. A tube, containing the t-shirt and a series of leaflets, was distributed to each student at an assembly and a subsequent stall held over lunchtime. With immediate effect students, adorned in their t-shirts, were posting selfies on social media, sharing water saving tips, messages, hits and pledges with their friends and family. The project will be delivered again in 2018 and then annually thereafter.

ESW also recognises the importance of providing advice and information to customers to ensure water is used wisely in the garden during the summer months. The Save a Bucket Load campaign was initiated in 2014 and aims to encourage customers to keep their gardens looking their best whilst using water wisely. The programme, which has evolved and adapted each year, aims to promote sustainable water use in the garden and generate long-term behaviour change. The BBC's One Show horticulturist Christine Walkden was engaged to be the 'face' of the campaign. In 2016, three routes were employed to spread the message of 'using water wisely' in the garden. Firstly, Christine Walkden did four informative talks across our supply area to gardeners and allotment holders on the top ways to save water. The talks were located in Brentwood in Essex, Lowestoft in Suffolk, Wingrove in Newcastle and also at Howard Nurseries Ltd in Wortham near Diss in Norfolk. Howard Nurseries Ltd won the Waterwise 2016 UK Water Efficiency Awards where they received both the Farming and Horticulture Award and the Environment Agency Chairman's award for their self-sufficient water management system. It was therefore a fantastic opportunity to be able to partner with Howard Nurseries Ltd and celebrate their achievement as a water efficient business. The talk at Howard Nurseries attracted over 100 attendees who alongside hearing great information on gardening from Christine also got to go on a tour of the nurseries. As a wholesale nursery, Howard Nurseries are almost unique in United Kingdom in offering an extensive range of field and container grown perennials, growing two million plants annually in over 1,500 varieties.

5.1.5 Water Saving Kits and Products

In 2009, ESW became the first water company to develop a water saving kit, aimed at providing customers with a variety of 'easy-to-install' products and information about saving water in and around the home. The kit proved effective in providing customers with the tools to make their home more water efficient and also provided details about how the customers could purchase further water saving products for elsewhere within the home. The water saving kit includes a five-minute shower timer, Save-a-Flush, in-line shower regulator, twin-pack of tap inserts, universal plug and an information leaflet/questionnaire.

To date, 60,863 water saving kits have been distributed to customers, upon request, following introduction in 2009. Water Saving Kits are promoted on the ESW website, at events and by Customer Advisors in the ESW Call Centre.

ESW also offers customers the opportunity to request a selection of products for their home and garden in the form of a bespoke kit. When requesting water saving products from the ESW website, customers have the option of requesting a 'standard' water saving kit or a 'bespoke' kit consisting of products selected from those mentioned previously and including a range of other products. The distribution of water saving kits to customers upon request has ensured that customers have enjoyed easy access to water saving products at no cost. It is believed that making such products available has made water efficiency applicable and available to a large proportion of customers.

5.1.6 Affordability and Vulnerability

Water efficiency can play an essential role in assisting vulnerable customers and those that struggle to pay their bills. ESW recognises this and has hence both incorporated vulnerability/affordability messages into the water efficiency retrofit visits and initiated a retrofit programme specifically targeted at customers that will benefit the most. AMP6 has seen closer ties develop between the Water Efficiency team and the Affordability and Vulnerability teams to ensure that the messaging, literature and programmes delivered by ESW focus on both aspects in parallel. Also, as described in the 'Collaborating with Trusted Third Parties' section below, ESW has and will continue to collaborate with organisations such as National Energy Action to tackle energy efficiency, water efficiency and fuel poverty more generally.

5.1.7 Research

ESW fully understands the importance of undertaking research in order to appreciate better the effectiveness of the projects carried out by the Company and to help shape future strategies. ESW collects a vast amount of data whilst carrying out water efficiency projects. This data can be used to better understand a range of interests. To name a few, it is important that the Company better understands why customers do or do not participate in projects, the effectiveness of water saving products installed and/or delivered, the longevity of the water saving achieved, what influences the water savings achieved and how the initiatives have influenced customer behaviour. The following research projects were carried out in order to help ESW better understand some of the points of interest noted above. The results of all are made available to the wider industry.

- Behavioural economics

  In 2014, ESW worked with leading professors in the field of behavioural economics to undertake research to understand how and whether financial incentives would encourage participation. Using ESW's home retrofit programme as a platform, our collaboration with Oxford University and the University of Chicago was split into two years. In the first year, the 15,000 customers invited to participate in Phase 9 of H_2eco were split into seven groups, each offered different financial incentives. One group acted as a control, and the remaining six groups were offered different financial values, ranging from £5 - £15 for taking part, some of which were also tasked with recruiting a friend or neighbour to receive the incentive. The second stage of the research, delivered as part of Phase 11 of H_2eco, was based on the programme's Recommend-a-Friend scheme. For many years, ESW has offered customers a £5 supermarket voucher for each friend or neighbour they recommend that then participates in the project. The research tested whether differing financial incentives, ranging from £10 for participating and recommending one friend, to £50 split by £10 per recommendee to a maximum of five. Again, the customer mailing list was split into groups, one as a control and the rest testing different financial incentives. The research provided some useful findings that have been applied to subsequent programmes. The collaboration with the two universities will also continue into AMP7.

- Home retrofit analysis

  ESW commissioned Artesia Consulting Ltd to perform an in-depth statistical analysis of the datasets for Phases 1-9 of ESW's H_2eco retrofit project. The work involved compiling the raw data from the individual project databases into one large database in order to explore the complete dataset to determine how the water savings vary between phases and what factors explain the difference in water savings. A key objective of the research project was to apply a range of statistical analysis techniques to the device data (point of use measurements such as pre and post flow measurements and cistern measurements) along with the meter read data to quantify the impact each key device has on the volume saved. Among other factors, the research also explored the long term sustainability of water savings, the characteristics of a property able to have an ecoBETA fitted and the socio-demographics of participating properties against water savings. The outcomes and findings have contributed significantly to the development of ESW's water efficiency programmes and also formed a key component to 'Water Efficiency Evidence Base; Review and Enhancement' (Environment Agency, 2012a) and the 'The Links and Benefits of Water and Energy Efficiency Joint Working' project (UKWIR, 2012b).

- Seasonal effects on measured water savings

  ESW has routinely carried out water efficiency projects since 1997. As part of these projects, ESW has installed thousands of water efficiency devices and encouraged customers to embrace water saving habits through behavioural change campaigns. These initiatives are monitored through the collection of three separate meter reads; these are used to calculate overall study savings. Through this process ESW has produced a measurable decrease in their customers' consumption. However, there is an understanding that the measured water saving resulting in a water efficiency project is subject, or at least influenced, by a variety of external factors. It was suspected that seasonal variations have an impact on the water savings calculated following the undertaking of a project. In order to explore whether any further value can be extracted by re-analysing the results, Artesia Consulting Ltd were employed in 2012 to analyse and report on the extent to which external factors influence demand during periods when water efficiency studies are undertaken. If external influences were found to be statistically significant a method of correctly adjusting for them was to be developed and reported upon in order that the analytical methods could be used for future studies. This study showed that, due to the nature of the project and the fact that audits are carried out over a number of months, the seasonal effect on the measured water savings was negligible.

5.1.8 Collaborating with Trusted Third Parties

ESW recognises the importance of delivering water efficiency in collaboration with trusted third parties. ESW has developed programmes that, even working alone, result in some of the highest levels of participation and engagement seen across the industry. That said, there are significant advantages to working in collaboration, whether it be to increase participation or deliver combined messaging and benefits to customers.

ESW is currently working with three organisations (Cenergist, AgilityEco and National Energy Action) on separate programmes that aim to deliver water saving advice and product installation in conjunction with energy saving initiatives already underway. ESW also has a long history of collaborating with housing associations to deliver water efficiency projects for their tenants. Based on a successful pilot with Flagship in 2011, ESW has since worked with Swan Housing to undertake water saving retrofits in their housing stock both through their refurbishment programme and as a distinct targeted project.

5.1.9 Customer-side Leakage

ESW has contributed to two industry-wide pieces of research which concluded that approximately 5% of toilets in the UK leak, each wasting on average 215 litres per day. ESW's evidence of measured savings to date indicates that the volume of wastage suggested in the industry-wide research is conservative. That aside, for ESW specifically this equates to approximately 37,000 properties with leaking toilets potentially wasting 7.96 Ml/d. In response to this finding, ESW has proactively focused on the identification and repair of leaking toilets through its water efficiency retrofit programmes and in response to high consumption queries.

ESW delivers approximately 4,000 water and energy saving retrofits per year. At each of these visits, the plumber or technician will use leak dye capsules in each toilet within the home to identify any leakage from the cistern. Upon identification, a repair will be made whilst at the home if possible or at a remedial visit if specific materials are required to make a satisfactory repair. Going forward, ESW has identified a number of additional routes by which it will identify and repair leaking toilets.

5.1.10 Industry Sharing, Involvement and Recognition

In May 2007 ESW distributed the first edition of Water Efficiency News. Since then, the Company has produced a further nine issues. The purpose of this newsletter is to keep stakeholders and other interested organisations up to date with the Company's work. Many projects are in progress at any one time and there is now too much material to be able to rely on others to spread the word for us. The latest issue was produced in 2017 and focused on the key water efficiency and demand forecasting projects being undertaken by ESW. It is hoped that Water Efficiency News will be able to be used to disseminate results and also to draw attention to key issues or aspects that have not received sufficient attention and to provoke discussion and new research ideas.

ESW remains actively involved in the water efficiency arena taking a lead wherever possible. The Company remains active contributors to the WaterUK Water Efficiency Network having chaired the network since 2005, providing the opportunity for companies to exchange ideas and experiences and to jointly meet with suppliers, regulators and others. ESW also actively supports Waterwise (a not for profit organisation), continues to sit on and contribute to the Water Efficiency Strategy Steering Group and is also influential in scoping and seeing to fruition the development of the Collaborative Fund. Lastly, ESW's Customer Director sits on the newly formed Leadership Group for Water Efficiency and Customer Engagement.

ESW has received industry recognition through receipt of numerous awards. Below is a list of awards that ESW has received since 2015.

- Winner of Water Resources Initiative of the Year at the 2017 Water Industry Achievement Awards for the Every Drop Counts campaign.

- Winner of Business and Industry Award at the 2016 Waterwise UK Water Efficiency Awards for the Bourne Leisure Holiday Home Retrofits programme.
- Winner of the Research & Evaluation Award at the 2016 Waterwise UK Water Efficiency Awards for the H$_2$eco Research and Analysis.
- Winner of the Innovation Award at the 2016 Waterwise UK Water Efficiency Awards for the #watersavingselfie project.
- Gold in the Utility category at the 2017 Green Apple Awards, demonstrating environmental best practice through the Every Drop Counts programme.
- Bronze in the Built Environment and Architectural Heritage category at the 2015 Green Apple Awards for the Swan Housing retrofit programme.

- Winner of a SWIG (Sustainable Water Industry Group) award in 2015 for Every Drop Counts.

5.1.11 Water Efficiency Strategy for the remainder of AMP6

ESW will continue to deliver projects and initiatives similar to those documented in the preceding sections for the remainder of AMP6. The Every Drop Counts whole-town approach will form the core activity in 2018 and 2019, within which water efficiency programmes will be delivered on an annual basis at a similar scale to that detailed above. This community-focused approach will ensure that ESW is able to maximise its effectiveness in terms of participation and water savings in target areas. The home retrofit programme will continue to be offered to a minimum of 4,000 domestic properties per year, acting as a cornerstone to the strategy as a means of ensuring the existing housing stock is as water efficient as possible whilst delivering behaviour change. The Super Splash Heroes programme forms an effective means by which ESW is able to engage with future generations and will be delivered to a minimum of 100 schools per year. ESW will continue to focus on housing associations, develop stronger links with its affordability strategy and focus on identifying and repairing internal plumbing losses. The majority of the aforementioned initiatives will be underpinned by a new digital engagement platform and an enhanced marketing strategy. This will enable ESW to offer its water saving initiatives, including water saving products, in a more personalised and bespoke way.

The strategy will continue to be designed to create water efficiency programmes that make genuine savings in water as cost effectively as possible. The programme will continue the detailed monitoring of results to find out what the actual savings in water are and how sustainable they are, and customer surveys to gauge the effectiveness of the approach.

ESW will continue to actively contribute to the industry's efforts to improve the water efficiency evidence base, through chairing the WaterUK Water Efficiency Network, sitting on numerous industry-wide steering and working groups and making the results of projects and initiatives available to the industry.

5.1.12 Water Efficiency Strategy for AMP7

In AMP7, water efficiency will be more important than ever. In addition to recognising the underlying and founding principle that water efficiency is a key tool for managing demand and therefore supporting the supply/demand balance, ESW has considered the numerous and varying drivers for water efficiency that now exist. In response, ESW will deliver a water efficiency programme between 2020/21 and 2024/25 that is even greater in scale and ambition than delivered previously. With more than twenty years' experience in the delivery of water efficiency programmes, ESW is best placed within the industry to develop a strategy that will deliver quantifiable water savings and sustained behaviour change. This section will detail the drivers that ESW deems important in developing the water efficiency programme for AMP7, highlighting the projects that ESW will deliver and the anticipated water savings resulting from such activities.

In Ofwat's draft PR19 methodology (Delivering Water 2020: Consulting on our methodology for the 2019 price review, July 2017), four key themes are emphasised that will focus on benefitting customers; namely great customer service, resilience, affordable bills and innovation. It is arguable that water efficiency plays a key role in the delivery of all four outcomes. Delivering an effective, engaging and ambitious water efficiency strategy has the ability to provide unrivalled customer service, manage demand such that ESW is more resilient in the future, provide support to vulnerable customers who are struggling to pay and demonstrate innovation through the use of new technologies and approaches. Further to this, Ofwat has proposed a new common performance commitment based on per capita consumption. Alongside an effective metering strategy, this common performance commitment emphasises the importance of demand management in general, and more specifically water efficiency.

'Water Resources Long-Term Planning Framework (2015-2065)' (WaterUK, 2016) suggests that more action is needed to protect against the growing risk of drought. The report emphasises the role that water efficiency at a greater scale can play in mitigating some of the risks. The Blueprint for Water's Blueprint for PR19 also emphasises the importance of using water wisely by reiterating Ofwat's suggestion that companies need to go much further on metering and leakage reduction, as well as working with customers to help them reduce consumption. Waterwise has also published a national water efficiency strategy that calls for greater ambition and collaboration in water efficiency.

ESW is able to demonstrate the Company's commitment to encouraging its customers to use water wisely through a long history of delivering effective water efficiency strategies and programmes. The drivers (regulatory and other) detailed above add further emphasis to the importance of water efficiency for varying reasons. In turn, **ESW will commit to delivering a programme of water efficiency activities that will deliver a 2% reduction in PCC by 2024/25, equating to an annual reduction of 0.57 litres per person per day**. The impact of this water efficiency, as shown in Figure 5.1, is to reduce overall PCC for ESW by 2.85 litres per person per day by 2024/25 with a further continuation of water efficiency across the planning horizon. The demand reductions highlighted here and in Figure 5.1 denote those from water efficiency activity alone and do not include the efficiencies related to the metering activities detailed in section 5.2.

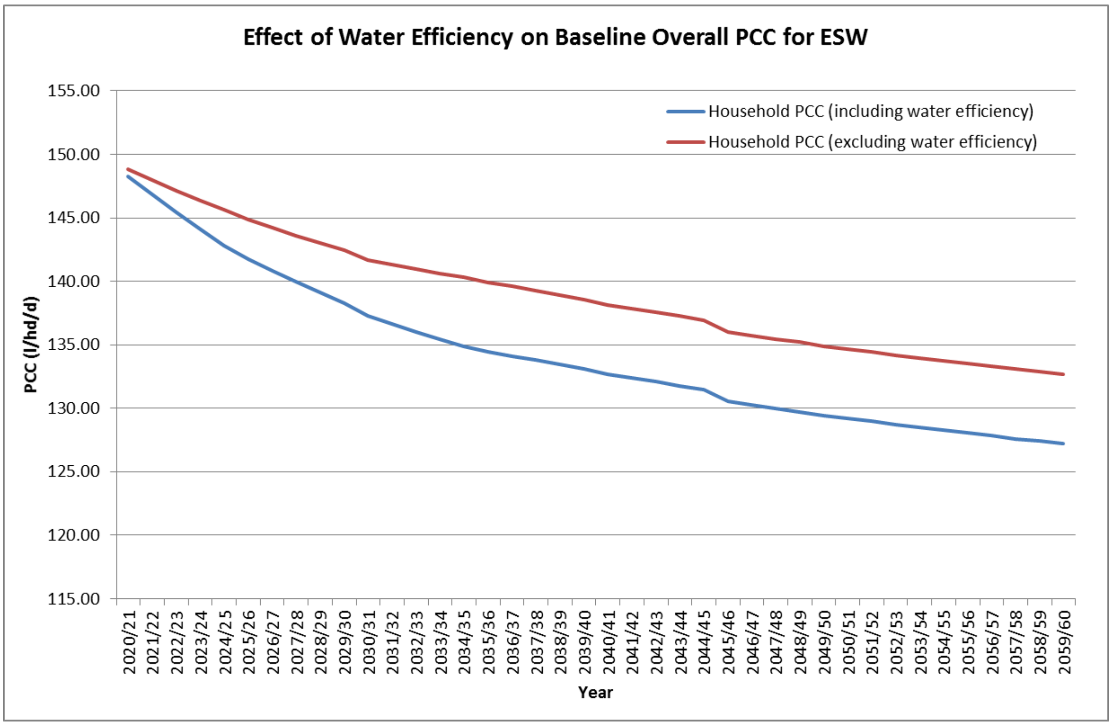


Figure 5.1: Effect of Water Efficiency on Baseline Overall PCC

ESW will achieve the ambitious demand reductions stated above through a continuation of the range of activities currently delivered although at a far greater scale. Central to the water efficiency strategy in AMP7 will be the Every Drop Counts programme, taking a community-focused and wide-reaching approach to saving water through the delivery of all of ESW's activities in one town at one time. The whole-town approach ensures that ESW is able to maximise its effectiveness in terms of participation and water savings in target areas. Home water efficiency retrofits will remain a cornerstone to the strategy as a means of ensuring the existing housing stock is as water efficient as possible whilst delivering behaviour change. The Super Splash Heroes programme forms an effective means by which ESW is able to engage with future generations. ESW will continue to focus on housing associations, develop stronger links with its affordability strategy and focus on identifying and repairing internal plumbing losses. Each of the activities discussed previously will be delivered in AMP7 at a greater scale.

It is however important to highlight that the water efficiency scene is changing, which in turn will influence the strategy as time progresses through AMP7. There will be three key priorities for water efficiency in the coming decade. Firstly, there will be a transition whereby the importance of behaviour change grows exponentially. Secondly, the delivery of home retrofits will need to become more targeted towards only those homes that will truly benefit from the programme. ESW's research and statistical analysis tells a story suggesting a limited lifespan of the home retrofit project as the stock of existing inefficient water using appliances is replaced with those that are more efficient. ESW is able to demonstrate that product installation rates associated with the home retrofit programmes are declining on an annual basis, in turn diminishing the cost-effectiveness of the projects. And thirdly, the use of smart metering/technologies will be deemed beneficial to water companies and an expectation of customers. In response, ESW will implement an innovative digital engagement platform that will underpin and assist in the delivery of these priorities whilst further supporting its drive to deliver unrivalled customer service. Linked to the digital engagement platform will be two additional themes. An innovative incentive scheme, building on the behavioural economics research undertaken by ESW in conjunction with Oxford University and the University of Chicago, will be implemented to intelligently incentivise customers. ESW will also deploy a series of smart technologies allowing more frequent and circular customer conversations around water efficiency.

5.2 Metering

5.2.1 Current Strategy

In Essex and Suffolk separate metering strategies have been run since 2003/04.

In Suffolk ESW has been “optant” only metering, as required by legislation since 2000. Although in Essex and Suffolk ESW had been offering free meter installation to some customers from 1997 as part of its demand management strategy. Optant metering is where a customer requests a meter from the company and, assuming the meter can be installed at reasonable cost, the company is required to install a meter free of charge. The customer then pays for their water and sewage on a measured basis. They also have a choice of reverting back to an unmeasured charge for two years of the meter being installed. A meter means a customer only pays for the volume of water used, which in low occupancy, high rateable value properties usually reduces their annual water bill. All unmetered customers continue to be charged according to the rateable value of their property. All new properties, and properties that have had significant alteration or installed large water using apparatus e.g. a swimming pool, are metered.

In Suffolk by the end of 2019/20 meter penetration is estimated to be 68.9% of domestic properties.

In Essex exactly the same optant, new property and high water users strategy has been in place. However in the early 2000s it was obvious that opting for a meter was far more popular in Suffolk than it was in Essex. The exact reason for this is unknown but the greater proportion of second homes in Suffolk, which are therefore only partially occupied, could account for it as they generally will have a low annual consumption. Historically there has also been a higher cost of water in Suffolk than Essex which may have made having a meter more financially attractive. Whatever the reason, the outcome was that the more water stressed area of Essex, compared to Suffolk, had a significantly lower meter penetration level. Looking at the declining trend in the annual number of optants in Essex, meter penetration was unlikely to increase sufficiently to support our demand management aspirations if only optant metering was available.

From 2003, initially in a pilot area, metering on change of property occupier (selective) metering was introduced. Selective metering is allowed under current legislation where, if the occupier of a property has never received an unmeasured bill for water to that property, then the company is allowed to install a water meter and charge the customer on a measured basis. In reality this means ESW can meter a property when it changes hands by either being purchased or having a new tenant.

This additional form of metering to the Essex strategy has meant that by 2019/20 64% of domestic properties will be metered. In Suffolk this figure will be 69%.

However, ESW now believes that selective metering in Essex has probably achieved as much as it can. Whilst ESW recognised that as more properties became measured the chance of a new occupier moving in to an unmeasured property decreased, after the first two years the numbers decreased markedly.

Initially selective metering in Essex started in 2005 and saw a peak of 14,235 selectively metered properties in 2006/7. However the financial crash in 2007 saw house moving plummet from 2008 onwards, with the number of selective meters falling to an average of 5,500 for the next five years. As house moves picked up ESW did not see the expected increase in selective meters coming through and has actually seen a steady decline in numbers from 5,300 in 2011/12 to 3100 in 2016/17 against the 6,000 forecast at PR14. These numbers are far below that forecast and far below the numbers expected if approximately 10% of properties change occupier per annum. What ESW has now come to understand is that even when the number of house moves returns to normal, a high proportion of the houses coming on to the market are those that have been sold within the previous 10 years. This reduces the opportunity to selectively meter dramatically as most properties have been selectively metered previously. Equally in the rented sector tenancies tend to be of fairly short duration meaning most of these properties will already have been selectively metered on their first change of occupier.

However, because ESW wants to meter above the “natural” optant rate in Essex it is going to introduce area metering will be introduced as described below.

<u>Purpose of metering properties</u>

A number of diverse reasons drive the move from an unmeasured water supply, where the occupant is charged according to the rateable value of the property, to a metered supply. All new properties are metered as the only way of charging for water and sewage services as assigning new rateable values ceased in 1989.

Customers who live in low occupancy premises with a high rateable value, tend to opt for a meter to lower their water and sewage bills. Other customers who opt perceive themselves to be low water users and again would financially benefit from paying by meter. Recent customer research shows the predominant reason for electing for a meter is financial.

Environmentally, meters are seen to be beneficial by lowering the demand for water. This uses the principle that if you pay for only what you use you are more likely to use less, thus leaving more water in the environment. In addition less energy, hence less carbon dioxide emissions, is used to pump and treat the water and less energy is needed to pump and treat the waste water.

There is also the question of equity. As more customers become metered, although the cost of the remaining unmeasured customers increases more than the measured, profligate unmeasured users are having the cost of their water subsidised by the metered customers.

Selective metering of large domestic water users

All water companies in England and Wales have powers to meter domestic properties that are deemed large water users. This does not refer to occupancy of a property but is mainly associated with customers who want to use a garden sprinkler, or similar non-handheld watering device, or properties where potable water is used to fill a swimming pool or pond greater than 10,000 litres capacity. There are a few other uses that could be selectively metered but these tend to be internal uses of water such as certain power showers and water softeners that the Company would rarely have knowledge of. ESW informs customers that if they wish to use a garden sprinkler, or install a swimming pool or pond above the stated capacity they will need to have a meter installed. The majority are then classed as optants. If ESW discovers an unmetered property using a sprinkler or having a swimming pool / large pond, in the first instance, the Company advises them of the need to have a meter. Most comply and are counted as optants. The few that do not, are selectively metered.

ESW believes the vast majority of its customers who are large users of water are, after over 20 years of the rules being in place, now metered.

In recent years ESW has only selectively metered 30 - 40 customers per annum in Essex and Suffolk combined because of their high use of water. These were all associated with swimming pools. Therefore the effect of metering was to collect a fair revenue from these customers rather than in controlling their water demand. Any demand savings would only come from them being more careful with their other water use and in total is negligible.

5.2.2 Customer Consultation

ESW operates in an area classed as Seriously Water Stressed by the Agency. As such the Defra Secretary of State can give permission for the introduction of compulsory metering in ESW's area. However, given that none of ESW's water resource zones are forecast to be in supply demand deficit over this period, meaning compulsory metering would not defer a new water resource scheme, ESW must seek its customer's approval for the introduction of compulsory metering.

Most customers' perceptions of how beneficial having a meter would be for them depend on how much lower their bills would be as a result (CCWater, 2016). ESW's 2010 metering research indicates that its customers are motivated to request a meter in the hope saving money, by the recommendation of a family member or friend, or because the Company told them about the benefits. Customers can be disappointed if the efficiency measures they take after having a meter fitted are not enough to reduce their bill (CCWater, 2013). Customers want information about the fitting and billing process and the financial impact, tailored to the type of tariff they are currently on (CCWater, 2016). A bill forecast helps customers to have realistic expectations of their new bill (CCWater, 2013).

In water stressed areas where the first large scale universal metering programmes have been undertaken, most customers regarded universal metering as a progressive necessity, an efficient way to record usage, resulting in fair billing (CCWater, 2016). Some also have a general sense that there would be a positive impact on the environment because of the water saved, but customers could not identify what these specific benefits would be (CCWater, 2013).

5.2.3 Overall acceptability

A YouGov survey completed in 2010 showed that 63% of customers agree that metering is an acceptable way to charge for water – leaving a significant minority unconvinced (ICSconsulting, 2010). In 2017, ESW therefore wanted to investigate attitudes towards choice, and how customers' views changed when they were informed of the wider context of metering.

A survey of ESW customers in 2017 analysed the views of 257 customers who had not chosen to have a water meter, as they had moved into a home with a meter already installed. Of these, only 11% said they disliked having a water meter. Nearly half actively liked it and 38% said it did not bother them. This contrasts with the views of customers who do not yet have water meters, where almost three times more (32%) are actively against having a meter installed. This contrast suggests that customers' experience of having a water meter is usually better than (or not as bad as) they expected (NWG, 2017).

5.2.4 Vulnerability and meters

While customers see metering as fair for the many, they fear it can be unfair for individual households (CCWater, 2013). They perceive that both metered and unmetered tariffs could unfairly penalise various groups in society, and do not like the concept of a tariff being used to influence their water usage (CCWater, 2013).

When informed of the financial and practical support NW and ESW offer to customers in vulnerable circumstances that are relevant to metering (the Priority Services Register and tariffs like SupportPLUS and Watersure) most (two thirds of) customers think this offers enough protection for people who might struggle to pay their bill if they were on a water meter. However one in ten (13%) felt this still wasn't enough protection for vulnerable customers (NWG, 2017). ESW's 2016 research into customer support for a social tariff (up to a 50% discount on bills) showed that the majority of customers supported a 75p annual cross subsidy to help customers genuinely struggling to pay their water bills, which will enrich ESW's offer for vulnerable customers (NWG, 2016).

Vulnerable customers who took part in ESW's 2017 deliberative events were positive about the support available. However, ESW knows from its Vulnerability Research in 2016 that awareness of the extra support available is very low in ESW customer base, so its support may not be reaching customers who need it most. Only 5% of NW customers and 6% of ESW surveyed in 2016 were aware of Watersure and additional services that are available, which reflects the average level of awareness across the industry (CCWater, 2017). Therefore, any metering programme needs to ensure that customers are informed about the extra support, should they require it.

5.2.5 Reversion

Very few customers in the 2017 research were aware that they can revert to an unmeasured tariff within two years of having a water meter installed. This is consistent with CCWater's finding that only 28% of unmetered customers are aware of the trial period (CCWater, 2016). Low awareness may partially explain why so few customers revert to unmeasured tariffs (only 1-2% of optants). However, ESW's reversion rates do also indicate that most optants are happy with their measured tariff.

The majority of customers were pleasantly surprised by and supportive of the idea of the government's reversion policy. In the 2017 deliberative research, it was observed that those who were initially completely against metering noticeably softened towards the idea of going on a meter when told about the right to revert to an unmeasured tariff. However, in the ESW survey it was possible to observe that fewer of those who inherited water meters (55%) supported reversion than optants (67%) or unmetered customers (73%). Some customers in the deliberative events suggested that the option to revert to unmeasured billing should be extended to customers who had not chosen to have water meters (NWG, 2017).

Customers often want to revert because they are disappointed by increased bills or find that other household members do not cooperate with the water efficiency measures they introduce (CCWater, 2013). Indeed, customers suggested ESW remind them of this right before the 24 month reversion period comes to an end (NWG, 2017).

5.2.6 Meter location

ESW knows that customers in England and Wales prefer being able to access their own meter to read it, and some cannot (CCWater, 2013). ESW also knows from research into the experience of having a meter fitted that the main issue causing customers to drop out of the process was the location of an internal meter (NWG, 2010).

ESW also has some evidence implying that the meter location can be an important barrier to getting a meter. ESW's own research into the experience of having a meter fitted in 2010 showed that the main issue causing customers to drop out of the process was the location of the internal meter (NWG, 2010).

In a survey of ESW customers in 2017, meter location preferences were as follows:

Table 5.1: Meter location preferences

Location	Current location	Preferred Overall	Preferred by Metered	Preferred by Unmetered
Outside their home in the pavement (or road if there is no pavement)	34%	**26%**	33%	17%
Outside their home in the ground (in the garden or driveway)	25%	**30%**	34%	24%
Inside their homes (e.g. under the kitchen sink)	21%	**15%**	12%	19%
Outside their home on the wall (in a box)	15%	**19%**	17%	23%
Don't know	5%	**9%**	4%	17%

76% of ESW customers preferred external options, with only 15% opting for an internal meter and 9% not knowing. Those already on meters were most likely to stick with their current option when asked their preference. However, those with internal meters were more likely to prefer external locations and only half would choose to have them there again, which suggests that their experience of having an internal meter has not been good (NWG, 2017).

Of the external options, customers were equally likely to choose a meter in the public highway as to choose to have it on their land (a third each). Not as many would choose to have one on their external wall. In view of the costs and delays associated with installations in the public highway we tested the acceptability of offering customers incentive payments for installations on customers' land. More than half (53%) of ESW customers agreed with this in the survey, with a further quarter (23%) neither agreeing nor disagreeing. Agreement was dependent on the amount of incentive that would be offered. Customers were less supportive of charging the additional cost of highway installations, with 42% disagreeing and 32% agreeing this would be a good idea.

Interestingly, many customers expressed that they would not expect to be given a choice and would expect to simply be told where the meter was going (NWG, 2017).

5.2.7 Reading and billing

Customers' preferences for how often they would want to read their own meters, ranged from monthly to yearly in the 2017 research. For most, this was an issue of managing their outgoings and customers are much better equipped to manage their finances if readings are required and bills are issued more frequently. Some also said leaks could be better detected through more frequent billing. Many customers prefer submitting meter readings online, with some already accustomed to not having to submit readings at all due to having a smart (energy) meter.

5.2.8 Meter capability desired

Awareness of smart meters was high across all customers reached in 2017 and about a quarter already had a smart energy meter. Appetite for smart water meters was high and about 60% of ESW customers surveyed were in favour of getting one. A further fifth were neutral about it. Older customers were most likely to be against getting smart meters which could be due to a distrust of technology (NWG, 2017). However, most (two thirds) said they would not be willing to see bills rise at all to cover the cost of rolling out smart water meters.

The level of interest found among customers was higher than national research has shown. Customers are more likely to be supportive (31%) than oppose (15%) the roll out of smart meters, but most have no opinion about it. Only around half of UK metered customers were satisfied with the appointment and the fitting processes, suggesting that these are important things to get right or there is a risk of an impact on overall satisfaction scores (DECC, 2014).

5.2.9 Impact of meters on consumption

Surveys attempting to measure the savings achieved through metering scientifically have shown various levels being achieved. According to some customer research, the majority of customers with meters take action to reduce consumption, but for many this predates the meter being installed (CCWater, 2013). Most water customers in England and Wales believe that they do not change their behaviour drastically when they have a meter installed. Optants are slightly more inclined to make modifications to their behaviour than non-optants (CCWater, 2013). Most of ESW customers said they want to reduce their usage but don't want to change their lifestyle. It was also noted that some vulnerable customers simply can't reduce their usage, even if they wanted to (NWG, 2017).

Some customers who are not metered are reducing their water consumption anyway. Two thirds of customers in England and Wales have made a conscious decision in the last three years to reduce their water consumption while only half are metered. This was an increase of 7% in one year while meter penetration increased by just 2% (CCWater, 2016). A recent global survey also found that 72% of citizens surveyed say they would change their water consumption if they were given better information about their usage (ECU, 2015).

5.2.10 Limitations of metering for reducing consumption

Customers who were motivated by financial or environmental reasons to get a meter, initially made efforts to save water, but they failed to maintain this behaviour if their expected financial savings did not materialise (CCWater, 2016). The receipt of a new bill renews interest in saving water for a while (CCWater, 2013) but ESW's customers are only guaranteed to receive a bill based on a reading once a year.

The average customer underestimates their consumption by 50%. Metered customers' estimates of consumption were not much better than unmetered customers showing that a meter by itself will not necessarily make a customer more conscious of how much water they use. Only bill payers are financially motivated to save water and can express frustration with family / household members who do not (NWG, 2017).

In 2017, customers told ESW that their strongest motivators to saving water would be saving money and water shortages, although there was significant scepticism about the need to save water in both NWG regions. Across our deliberative workshops in 2017, there was so little support for stepped or seasonal tariffs to increase the financial incentive that the subject was dropped from the survey (NWG, 2017). Willingness to reduce consumption falls when customers are aware of the amount of water lost through leakage or if they experience a burst.

5.2.11 Attitudes to compulsory metering

In ESW's 2017 research, the freedom to choose whether or not to go on a water meter was considered an important 'right' by the majority of customers, before they were informed of the wider context of water metering. Nearly two-thirds (63%) of ESW customers agreed that people should be able to choose whether or not to have a water meter, whilst 38% agreed that ESW should make it compulsory for all households to have a water meter. However, as more information about the benefits and safeguards for metering was provided, many customers' attitudes changed and the proportions of customers supportive of compulsory metering increased by 15%, as shown in the table 5.2 below.

Table 5.2: Attitudes to compulsory metering

	Unmetered customers	Metered customers	Combined metered and unmetered
Uninformed customers (at beginning of research)	22%	49%	38%
Informed customers (at end of research)	37% (+15%)	63% (+14%)	53% (+15%)

(NWG, 2017)

The survey from which these figures are taken was only conducted with ESW customers because the operating area is designated 'seriously water stressed' and could qualify for compulsory metering. Although a small majority of informed customers were supportive of compulsory metering overall, ESW do not consider that this justifies a programme of compulsory metering in view of the majority of unmetered customers being opposed to it, especially when uninformed.

At the end of our 2017 online survey, ESW customers allocated £10 across five potential water resource management investment options, in order to understand participants' perceived priorities. Increasing supplies and reducing leakage were seen as priorities over metering options, but metering had much more support than it did at the outset of the research. The option for compulsory metering was invested in just as much as simply providing information to customers on optional metering.

Table 5.3: Customer investment priorities (NWG, 2017)

Option	Total amount 'invested' by all respondents (£)
Build more reservoirs, treatment works and pipes	**802**
Reduce leaks	**795**
Reduce water usage and inform customers about optional meters	**237**
Reduce consumption with compulsory water meters at all customers' homes	**232**
Install water meters whenever someone moves house	**209**

We were able to calculate from this exercise that 53% of customers put some money against compulsory metering (63% of metered and 37% of unmetered customers).

From this customer information ESW deduce that the introduction of compulsory metering in to the Essex & Suffolk area is not supported by customers. This information was given to the CCWater committee and Water Forum (Customer Challenge Group) who agreed ESW had no customer mandate for the introduction of compulsory metering.

Their views also support ESW's move away from selective metering on change of occupier in Essex to Area Metering.

5.2.12 Changes to Draft WRMP metering strategy for 2020 – 2025

Essex

In Essex ESW will continue with the current strategy of optant metering but will no longer continue with selective metering on change of occupier of a domestic property. Instead ESW is going to introduce Area Metering which ESW predicts should add a further 5,000 meter optants per annum to the forecast number of "natural" optants that are expected.

Area Metering is the name given to a new programme of installing meters in to existing empty meter chambers, the customers will remain unmeasured but over a two year period will be sent a “water bill” showing what they would have paid had they opted for a meter.

As a result of ESW’s mains renewal programmes over the last 30 years, including a significant replacement of mains during the 1990s for quality reasons (Section 19 Quality Programme), there are a large number of empty meter chambers. This has arisen because when water mains are renewed ESW has also taken the opportunity to renew the communication pipe (the pipe between the main and the customer’s curtilage) and install a meter chamber. ESW estimates that there are currently approximately 70,000 empty chambers and will continue to add to this number as mains are renewed.

ESW’s proposal is to drop meters in to these chambers, at the rate of 10,000 per annum, and inform the customer that whilst they remain an unmeasured customer we will send them “dummy bills” over a two year period showing what their water bill would be if they were metered. From customer research ESW forecast that over the two year period 5,000 of these customers will opt to go on to a measured bill. Some very early on and others when they see that financial savings are sustainable and not a single aberration. Once they opt for a meter they have a further two years in which to revert, potentially giving customers up to four years of measured bills before they become permanently metered. Equally any change of occupier to these properties, at any time, will automatically become metered. Even for those properties that chose not to become measured, or changed ownership, ESW believe knowing that the property has a meter will have a ‘Hawthorn’ effect on their use, certainly reducing wasteful use.

Moving to this area metering at the start of AMP7 (April 2020) would mean far less than 5,000 new optants from Area Metering in the first year of installing the 10,000 meters pa, as ESW expects the 5,000 optants over the two years. Therefore ESW proposes to begin the 10,000 meters per annum from April 2018, meaning that by the first year of AMP7 the first 10,000 customers will be at their two years of “dummy” bills and a further 10,000 reaching one year of “dummy” bills. ESW intends stopping selective metering at end of March 2018 as the number of optants from Area Metering in the last two years of this AMP is likely to exceed the number of new measured properties from continuing with selective metering.

With ESW’s planned level of mains renewal for the remainder of AMP7 and during AMP7, it is forecast there will be sufficient empty meter chambers to continue Area Metering through AMP8.

Table 5.4: Number of optants and area metering optants for AMP 7

	2020/21	2021/22	2022/23	2023/24	2024/25
Optants	4,000	3,750	3,500	3,250	3,000
Area Metering Optants	5,000	5,000	5,000	5,000	5,000
Totals	9,000	8,750	8,500	8,250	8,000

At the end of each AMP the Essex meter penetration is forecast to be as below:

Table 5.5: Essex meter penetration forecast

AMP6	AMP7	AMP8	AMP9	AMP10	AMP11
64.24%	72.23%	78.35%	80.85%	82.61%	84.22%

<u>Savings in water use from metering</u>

ESW assumes an average saving from an optant metered customer having a meter installed is 5% of the unmeasured consumption. These savings are based on experience in Essex. The rationale for the difference is that those who tend to opt for a meter are often lower than average users of water to begin with. This is often why they opt so as to gain a financial benefit for careful water using behaviour. Therefore after a meter is installed they have less opportunity to make further water savings to lower their bill.

The optant water savings are based on the forecast average pre-switch unmeasured household consumption for 2016 /17 of 553.97litres, unmeasured occupancy of 3.26, optant occupancy 1.84, water saving of 5%, is calculated as:

(553.97 x 0.05 / 3.26) x 1.84 = 15.63l/p/d (litres/property/day)

Installing 42,500 optants in AMP7 = 664,725 litres water per day saved.

This assumes the daily consumptions and occupancies remain constant over the AMP7 period which for ease of calculation is a reasonable estimation.

<u>AMP7 Costs</u>

The cost of installing a meter varies according to where on the property ESW can fit the meter. There are four possible locations with five different costs. All proposed meters will be AMR with Walk by / Drive by reading capability. ESW's intention is to always install a meter in the cheapest practical location. These locations are:

- Drop in (to an empty existing meter chamber)
- Internal
- External private (new chamber installation in customers ground)

- External public (new chamber installation in public footpath /road)

The respective costs for these are (2016/17 prices):

- Drop in (Area Metering) £50.89
- Drop in (Single optant) £94.04
- Internal £171.47
- External private £327.28
- External public £438.79

- Drop in (Area metering) 100%
- Drop in 36.4%
- Internal 15.4%
- External Private 6.8%
- External public 41.4%

Drop in (Area metering)	50,000 meters	@ £50.89	= £2,544,500
Drop in	6,370 meters	@ £94.04	= £599,035
Internal	2,695 meters	@ £171.47	= £462,112
External Private	1,190 meters	@ £327.28	= £389,463
External Public	7,245 meters	@ £438.79	= £3,179,034

Total AMP7 cost for Essex = £7,174,144

Suffolk

In Suffolk ESW will continue with the current strategy of optant metering. With approximately 69.24% of properties being metered by 2020, the number of new optants coming forward will decline to a lower level than experienced in AMP6. The number of meters forecast to be installed in each of the 5 years is:

Table 5.6: Number of optants for AMP7

	2020/21	2021/22	2022/23	2023/24	2024/25
Optants	675	650	600	550	500

At the end of each AMP the Suffolk meter penetration is forecast to be as below:

Table 5.7: Suffolk forecasted meter penetration

AMP6	AMP7	AMP8	AMP9	AMP10	AMP11
69.24%	73.02%	75.25%	76.31%	77.27%	78.13%

Savings in water use from metering

ESW assumes an average saving from a customer having a meter installed of 5% of the unmeasured consumption from an optant.

The optant water savings, based on the forecast average unmeasured household consumption for 2016 /17 of 459 litres, unmeasured occupancy of 2.88, optant occupancy 1.76, water saving of 5%, is calculated as:

(459 x 0.05 / 2.2.88) x 1.76 = 14.03l/p/d (litres/property/day)

This gives an AMP7 total of water saved in Suffolk from optant metering of 41,739 litres per day.

<u>AMP7 Costs</u>

The cost of installing a meter varies according to where on the property ESW can fit the meter. There are four possible locations with four different costs. All meters will be AMR with Walk by / Drive by meter reading capability. ESW's intention is to install in the cheapest practical location.

These locations are:

- Drop in (to an empty existing meter chamber)
- Internal
- External private (new chamber installation in customers ground)
- External public (new chamber installation in public footpath /road)

The respective costs for these are (2016/17 prices):

- Drop in £103.10
- Internal £155.16
- External private £409.79
- External public £462.95

The forecast location split for optant meters in AMP7, derived from location splits out turned in AMP6 and the company's meter location policy is:

- Drop in 26.1%
- Internal 16.1%
- External Private 17.3%
- External public 40.5%

The 2,975 forecast optant meters for AMP7 break down to the following costs:

Drop in	776 meters	@ £103.10 = £80,006
Internal	479 meters	@ £155.16 = £74322
Private	515 meters	@ £409.79 = £211,042
Public	1,205 meters	@ £462.95 = £557,855

Total cost of Suffolk optant metering for AMP7 = £923,225

5.2.13 Overall impact of metering strategy on ESW

The Company will install a total of 70,475 meters during AMP7 at a total cost of £8.1m. This will result in water demand savings of 0.706Ml/d.

5.3 Leakage Forecast

5.3.1 Background

Water companies have been working together, co-ordinated by Water UK, to improve the consistency of reporting of definitions of key measures of performance, so that performance can be compared between companies more easily. This work is supported by Ofwat, the Environment Agency, Natural Resources Wales and the Consumer Council for Water.

Companies need to make changes to their current reporting to align with the new, more consistent, reporting definitions, and for some of these changes it will take some time to have robust data. One of the measures of performance this applies to is leakage. Each company's draft WRMP explains how the company is implementing the new reporting definition for leakage and the extent to which it might impact on their future plans for balancing supply and demand for water. The change in reporting of leakage is purely a change in reporting; it does not affect the actual amount of water lost through leakage.

Each company will be making different changes to their current reporting to come into line with the more consistent definition, and so the impact will be different for each company. For ESW, the changes and their potential impact are explored below.

5.3.2 Summary of Approach

In the course of preparing the WRMP, ESW has considered the outputs of the report on Consistency of Reporting Performance Measures (UKWIR, 2017). Some of the elements have been readily implemented but others require detailed studies or significant investments which are likely to take two to three years to complete. The impact of each of these elements has been assessed and an overall range of outputs derived.

The SELL model used for PR14 has been updated with new company-specific input data. The minimum achieved leakage levels (MAL) within DMAs have been referenced to the range of industry "Frontier" values.

The 2016/17 base year has been derived and a number of scenarios forecast to reflect the potential range of impacts from the consistency projects. For each of these starting values, future profiles of leakage levels have been projected forward to 2045.

5.3.3 Adoption of Consistency of Reporting Measures

The 2017 UKWIR report contains a compliance checklist containing sixteen components. The checklist requires each element to be assessed using a Red / Amber / Green scale and any reasons for non-compliance to be documented.

The Company has further divided this checklist into sub-criteria and assessed each element individually. The output of this work identifies a number of enhancements to the current reporting methods which are categorised into two main areas:

a) Changes to the calculation method
b) Improvements to the data quality.

Work is under way to ensure that ESW is fully compliant with all aspects by the commencement of the AMP7 period.

Changes in Calculation Method

The calculation changes have been incorporated within the corporate leakage analysis software (Netbase). A second database has been constructed adopting these changes to enable the effects to be monitored alongside the existing reported values.

The key changes are:

a) Weekly leakage values calculated from a seven-day mean rather than median value.
b) The minimum night flow period is calculated from a fixed hour rather than a minimum rolling one hour period.
c) Individual daily leakage values are allowed to be lower than zero rather than fixed at zero.

The effect of these improvements is, therefore, fully accounted for in the company "bottom-up" pre-MLE value of leakage.

Improvements in Data Quality

The improvements in data quality require significant investment in terms of time and money and it is not possible to predict the effect of these accurately.

The key requirements are:

a) Implementation of Fast Logging Technology – The report identifies a requirement to calculate leakage values from all 52 weekly values. In areas where seasonal demands are encountered, fast logging techniques will be used to derive dynamic household night use values.

b) Large Metered Customer Logging – All customers with a daily consumption of a minimum of 24 – 48 m^3/hour will be continuously logged using telemetry loggers.
c) Study of Plumbing Losses – A company specific study will be undertaken to understand the magnitude of customer plumbing losses. These company values will replace the generic industry values currently used.
d) District Metered Area (DMA) Coverage – Additional DMA's will be created to ensure that a minimum of 95% of properties are within reporting areas.
e) Non-Household Seasonal usage – A study will be undertaken to identify customers with significant seasonal usage patterns. A sub-set of these customers will be permanently logged and the seasonal profiles defined will be applied to other customers with a similar demand type.
f) Night Flow Interpolation of Missing Data – The report identifies a requirement to treat missing and corrupted data differently. This requires a change to the analysis routines within Netbase and will be incorporated in the next software release.

These data improvements will be delivered within a three year period and, as each individual element is delivered, the effect on leakage will be incorporated into the second Netbase database. This will ensure that the effects of all changes are fully understood and incorporated prior to the AMP7 reporting period.

5.3.4 SELL Review

Overview of SELL Model

In 2007 ESW introduced a new SELL model to replace the earlier LIMES model. The model is based on the natural rates of rise of leakage, with the economics of active leakage control being optimised at DMA level. It was conceived and designed in 2007 by in-house experts but has been completely rebuilt for the PR19 submission. It is fully compliant with the recommendations of the Tripartite Report of 2003, and therefore conforms to best practice.

ESW has also complied with most of the recommendations of the Strategic Management Consultants (SMC) report "Review of the calculation of sustainable economic level of leakage and its integration with water resource management planning" commissioned by Defra, Environment Agency and Ofwat (2012). Specific actions we have taken include:

- ESW has considered all operational leakage options to reduce leakage. ESW has also included a stand-alone optimisation of pressure management. However ESW has not considered other capital options such as mains renewal as we have not constructed a least cost plan for any of our resource zones, as none are expected to be in deficit within the planning period.
- ESW has included the environmental, social and carbon costs of leakage and leakage management, using company or catchment-specific values where appropriate.

- The study on "Factors Affecting Minimum Achieved Leakage Levels" (UKWIR, 2016) found that it is not currently possible to forecast minimum achievable leakage levels. However ESW has used the methods presented in this report to calibrate our minimum achieved levels against those of other UK companies to demonstrate that they are appropriate for a company with relatively low leakage.
- ESW has not considered the economics of operating slightly above or below the SELL, as our proposed performance commitments for leakage are substantially below the SELL.
- In the derivation of ESW's leakage cost curves, ESW has assumed that it will achieve substantial future improvements in the efficiency of our active leakage control processes.
- ESW is actively investigating and trialling opportunities to reduce leakage by the use of innovative techniques.
- Since 2010 we have routinely carried out leakage assessments at sub-DMA level prior to implementing leakage-driven mains renewal schemes, and as a result have achieved efficiencies in our renewal programme by renewing parts of DMAs where appropriate.

The SELLs are calculated at DMA level, and these are then simply summed to give the overall ELL at company level. The model is applicable to a system in steady state.

A water undertaker has a choice of two operational options in response to increasing levels of leakage:

i. Increase the volume of water put into supply
ii. Increase the level of effort on active leakage control (ALC).

Figure 5.2 illustrates the trade-off between the two options. Increasing the volume of water put into supply results in increased production costs (i.e. cost of water), which follows a linear relationship. The cost of increasing effort on active leakage control (ALC) is non-linear and shows diminishing returns. The total cost curve is the sum of the marginal supply cost curve (the cost of water lost) and the manpower cost curve (the manpower costs incurred in undertaking ALC). It is at a minimum when the gradients of the two component curves are equal and opposite.

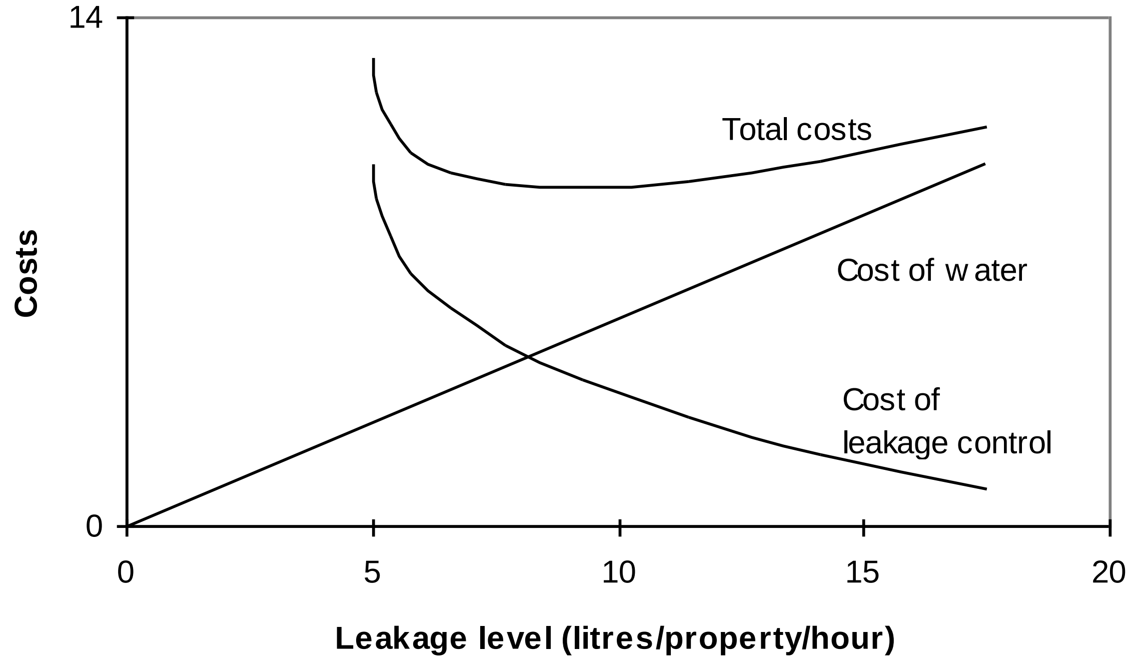


Figure 5.2: Leakage cost curves behaviour of leakage in a DMA

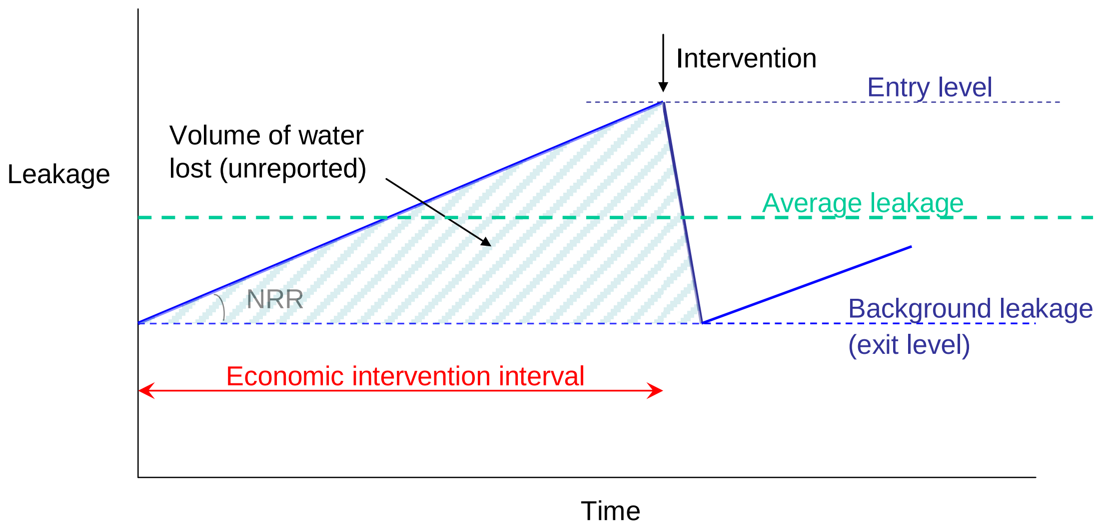


Figure 5.3: Hypothetical profile of leakage in a DMA

At time zero on Figure 5.3, an intensive leak detection and repair campaign has just been completed, and leakage has been reduced to the background level. Thereafter leakage rises at a gradient equal to the natural rate of rise. Eventually another leakage reduction campaign is undertaken, and leakage is again brought down to the background level. The shaded triangle represents the volume of water lost above the background level between interventions, i.e. water lost due to unreported burst leakage. It can be shown that the total cost to the company is a minimum when the value of the water lost between interventions is equal to the cost of the intervention. The intervention frequency will then be the economically optimum intervention frequency.

The average leakage level in the medium or long term is at half the height of the triangle as shown, and this is the economic level of leakage for the DMA. The ELL for the company is then calculated by summing the ELLs for the DMAs.

The output of this calculation process is the short-run SELL, which represents the optimum balance between the manpower costs of active leakage control and the marginal operational costs of water (power and chemicals). For zones which are in supply-demand deficit at some time within the planning horizon, additional leakage control options must be considered, along with other demand management options and possible new resource schemes. However none of the resource zones in ESW are expected to be in deficit within the planning horizon.

In keeping with the 2012 SMC report, a separate economic optimisation of pressure management is carried out as a stand-alone option even in zones without resource deficits. Detailed analysis has shown that there is very little scope for additional pressure management schemes to be implemented economically. Further work will continue, however, to optimise all existing schemes to ensure that the benefit of pressure management is maximised.

Data Updates

Background leakage levels and Natural Rate of Rise values have been updated with new data values representing the five years since the PR14 submission. These elements were completed within separately commissioned studies.

All other elements of data for the model were collated and updated in-house, incorporating Netbase data outputs, Active Leakage Control (ALC) team records and marginal cost of water values.

External costs of leakage have also been updated, the most notable being the carbon cost of leakage. This utilises an emission factor of 0.44 kg of CO_2 per KWh and a non-traded cost of carbon of £14 per ton of CO_2. The resulting cost was £0.71/Ml.

Background Leakage Frontier levels

For each of the DMAs with observed MAL values, the MAL values and other DMA characteristics data were used to calibrate the “MAL explanatory factors relationships” developed by RPS as part of the 2016 UKWIR study on “Factors Affecting Minimum Achieved Leakage Levels” (Report No. 16-WM-08-58)

An equation was calibrated for each of the four mains material cohorts. The equation is of the form:

$MAL\ (l/hr) = (L/N)^{a}.AZNP^{b}.R1^{c}.D1^{d}.R2^{e}.D2^{f}.kJ^{g}.Age^{h}$

Where:

L/N = Network Density (m/prop)
AZNP = Average Zonal Night Pressure (m)
kJ = size (joints in thousands)
R1 = Reported customer-side repairs (CSP) per year per 100 properties
R2 = Reported company-side repairs (mains, communications pipe and ancillary leaks) per year per kJ
D1 = Detected customer-side repairs (CSP) per year per 100 properties
D2 = Detected company-side repairs (mains, communications pipe and ancillary leaks) per year per kJ
Age = Average DMA age based on mains pipe age weighted by length (years).

a to h are exponents determined through regression performed on the MAL_{50} values.

These relationships were then utilised to derive additional frontier level values in the range MAL_{15} to MAL_{50}. The background levels derived were then compared to these reference values as follows:

Table 5.8: MAL reference values

MAL (m^3/d)	MAL_{50} (m^3/d)	MAL_{45} (m^3/d)	MAL_{40} (m^3/d)	MAL_{35} (m^3/d)	MAL_{25} (m^3/d)	MAL_{15} (m^3/d)
34.39	43.97	39.63	35.72	31.85	24.45	16.74

This work shows that the calculated background level of leakage of 34.39 m^3/day is equivalent to an industry value of approximately MAL_{39}. In other words, the overall level of minimum achieved leakage levels in ESW is equivalent to the 39th percentile of values achieved at UK national level. This is appropriate for a company with lower than average leakage levels.

Results of ALC Modelling

The resulting leakage-cost curves for active leakage control are shown in Figure 5.4.

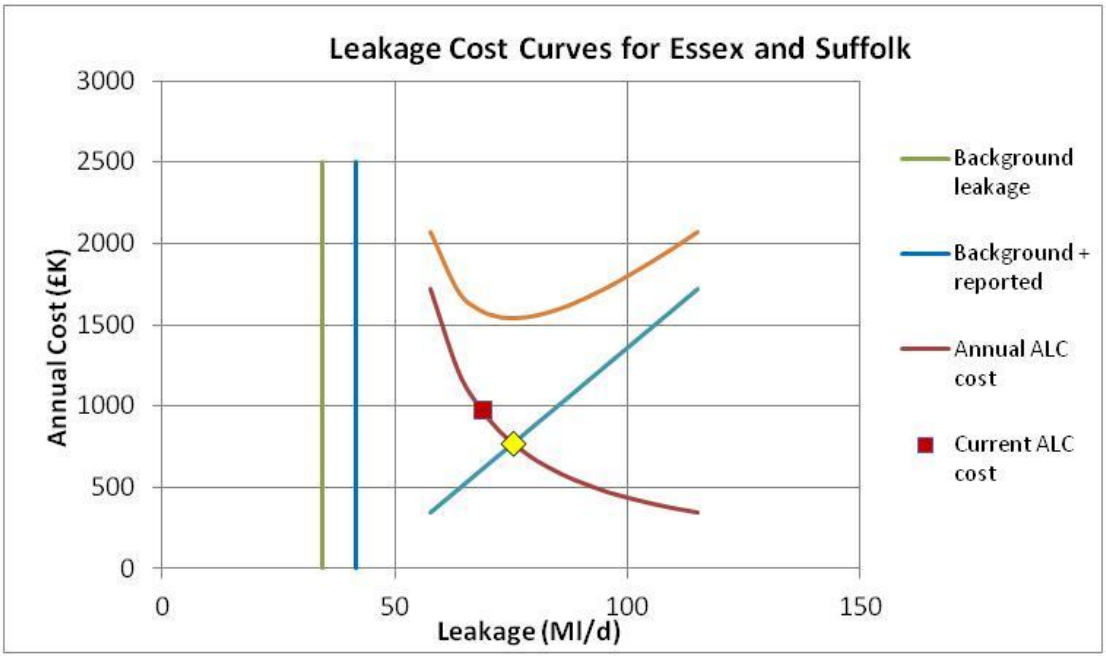


Figure 5.4: ALC cost curve for Essex and Suffolk

Figure 5.4 shows that the current SELL is 75.35 Ml/d. This SELL is a short-run economic level, and is considerably higher than both the current leakage level and the current target. This is because at all previous periodic reviews the Essex zone was in supply-demand deficit. This meant that the economic level of leakage was a long-run SELL which resulted in leakage targets which were substantially lower than the current short-run SELL. The completion of the Abberton Reservoir scheme means that Essex is no longer in deficit, which leads to a short-run SELL which is now much higher. However the Company accepts that performance commitments for leakage cannot rise.

Figure 5.4 shows that the point representing the current position, i.e. the current leakage level and the current annual expenditure, lies on the ALC curve. For this purpose, the calculation of current expenditure is consistent with the unit rates used for the derivation of the ALC cost curve itself, i.e. it includes all marginal costs relating to the active leakage control process. The current leakage level is the reported value for 2016/17, as for a given level of expenditure the actual leakage level will vary with weather conditions

Previous submissions and current position

The most recent submissions on the SELL analyses and leakage targets were made as part of the Strategic Business Plans and WRMP for AMP5 and AMP6. It was demonstrated that the SELL for AMP5 was 68.5Ml/d and for AMP6 was 81.81Ml/d. The stepped increase was due to the completion of the Abberton scheme and the resulting need to change from a long run to short run marginal cost adoption. The leakage targets since AMP5 have always been below the SELL value.

The following leakage targets through the AMP5 and AMP6 periods were agreed with OFWAT.

Table 5.9: Leakage targets for AMP5 and AMP6.

Annual Reporting Period	Leakage Target (Ml/d)
2010/11	66.0
2011/12	66.0
2012/13	66.0
2013/14	66.0
2014/15	66.0
2015/16	66.0
2016/17	66.0
2017/18	66.0
2018/19	66.0
2019/20	66.0

5.3.5 Future Profiles of Annual Leakage

Scenario Approach

The ongoing consistency programme creates a new problem for this WRMP submission. Whilst the reported value of leakage for 2016/17 has been calculated, audited and submitted, this value will change as the individual projects are completed and the effects incorporated into the calculation. A further complication is that the changes will be made to the value of bottom-up leakage, hence all of the outputs from the MLE water balance process will also change.

At this stage ESW has taken the reported 2016/17 values to be equivalent to the base year. In parallel, a further number of scenarios have been calculated which will represent a range of leakage outputs including one value which is considered to be the most probable outcome. All of these scenarios are based on the incorporation of calculation method changes which are fully understood. Each of the bottom-up scenarios will be separately input into the MLE water balance process to output each of the other associated parameters.

Leakage Reductions during AMP7

Leakage reductions have been proposed for AMP7 and are calculated as a percentage reduction below the existing 2019/20 performance commitment value. The absolute values for leakage performance commitments within AMP7 will, therefore, be calculated as:

2019/20 Perf. Commitment ± Consistency Adjustment – AMP7 Reductions %

With the current leakage calculation method, the Performance Commitment for 2019/20 is 66 Ml/d. Following the changes to be made for compliance with the Leakage Consistency report, we estimate that the most probable value of this Performance Commitment will be 62.6 Ml/d. However our scenario analysis shows that the actual value of this PC could range from 67.6 to 57.5 Ml/d.

For AMP7, the planned percentage reduction over five years is 17.5%. Therefore the range of Performance Commitments through the five-year period for the three scenarios is as shown in the following table.

Table 5.10: Performance commitments through AMP7

AMP	Year	Leakage Performance Commitments (Ml/day)		
		Most Probable	Upper Scenario	Lower Scenario
AMP6	2019/20	62.6	67.6	57.5
AMP7	2020/21	60.4	65.2	55.5
	2021/22	58.2	62.8	53.5
	2022/23	56.0	60.5	51.4
	2023/24	53.8	58.1	49.4
	2024/25	51.6	55.7	47.4

These leakage reductions will be achieved by a combination of the following measures:

- Maintaining the right level of committed resources for leak detection and repair
- Optimisation of all existing pressure management installations
- Increased efficiency in the active leakage control process, especially through the use of noise loggers. ESW already make use of temporary noise logger deployments, but from 2018 onwards ESW intends to invest heavily in the latest generation of noise loggers for permanent or semi-permanent installation.
- An expanded programme of leakage driven mains renewals
- Other innovations (see Section 5.3.6)

This plan will maximise the most cost effective solutions available to achieve the target reduction by 2024/25.

Leakage Reductions beyond AMP7

For each of the four periods of five years, the Company proposes a further 10% reduction on the performance commitment for the final year of the preceding AMP period. Over the 20 year period 2025 to 2045 this will equate to a further 34% reduction on the PC for 2019/20. The proposed PCs for the final year of each of the four AMPs, for the three scenarios, are listed in the following table.

Table 5.11: Performance commitments beyond AMP7

AMP	Final Year	Leakage Performance Commitments (Ml/day)		
		Most Probable	Upper Scenario	Lower Scenario
AMP6	2019/20	62.6	67.6	57.5
AMP7	2024/25	51.6	55.7	47.4
AMP8	2029/30	46.5	50.2	42.7
AMP9	2034/35	41.8	45.1	38.4
AMP10	2039/40	37.6	40.6	34.6
AMP11	2044/45	33.9	36.6	31.1

These leakage reductions will be achieved by a combination of the following measures:

- Maximise resource levels for leak detection based on the SELL ALC curve.
- Increased efficiency in the active leakage control process.
- Other innovations (see Section 5.3.6 below)
- Increased levels of mains replacement

Most of the cost effective solutions will be exhausted during AMP7 and at the moment the only remaining option to reduce leakage further will be through increased mains replacement. This is much more expensive per Ml/d reduction so the forecast costs for AMP8 to AMP11 increase significantly.

5.3.6 Innovations for Leakage Management

In addition to the measures listed above in ESW will invest in the following innovative initiatives for leakage management during the latter part of AMP6 and into AMP7.

- Sophisticated data analytics to seek new insights into leakage and leakage management. This will be a direct follow-up to the very successful NWL Festival of Innovation held in Newcastle in 2017.
- Detailed review of operational leakage survey strategy
- Investigations into the impact of pressure transients
- Trials of new leak detection equipment

ESW will also continue to take the lead role in UKWIR's "Zero Leakage by 2050" research programme.

6.0 CLIMATE CHANGE

6.1 Introduction

This chapter outlines how ESW has assessed the risk and possible impact of climate change on the deployable output (DO) of current sources of water and on customer demand. The assessment has been undertaken following guidance set out in the WRPG (Environment Agency, 2017) and is presented in the following sections:

- Vulnerability to climate change;
- Method selection;
- Presentation of climate change assessment results (scenarios);
- Scaling method used to factor in any climate change that has already happened; and
- Allowance for climate change in the headroom assessment

6.2 Vulnerability to Climate Change & Method Selection

6.2.1 Climate Change Vulnerability Assessment

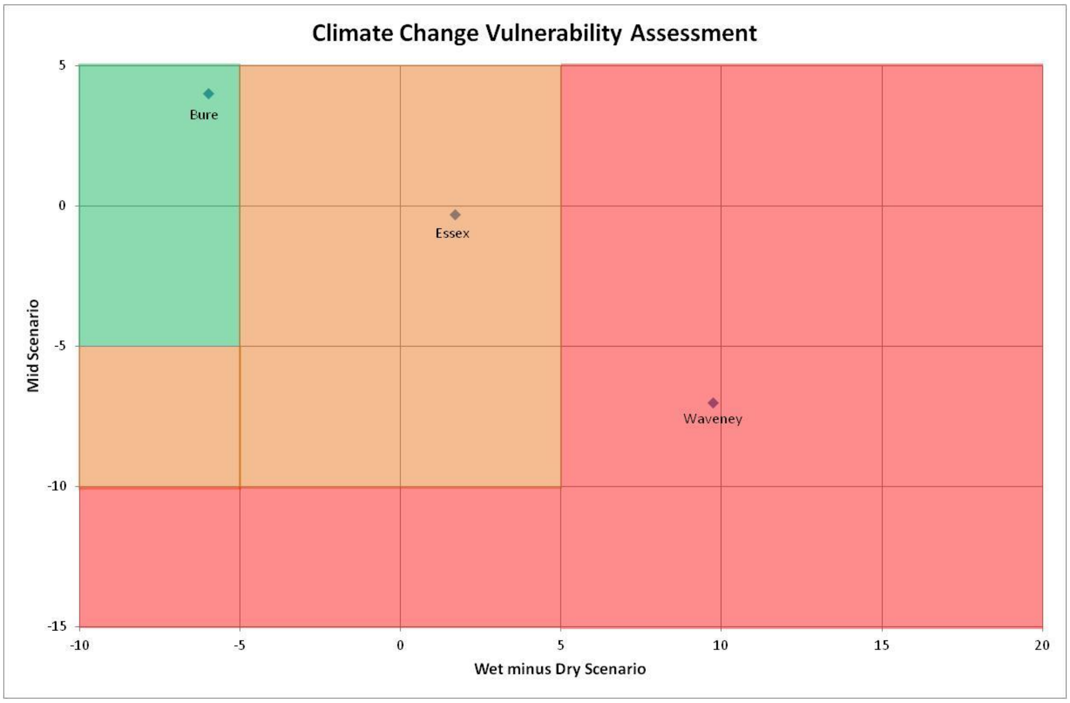
A climate change vulnerability assessment is required to understand how vulnerable each Water Resource Zone (WRZ) is to changes in DO as a result of climate change and therefore which method should be used to assess the effect of climate change on WRZ deployable output.

ESW has undertaken a climate change vulnerability assessment which was based on:

- A magnitude versus sensitivity plot of DO change from previous climate change assessments; and
- A table summarising the information which will be used to determine the final vulnerability of a resource zone to climate change;

6.2.2 Magnitude versus Sensitivity Plot

A Magnitude versus Sensitivity Plot (Figure 6.1 below) covering all four of ESW's WRZs was prepared using data from ESW's PR14 WRMP assessment of climate change on DO. It shows the change in DO for the "mid" climate change scenario plotted against the uncertainty range, where the latter is calculated as the difference between the "wet" and "dry" scenarios.



Uncertainty Range (% change wet to dry)	Mid-scenario (% reduction in deployable output)		
	5%	>5%	>10%
<5%	Low	Medium	High
6% to 10%	Medium	Medium	High
11% to 15%	High	High	High
>15%	High	High	High

Figure 6.1: Magnitude verses Sensitivity Plot

The above plot is based on the following data:

Table 6.1: PR14 Climate Change Data - %age Change from Baseline DO

	Essex	Waveney	Bure
without climate change	-	-	-
with climate change (Driest)	-6	-10.1	-1.08
with climate change (Mid)	4	-7	-0.31
with climate change (Wettest)	10	-3.7	0.61

Using the Magnitude verses Sensitivity Plot approach as an initial climate change vulnerability assessment tool, it is possible conclude that:

- the River Bure DO has a low vulnerability to climate change;
- the Essex WRZ as a whole has a medium vulnerability to climate change; and
- the River Waveney DO has a high vulnerability to climate change.

However, the WRPG states that the methods a water Company uses to assess the effect of climate change on DO should be proportionate to the risks presented by climate change to each water resource zone.

Early draft PR19 supply demand balance calculations indicated that all four WRZs will have a supply demand balance surplus across the full planning horizon. Consequently, climate change poses a lower risk to security of supply than otherwise would have been the case.

Additionally, ESW's surface and groundwater sources have historically performed well during drought.

For groundwater, lowest pumped water levels in all sources have always remained significantly above deepest advisable pumped water levels. For surface water, Ormesby Broad, Lound Lakes and Fritton Lake have always quickly recharged during the winter.

Additional investment, namely Hartismere Borehole 1, a new treatment works in Hartismere WRZ and the Abberton Scheme in Essex WRZ mean that both WRZs will be more robust during future droughts compared to those in the 1990s and therefore less vulnerable to climate change.

Tankering of treated water was required between the Northern, Central and Hartismere WRZs in 1997. However, subsequent investment in a new groundwater source and treatment works at Bedingfield would mean that tankering would now not be required should a similar drought be experienced with similar customer demand.

Although Chalk groundwater levels in Hartismere Borehole 6 were slightly more susceptible to drought than elsewhere in the Company, even here, groundwater levels in the 1997/98 drought remained well above the defined deepest advisable pumped water level. This would also indicate that climate change poses a lower risk to security of supply within the Hartismere WRZ which historically has been most effected by drought.

Taking account of the above, ESW considers it is reasonable and appropriate to use medium or low vulnerability methods for its four WRZs. The chosen methods are detailed in section 6.3 below.

6.3 PR19 Climate Change Assessment Method

6.3.1 General Approach

The impact of climate change on supply has been considered in terms of:

- the explicit effect on DO; and
- the uncertainty of the effect on DO as described in target headroom (using triangular distributions defined by minimum, best estimate and maximum scenarios)

In line with the WRPG, ESW has estimated the impact of climate change on DO using the following four stage approach:

Stage 1: Calculate river flows and/or groundwater levels for a water resource zone in the 2080s, under the number of climate projections appropriate to the level of assessment being carried out.

Stage 2: Calculate DO for the water resource zone in the 2080s under each climate projection being assessed.

Stage 3: Scale the impacts of climate change by determining the change in DO for each year of the planning period and input these figures into the water resources planning tables.

Stage 4: Determine the uncertainty associated with climate change for inclusion in target headroom.

6.3.2 Essex WRZ Surface Water Climate Change Assessment Method

The previous guidance (Environment Agency, 2012b) for estimating deployable output for river flows under climate change has been superseded by a new approach, outlined in *Estimating the impacts of climate change on water supply* (Environment Agency, 2017b). An important difference is that this updated approach uses the 2080s time period, which ensures that the climate signal is identified over natural variability, resulting in greater consistency between different sources of climate information.

Three tiers of analysis are presented for calculating river flows for input into a water resources model:

- Tier 1 analysis for if the vulnerability is low and there are no rainfall runoff models
- Tier 2 analysis for if the vulnerability is medium or there are available rainfall-runoff models
- Tier 3 analysis for where there is high vulnerability

As ESW has rainfall-runoff models for its Essex System surface water catchments, it was agreed that Tier 2 analysis should be used for the Essex System. The Tier 2 approach involves using the 11 climate data scenarios from the UKCP09 Spatially Coherent Projections to generate monthly climate change factors for precipitation and PET in the 2080s, to carry out rainfall-runoff modelling and create flow sequences to be used in water resource modelling.

An additional advantage of having rainfall-runoff models, and using future climate data sets which may include a drought worse than that currently on record, is that ESW is able to assess resilience "from baseline through to the end of period of interest", as specified in the WRPG.

Each of the 19 Essex System sub-catchments selected for the climate change analysis (Table 6.2) were attributed to a UKCP09 SCP grid cell, and monthly climate change factors were obtained for each relevant grid cell in the form of monthly percentage change in rainfall and temperature. Rainfall and PET time series are required for input into the rainfall-runoff models, so the monthly temperature climate change factors were converted into a monthly percentage change in PET. The baseline rainfall and PET time series for each sub-catchment were then perturbed using the monthly climate change factors, and rainfall-runoff model input files were created containing the perturbed rainfall and PET time series.

The input files were run through the rainfall-runoff models to obtain 19 river flow time series for the Essex System sub-catchments. These river flow time series were then aggregated and factored to produce the four river flow time series to be input into the Essex System Aquator model. This process was repeated for each of the 11 climate change scenarios.

In total, 44 perturbed time series were imported into the model, 11 for each river flow time series, and the appropriate time series were assigned to catchment components for each of the 11 climate change scenarios. The components that are assigned a river flow time series sequence in the model are listed in Table 6.3.

Table 6.2: The nineteen sub-catchment river flow time series used to create the four river flow time series for input to Aquator model

Ely Ouse @ Denver	Little Ouse @ Abbey Heath Lark @ Temple Wissey @ Northwold Stringside @ Whitebridge Lea Brook @ Beck Bridge Rhee @ Burnt Mill Cam @ Dernford Snail @ Fordham Swaffham Lode @ Swaffham Bulbeck Quy Water @ Lode
Chelmer @ Langford	Chelmer @ Springfield Can @ Beach's Mill Ter @ Crabbs Bridge Sandon Brook @ Sandon Bridge
Blackwater @ Langford	Blackwater @ Appleford Bridge Brain @ Guithaven Valley
Stour @ Stratford	Stour @ Langham Box @ Polstead Brett @ Hadleigh

Table 6.3: Components Assigned a River Flow Time Series Sequences

Catchment Model Reference	Catchment Name	Assigned time series
CM2	Upper Stour Kedington	Stour @ Stratford
CM3	Roman River	Blackwater @ Langford
CM4	Upper Blackwater	Blackwater @ Langford
CM5	River Chelmer	Chelmer @ Langford
CM6	Hanningfield Inflow	Chelmer @ Langford
CM7	Abberton Inflow	Stour @ Stratford
CM8	Lower Stour Stratford	Stour @ Stratford
CM9	Upper Stour Wixoe	Stour @ Stratford
CM10	Lower Stour Langham	Stour @ Stratford
CM11	Upper Stour Westmill	Stour @ Stratford
CM12	Lower Stour Lamarsh	Stour @ Stratford
CM13	Lower Blackwater	Blackwater @ Langford
CM14	Ely Ouse	Ely Ouse @ Denver
CM15	Cut off Channel	Ely Ouse @ Denver

6.3.3 Suffolk Northern Central WRZ Surface Water Climate Change Assessment Method

ESW does not yet have rainfall-runoff models for surface water resources in Suffolk, namely the River Bure and Waveney, which constrains the range of potential options available. Tier 1 analysis is required, which involves the use of Future Flows Hydrology monthly change factors.

Climate change factors were required for the following Suffolk catchments:

Table 6.4: Gauging station flows required for climate change analysis

River	Station	Station No.	Period of Record	Catchment Area (km^2)
Waveney	Ellingham Mill	34013	1972-2001	670.0
Bure	Ingworth	34003	1959-2011	164.7

Neither of these catchments is a Future Flows (FF) catchment with derived perturbed time series, therefore it was necessary to estimate factors from catchments that do form part of the FF database.

Proximal FF catchments were identified, and their characteristics were assessed. The proximal catchments for each location are:

Table 6.5: Proximal Future Flows Catchments to Waveney at Ellingham Mill and Bure at Ingworth

ESW River	FF Station No.	FF River	FF Station	FF Catchment Area (km^2)
Waveney	34006	Waveney	Needham	370
Bure	33019	Thet	Melford Bridge	316
	33044	Thet	Bridgham	278
	33063	Little Ouse	Knettishall	101
	34002	Tas	Shotesham	147
	34011	Wensum	Fakenham	162
	34014	Wensum	Swanton Morley	398
	34018	Stiffkey	Warham All Saints	88

For the River Bure, the Thet at Melford Bridge (33019) was identified to be a more favourable selection than the other options based on its Nash-Sutcliffe statistic of 0.80, a measure of whether the modelled time series describes the observed time series better than the long-term average (a value of 1 means perfect agreement). The decision was therefore made to use this catchment to derive the climate change factors for the Bure.

The FF monthly change factors were obtained for FF stations 34006 (Waveney at Needham) and 33019 (Thet at Melford Bridge) and used to perturb the baseline flows for the Waveney at Ellingham Mill and the Bure near Wroxham, to obtain a river flow time series for each of the 11 FF climate change scenarios.

6.3.4 Groundwater Climate Change Assessment

Background

The WRPG states that a water company's previous assessment of climate change as used for WRMP14 can be used. This PR19 WRMP has used the PR14 WRMP groundwater climate change assessment output to define groundwater deployable outputs with the effects of future climate change. This is because:

i. the CP09 climate projections have not been updated in the intervening period. The CP18 climate projections will not be published until 2018;
ii. The Environment Agency's regional model, which was used for the PR14 assessment, remains the model of choice for East Anglia; and
iii. There have been no known changes to borehole performance that could be related to dry weather and climate change.

Therefore, the effect of climate change on groundwater DO for this PR19 WRMP remains the same as that reported in the PR14 WRMP. Nevertheless, the effect of climate change has been applied to the latest PR19 groundwater source deployable output assessments.

PR14 Method

The PR14 climate change assessment for ESW groundwater sources was undertaken in 2012 by consultants Amec. The PR14 method used the Environment Agency's regional groundwater model and a targeted sample of the UK CP09 data set that was chosen following drought indicator analysis. The method was very similar to the PR19 Tier 2 approach outlined in the Environment Agency's supplementary guidance entitled, "Estimating the Impacts of Climate Change on Water Supply (Environment Agency, 2017).

This two staged process involved undertaking a drought indicator analysis to determine the sensitivity of the system to water availability in drought conditions and then using the drought indicator to sample climate change projections.

In order to avoid running a large number of projections that were not the focus of interest for water resources planning, the PR14 WRPG stated that where a water resource zone was confirmed as being sensitive to drought, then the UKCP09 data set should be sampled in two stages:

- First using Latin Hypercube Sampling (LHS) to develop a minimum of 100 climate projections;

- Secondly, creating a sub-sample of this data set of a minimum of 20 scenarios, based on the drought indicator that selects sufficient dry samples in addition to achieving a representative spread of projections across the full sample.

Selecting a Sub-Sample of 20 UKCP09 Scenarios

This work was completed by HR Wallingford for AWS, who like ESW, operate in the Anglian River Basin. LHS was employed to select a sub-sample of 100 UKCP09 scenarios of monthly climate change perturbation factors for precipitation and temperature. Factors for Potential Evaporation (PET) were then derived from the temperature data using the Oudin *et al* (2005) approach (AWS, 2012).

The range and likelihood of projected changes for the 100 scenarios were consistent with scenarios from individual UKCP09 grid squares across the area of interest. Consequently, HR Wallingford concluded that the 100 scenarios are representative of the Anglian River Basin (AWS, 2012).

HR Wallingford then undertook further analysis and reduced the sub-sample of 100 scenarios down to 20 scenarios for groundwater modelling purposes (AWS, 2012).

To do this, AWS initially intended to use hydrometric data from a number of key monitoring points to derive a suitable drought indicator such as annual aridity. This indicator would have then been used to characterise the sensitivity of an aquifer to climate variability and to guide sampling of the UKCP09 projections. However, this was not possible given the complexity of the hydrogeology and also due to the limited data and drought events within the data. There was reasonable correlation between annual precipitation and groundwater level at three AWS groundwater sources. However, AWS and HR Wallingford concluded that using precipitation alone to sample UKCP09 scenarios would carry the risk of sampling a set of unrepresentatively hot or cool scenarios (AWS, 2012).

Consequently, HR Wallingford concluded that temperature should also be included in the process as changes to temperature in the future will significantly affect future evapotranspiration and soil moisture deficit. Given the above, HR Wallingford used the following methodology to reduce the sub-sample of 100 scenarios down to a sub-sample of 20:

- LHS was employed to provide an initial sub-sample of 100 scenarios from the full UKCP09 ensemble of 10,000 projections of rainfall and temperature. This considered the covariance across 8 dimensions (precipitation and temperature for four seasons);
- A comparison of the sub-sample of 100 scenarios was made against the full ensemble of 20,000 in terms of changes to annual and seasonal precipitation and temperature;
- The 100 samples were then ranked using a FAO-56 based lumped recharge model to derive relative estimates of changes to average annual recharge;

- From the ranked 100 scenarios, 10 scenarios were then selected that produced the greatest reductions in average annual recharge. A further 10 scenarios were then selected that were evenly distributed over the full range of estimated changes to average annual recharge (the split sample);
- A comparison of the split sample against the 100 LHS scenarios and the full UKCP09 ensemble of 10,000 scenarios was then made in terms of changes to annual and seasonal precipitation and temperature; and
- Sample weights were then derived based on average annual recharge to avoid introducing bias in the interpretation of the projected impacts on groundwater levels due to the split sampling approach (AWS, 2012).

HR Wallingford confirmed that the sub-sample of 20 scenario perturbation factors should be applicable for the whole of the NEAC and Essex groundwater model areas which cover all of ESW's WRZs.

Modelling Approach

ESW commissioned AMEC to assess the potential impacts of climate change on groundwater levels in the aquifers from which it abstracts. AMEC used two existing groundwater models, the NEAC model for the Suffolk sources and the Essex model for the Essex sources, together with the selected 20 UKCP09 perturbation factors to predict the change in groundwater levels expected under future climate change. In addition, a number of demand restriction scenarios were conducted.

This project utilised model output from runs undertaken by AMEC for AWS on a parallel project. The project extracted results from two existing suites of 20 model runs of the NEAC and the Essex models (respectively) based on perturbed climate. The perturbation factors were derived by HR Wallingford for AWS.

The project work was split into a number of tasks as follows:

- Review of baseline model representation and calibration;
- Climate change scenario model runs – non demand restriction
- Climate change scenario model runs – demand restriction
- Summary of model output and predicted change in groundwater levels under climate change.

Review of Model Calibration

AMEC reviewed the model representation and calibration in the vicinity of the ESW sources by comparing abstraction return data to how the abstractions were represented in the groundwater model. A further check was also undertaken to review regional groundwater heads in the vicinity of the sources. The sources were grouped geographically by model area and a hydrogeological context diagram for each source was produced that included solid geology and surface water features as well as the abstraction and observation locations. Model refinement would have been evoked if review of the model representation had identified significant differences between modelled and real abstraction or modelled and observed heads.

However, this was not the case and the model representation was considered fit for purpose.

Climate Change Scenario Model Runs

The predictions of future rainfall and temperature, which form the basis of the scenario runs, were taken from the UKCP09. A key feature of UKCP09 compared with earlier climate projections such as UKCIP02 is that the projections are probabilistic, i.e. they describe a range of possible future climates with associated probabilities.

The potential impacts of climate change on groundwater levels were assessed using the North East Anglian Chalk (NEAC) groundwater model and the Essex groundwater model. This model system, developed by AMEC for the Environment Agency, comprises two separate models: a 4R (Rainfall, Runoff, Routing, and Recharge) model, which simulates recharge to groundwater, and a MODFLOW 96 VKD regional groundwater flow (AMEC, 2013).

The 4R model estimates spatially and temporally distributed recharge to groundwater as a function of landscape data (soils, topography, geology, and land use), artificial influences (surface water abstractions and discharges) and meteorological data (rainfall and evapotranspiration). The model produces daily output on a regular 200 m grid. The output from the 4R model is then used with the Modflow model to simulate groundwater levels and surface water flows (runoff and base flow).

To simulate the potential impact of climate change on recharge to groundwater, and hence on groundwater levels, the 4R model was run a number of times with “perturbed” meteorological input data. The perturbed input data were derived by applying multiplication factors to historical time series of rainfall and potential evapotranspiration (PE), which represent the change in rainfall and PE relative to a 1961-1990 baseline which is predicted to occur under climate change. The perturbation factors are based on the UKCP09 climate projections (Murphy, J.M. et al 2009 UK Climate Projects Science Report), and were derived by HR Wallingford. Twenty perturbed model simulations were then carried out for each model, together with a baseline simulation using historical time series of rainfall and PE. These models used an historical representation of abstraction and discharge. Each perturbed simulation used a different set of perturbation factors representing one possible future climate scenario. All model runs covered a period of 50 years, although the first ten years of each model run is regarded as “spin-up” during which time the output can be significantly influenced by choice of initial conditions, and model output from this period was discarded, leaving a time series of 40 years of output from each simulation.

A total of 20 model runs were performed to cover the entire range of predicted changes in recharge for both the NEAC and Essex models. The groundwater recharge for each scenario varies with one extreme representing 75% of the baseline recharge amount (the driest scenario) to 120% (the wettest scenario).

To assess the potential impact on groundwater levels, a comparison between groundwater levels during the drought period in the 1990s in the baseline run and in a selection of scenario runs at representative groundwater sources was been carried out.

Figure 6.2 shows an example of the output for Blyth Borehole 2. There is generally a consistent pattern across the results which are as AMEC expected (i.e. modelled water levels in the wetter scenarios are higher than those in the drier scenarios). The differences of the modelled water levels are generally between 0.5 and 2 m lower for the driest scenarios and 0.3 to 1.5 m higher for the highest water levels.

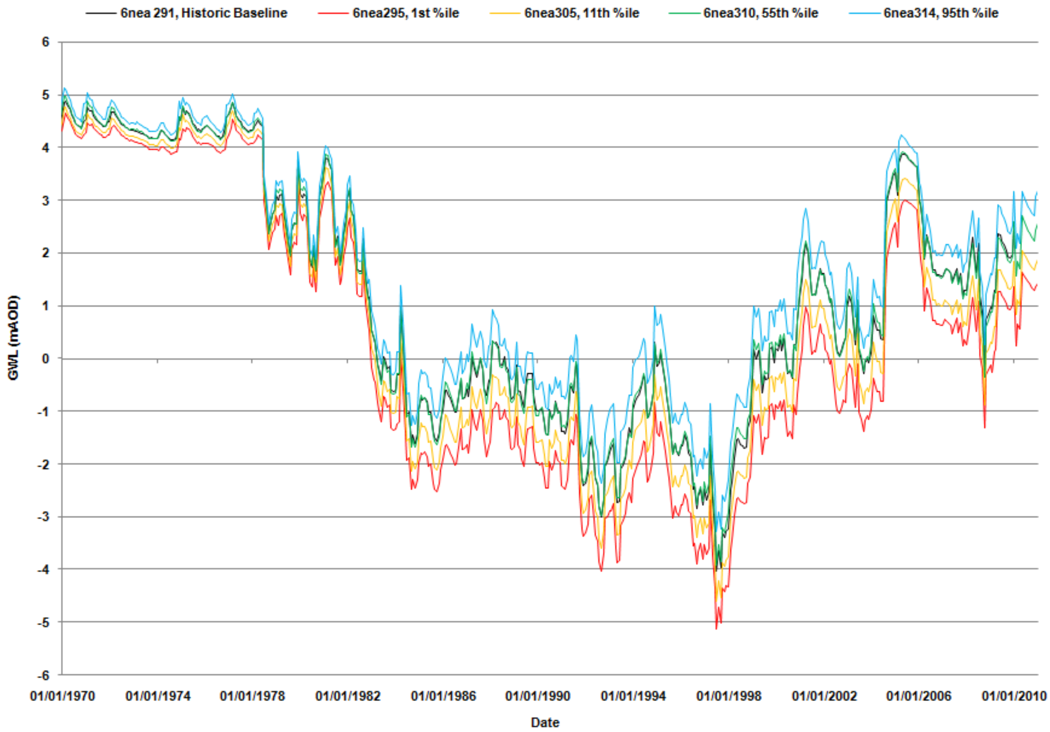


Figure 6.2: Modelled Blyth Borehole 2 Groundwater Levels

At a few of the sources there are very low impacts (e.g. Northern Central Borehole 3 and Colchester Borehole 1). This is a result of local factors, for example a very thick confined layer above the Chalk insulating the deep Chalk water levels from changes in recharge. There are a number of anomalously large drawdowns at a number of sites for the driest scenarios, i.e. at Hartismere Borehole 6. These are not thought to be ‘real’, but are artefacts of certain parts or layers of the model drying up in the driest scenarios. Conversely there appears to be a significant increase in modelled groundwater levels at Blyth Borehole 6 which again is a facet of the model layers wetting up in the high recharge scenarios compared to the baseline, and these recoveries are not thought to be ‘real’.

AMEC Conclusions

The results of the AMEC assessment can be summarised as follows:

- An initial review of the calibration in terms of heads and the abstraction representation in the NEAC Model and the Essex model lead to the conclusion that the representation was fit for purpose.;
- The NEAC and Essex regional groundwater models have been used to predict the potential impact of climate change on recharge and groundwater levels by the 2030's;
- The predictions were carried out using estimated perturbations to rainfall and potential evapotranspiration taken from the UKCP09 climate projections, for the medium emissions scenario;
- Twenty climate change scenarios were selected from the UKCP09 projections, covering the range of predicted changes in recharge compared with the 1961-1990 baseline period;
- The perturbations were applied to the historic rainfall and PE time series used with the model;
- Under the driest recharge scenario, drought groundwater levels are predicted to drop by between about 2.5 m and 0.03 m at source locations;
- Under the wettest recharge scenario, groundwater levels are predicted to rise at all source location, by between 0.08 m and about 1.5 m;

Effect of Climate Change on PR19 Groundwater Source Deployable Output

The head differences between baseline and climate change model runs identified in the above AMEC assessment have been used to establish whether climate change effects source DO.

A baseline (without climate change) DO assessment for each groundwater source has been undertaken using the 1995 UKWIR methodology (see section 3) (UKWIR, 1995a). A groundwater source performance graph has been prepared for each source which plots the following information:

- Observed groundwater levels; and
- Constraints (including deepest advisable pumped water level, pump intake depth, annual average daily licence and treatment works capacity).

The head difference between the baseline model run and the mean of the 75% and 119% recharge scenario was then applied to an observed groundwater level on the initial DO assessment groundwater source reliable output graph. Figure 6.3 below provides an example and is the assessment for Northern Central Borehole 6.

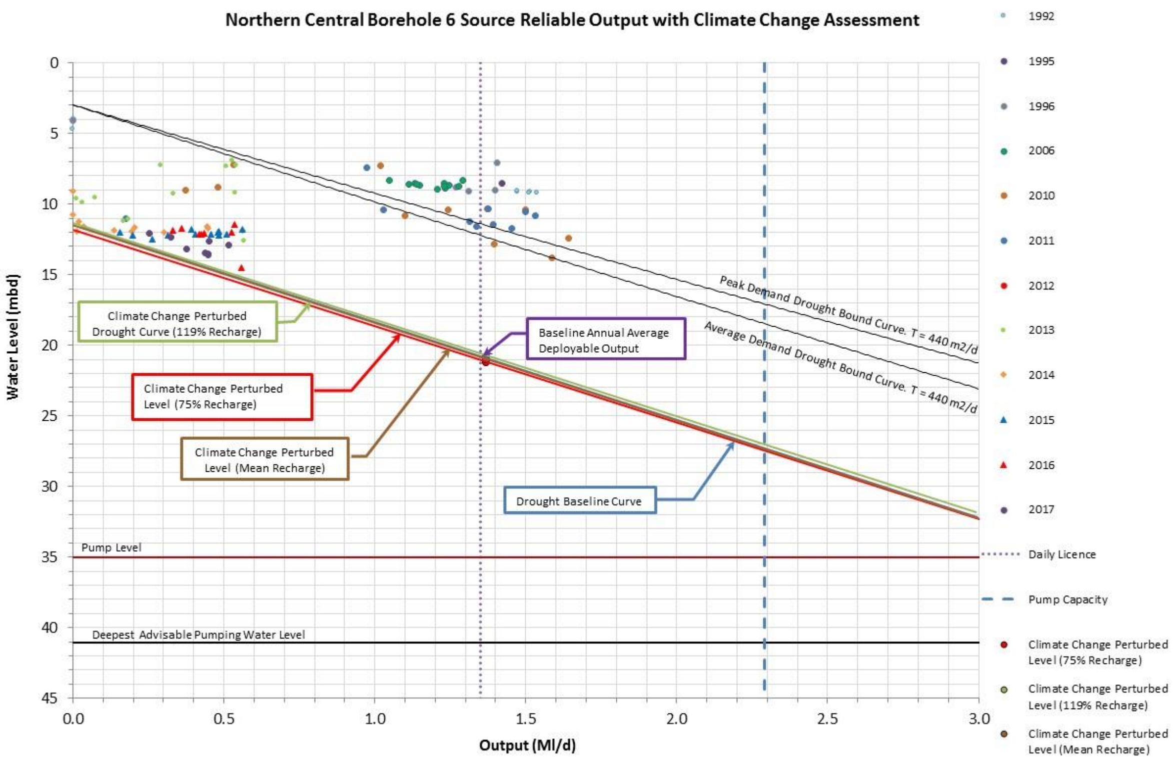


Figure 6.3: Groundwater Source Reliable Output with Climate Change Perturbed Bounding Curve

The chosen observed groundwater level was always one which intersects the drought bounding curve. A new drought bounding curve has then been created by dropping the initial curve so that it intersects the climate change perturbed groundwater level. The first constraint the new climate change perturbed bounding curve intersects is then used to define DO (with climate change).

For all of the Suffolk groundwater sources, the annual average daily licence remains the constraining factor and climate change does not cause groundwater levels to drop below the deepest advisable pumped water level (DAPWL). Consequently, DO in both the base year (2016/17) and in 2039/40 remain the same.

The same conclusion can be drawn for all of the Essex groundwater sources with the exception of South Essex Well 2. For this, DO is reduced from 3.4Ml/d (base year) to 3.3Ml/d in 2035. DO has been profiled across the planning horizon in line with the WRPG.

6.4 Presentation of climate change assessment results (scenarios)

6.4.1 Essex WRZ Surface Water Climate Change Assessment

The DO of the Essex System under each of the 11 UKCP09 SCP scenarios is shown in the table below, along with the associated change in DO relative to the baseline.

Table 6.6: Planned Levels of Service Deployable Output

Planned LoS Scenario: Essex System		Essex System Deployable Output (Ml/d)	Change from Baseline (Ml/d)
Baseline (no climate change)		392	
UKCP09 SCP Climate Change Scenarios	Scenario 1	394	+2
	Scenario 2	401	+9
	Scenario 3	403	+11
	Scenario 4	403	+11
	Scenario 5	403	+11
	Scenario 6	403	+11
	Scenario 7	380	-12
	Scenario 8	391	-1
	Scenario 9	401	+9
	Scenario 10	394	+2
	Scenario 11	396	+4
Minimum climate change scenario DO		380	-12
Average climate change scenario DO		397	+5
Maximum climate change scenario DO		403	+11

The greatest loss of DO is 12Ml/d, and the greatest gain of DO is 11Ml/d. The average change is an increase of 5Ml/d.

Generally, the climate change scenarios have a greater number of high flow days and a greater number of low flow days compared to the baseline, reflecting the predicted change in rainfall patterns with drier summers and wet winters. The Essex System is relatively insensitive to reductions in summer river flow because under the baseline scenario during the design drought, river water availability is already extremely low. However, the model is relatively sensitive to increases in winter river flow because there is capacity within the system's infrastructure to take advantage of these higher flows by abstracting the river water, and putting it into storage in the reservoirs.

The impact of climate change on the DO of the Essex System is included in the supply demand planning tables. The minimum, average and maximum DO figures calculated from the 11 climate change scenarios will be used.

The uncertainty of climate change impact on DO of the Essex System is included in target headroom. The required triangular distribution for the headroom uncertainty calculation will use the minimum, average and maximum loss to DO.

6.4.2 Suffolk Northern Central WRZ Surface Water Climate Change Assessment

River Bure Results

The results of the FF climate change assessment for the River Bure are as summarised in the table below.

Table 6.7: River Bure Deployable Output

ESW River Bure Intake			Deployable Output (Ml/d)	Change from Baseline (Ml/d)
Baseline (no climate change)			26.67	
Future Flows Climate Change Scenarios	1	FF-HadRM3-Q0_afgcx	25.91	-0.77
	2	FF-HadRM3-Q3_afixa	25.95	-0.72
	3	FF-HadRM3-Q4_afixc	24.98	-1.69
	4	FF-HadRM3-Q6_afixh	25.86	-0.82
	5	FF-HadRM3-Q9_afixi	25.86	-0.82
	6	FF-HadRM3-Q8_afixj	24.51	-2.16
	7	FF-HadRM3-Q10_afixk	24.48	-2.20
	8	FF-HadRM3-Q14_afixl	25.21	-1.46
	9	FF-HadRM3-Q11_afixm	25.91	-0.76
	10	FF-HadRM3-Q13_afixo	25.37	-1.30
	11	FF-HadRM3-Q16_afixq	25.47	-1.20
Minimum climate change scenario DO			24.48	-2.20
Average climate change scenario DO			25.41	-1.26
Maximum climate change scenario DO			25.95	-0.72

The minimum, average and maximum climate change scenario DO values are all significantly higher than the 17.84Ml/d baseline DO that ESW is reporting for this draft WRMP, therefore climate change would not constrain DO for the River Bure.

River Waveney Results

The results of the FF climate change assessment for the River Waveney are as summarised in the table below.

Table 6.8: River Waveney Deployable Output

River Waveney			Deployable Output (Ml/d)	Change from Baseline (Ml/d)
Baseline (no climate change)			13.8	
Future Flows Climate Change Scenarios	1	FF-HadRM3-Q0_afgcx	4.5	-9.3
	2	FF-HadRM3-Q3_afixa	4.7	-9.1
	3	FF-HadRM3-Q4_afixc	4.5	-9.3
	4	FF-HadRM3-Q6_afixh	4.7	-9.1
	5	FF-HadRM3-Q9_afixi	4.5	-9.3
	6	FF-HadRM3-Q8_afixj	4.5	-9.3
	7	FF-HadRM3-Q10_afixk	4.5	-9.3
	8	FF-HadRM3-Q14_afixl	4.5	-9.3
	9	FF-HadRM3-Q11_afixm	4.7	-9.1
	10	FF-HadRM3-Q13_afixo	4.5	-9.3
	11	FF-HadRM3-Q16_afixq	4.5	-9.3
Minimum climate change scenario DO			4.5	-9.3
Average climate change scenario DO			4.6	-9.2
Maximum climate change scenario DO			4.7	-9.1

Under the 11 scenarios, DO reduces by between 9.1Ml/d and 9.3Ml/d, with the average change reducing the River Waveney DO to 4.6Ml/d. This is equivalent to a reduction of 9.2Ml/d.

Ormesby Broad and Lound Ponds Results

There is not an obvious method for assessing the impact of climate change on DO of a groundwater-fed lake. For this draft WRMP, a 2080 climate change factor was estimated by taking an annual average percentage change in rainfall for the area using the UKCP09 SCP factors, and applying it to the baseline DO of both Ormesby Broad and Lound Ponds as a percentage change in DO in 2080 under a minimum, maximum and average climate change scenario. The results are presented in Table 6.9 and Table 6.10.

Table 6.9: Ormesby Broad Deployable Output

Climate change scenario	Annual average change in rainfall (%)	2080 DO (Ml/d)	Change from baseline (9.56 Ml/d)
Minimum	-8.1	8.79	-0.77
Average	1.05	9.66	0.10
Maximum	11.23	10.63	1.07

Table 6.10: Lound Ponds Deployable Output

Climate change scenario	Annual average change in rainfall (%)	2080 DO (Ml/d)	Change from baseline (8.09 Ml/d)
Minimum	-8.1	7.43	-0.66
Average	1.05	8.17	0.08
Maximum	11.23	9.00	0.91

ESW will discuss with the Agency whether there is a more appropriate approach for the final WRMP. For example, all of these lakes are predominantly groundwater fed and so a similar approach to the groundwater climate change assessment could be used. An assessment could be made by comparing the climate change perturbed groundwater level against the lake bed level to establish whether base flow could still be maintained in worse case drought years. This approach will need a water balance model to be developed for each of the lakes. It is ESW's intention to develop such a model for Fritton and Lound lakes over the coming year.

6.4.3 Suffolk Blyth and Hartismere WRZ Climate Change Assessment

Blyth and Hartismere WRZs are supplied by groundwater abstracted from Chalk and Crag aquifer boreholes.

6.5 Scaling method used to factor in any climate change that has already happened

Once a range of DO scenarios for the year 2080 have been calculated, the results then need to be scaled back to enable definition of climate change impact for any year of interest, and to account for uncertainty for inclusion in the target headroom assessment.

The WRMP19 supplementary information (Environment Agency, 2017b) defines a new scaling equation, to be applied for every year from the start of the planning period of (2016/17, in this case) to 2079/80:

$$\textit{Scale factor} = \frac{Year - 1975}{2085 - 1975}$$

The WRMP14 guidance (Environment Agency, 2012b) recommended the use of two separate scaling factors – one to be applied before 2029/30, and one to be applied after. The WRMP19 equation supersedes the WRMP14 equations based on the following:

- The inclusion of year 2085 in the equation is necessary for the calculation of impact in the 2080s;
- The gradient of the climate change impact is reduced;
- The equation results in a loss of DO by the start of the planning period, therefore accepts that some climate change will have already occurred; and

- Initial impacts are brought forward, but within 10 years the paths of the WRMP14 and the WRMP19 equations converge (Figure 6.4).

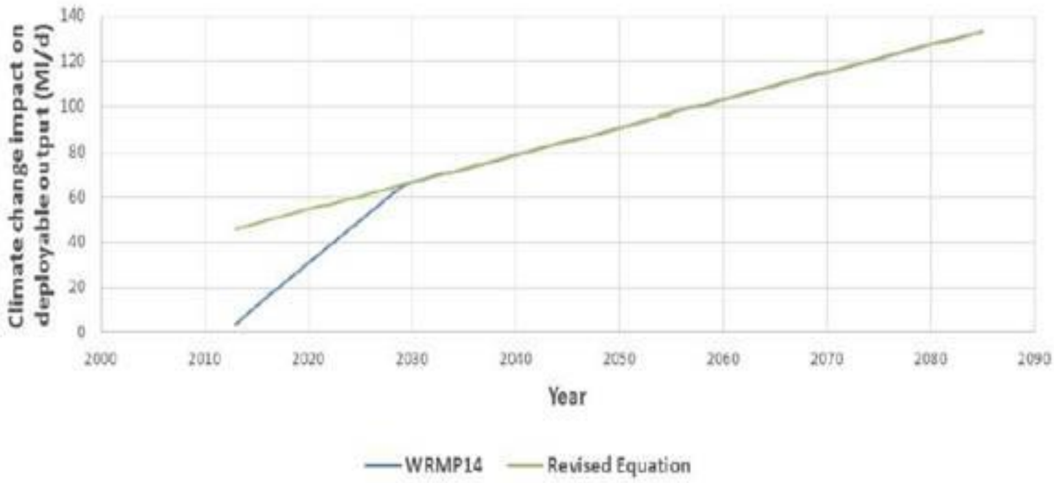


Figure 6.4: Impact of climate change on deployable output scaled using the WRMP14 guidance equations and the revised equation for WRMP19 (Environment Agency, 2017a)

6.6 Allowance for climate change in the headroom assessment

An allowance for the uncertainty of climate change is taken into account in the headroom assessment on both the supply and demand side, by means of components S8 uncertainty of impact of climate change on source yields and D3 uncertainty of impact of climate change on demand.

Further information can be found in section 7.2 of this report and in ESW's PR19 Headroom Calculations Report (ESW, 2017a).

6.7 Effect of Climate Change on Water Resource Zone Supply

6.7.1 Essex WRZ

The effect of climate change on WAFU in the Essex WRZ is illustrated in Figure 6.5 and summarised in Table 6.11 below.

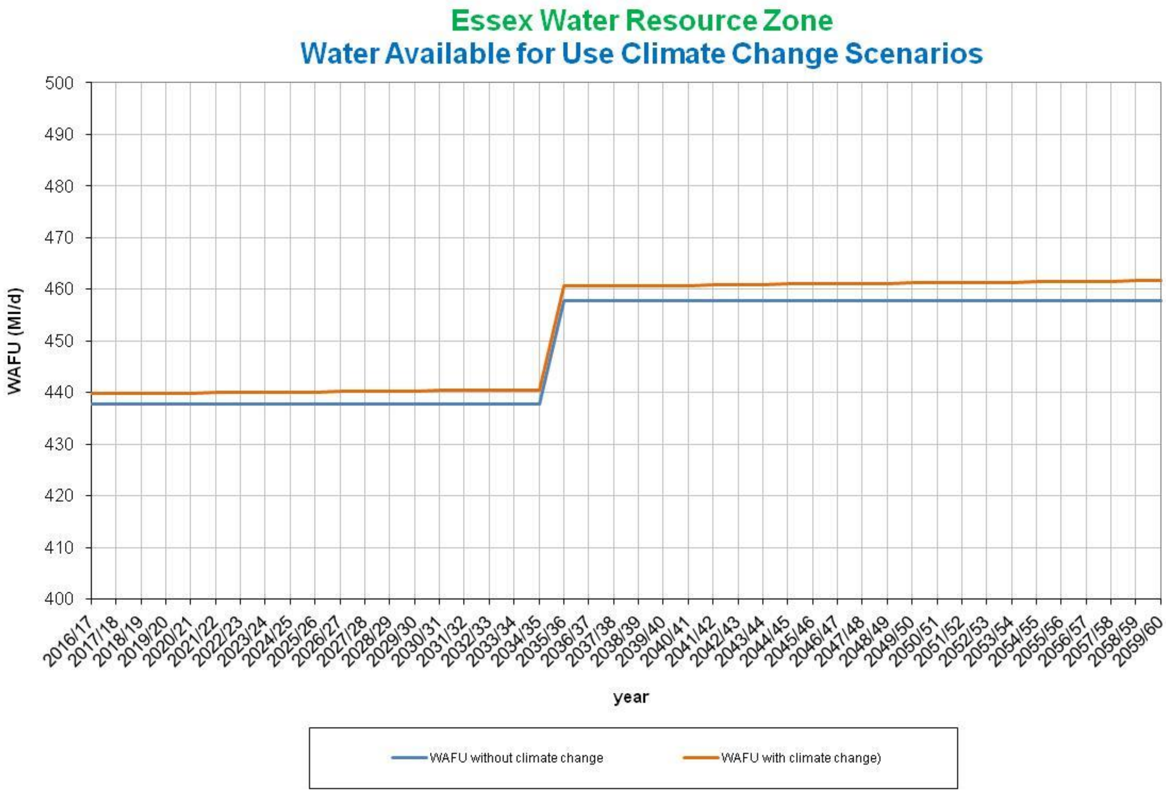


Figure 6.5: Essex WAFU – With and Without Climate Change

Table 6.11: Essex WAFU – With and Without Climate Change

	201617	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
WAFU without climate change	437.9	437.9	437.9	437.9	437.9	457.9	457.9	457.9
WAFU with climate change	439.8	439.9	440.1	440.3	440.5	460.8	461.0	461.7

6.7.2 Blyth WRZ

Climate change does not affect WAFU in the Blyth WRZ. This is because all sources in Blyth WRZ are groundwater sources and there was no effect of climate change on groundwater sources.

6.7.3 Hartismere WRZ

Climate change does not affect WAFU in the Hartismere WRZ. This is because all sources in Hartismere WRZ are groundwater sources and there was no affect of climate change on groundwater sources.

6.7.4 Northern Central WRZ

The effect of climate change on WAFU in the Northern Central WRZ is illustrated in Figure 6.6 and summarised in Table 6.12 below.

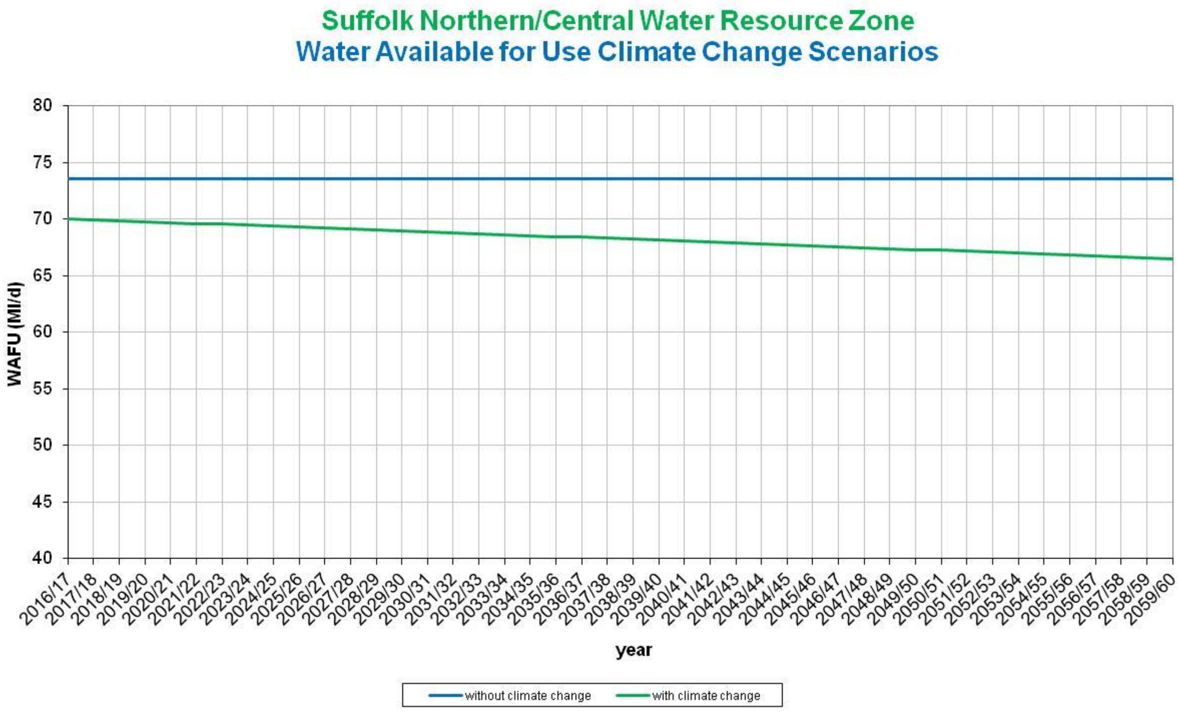


Figure 6.6: Northern Central WAFU – With and Without Climate Change

Table 6.12: Northern Central WAFU – With and Without Climate Change

	201617	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
WAFU without climate change	73.53	73.53	73.53	73.53	73.53	73.53	73.53	73.53
WAFU with climate change	70.02	69.77	69.36	68.95	68.54	68.13	67.72	66.49

6.8 Effect of Climate Change on Demand

6.8.1 Background

The impact of climate change on demand has been considered in terms of:

(1) The explicit effect on distribution input. This has been defined for two scenarios; the most-likely and least likely (maximum) scenarios. The most-likely scenario has been chosen as the central scenario to be included within the DO in the supply demand balance.

(2) The uncertainty on the effect on distribution input as described in target headroom (using triangular distributions defined by zero, best estimate and maximum scenarios)

The above assessment can also enable definition of an envelope of climate change. Such an envelope can be defined for each weather scenario considered in demand forecasts (principally dry and normal).

The above information has been used to illustrate the effect of climate change on demand in each resource zone both in tabular and graphical format. The following sections give a brief synopsis as to how climate change has been considered followed by this summary information of the results.

6.8.2 Methodology

The UKWIR 'Impact of Climate Change on Water Demand' project (UKWIR, 2013) results have been used to calculate forecasts of climate change impacts on household water demand for this WRMP. The report associated with this project has been used as an updated reference source that quantifies the impact of climate change on demand.

In summary, this UKWIR project used statistical analysis on five case studies looking at household and micro-component water consumption and non-household water consumption. The weather- demand relationships developed from the case studies have been used in combinations with UKCP09 climate projections to derive algorithms for calculating estimates of the impact of climate change of household water demand for each UK region in the format of look-up tables (UKWIR, 2013). These look-up tables present the estimated future impacts of climate change on household demand for any river basin between the years 2012-2040 and for a range of percentiles to reflect the uncertainty of the UKCP09 climate projections (UKWIR, 2013). Please refer to the report for a complete description on the methodology in creating the look-up tables' used (UKWIR, 2013).

A look-up table is provided for each UKCP09 river basin areas and the associated area. Within each area look-up table demand factors, describing the percentage change in household demand, are for two case study relationships (Thames Water and Severn Trent Water) and three demand criteria (annual average, minimum DO and critical period). The changes in household demand are provided for the 10th, 25th, 50th, 75th and 90th percentile to reflect the uncertainty in UKCP09 climate projections.

Due to the planning scenario selected for the Company the annual average demand criterion is the only one that applies to ESW, therefore this is the only set of rows that have been employed.

The table below shows the river basin area and case study relationship chosen for each area.

Table 6.13: River basin and case study relationship

Area	River Basin look-up table selected	Case Study relationship selected
Essex	Thames	Thames
Suffolk	Anglian	Severn Trent

The Severn Trent case study relationship was selected for Suffolk as the Severn Trent area is more rural than Thames and provides a better representation of Suffolk. The Essex area is believed to be closer in similarities to the Thames area than the Anglian area which is the reason why the Thames river basin and case study relationship have been chosen for the Essex area.

Different percentiles have been selected to give the most-likely and least likely (maximum) effects of climate change on demand across the planning horizon. For the most-likely effects of climate change the 50th percentile has been chosen (a one in two chance of occurrence). To determine the least likely (maximum) effect of climate change of demand the 90th percentile was selected (a one in ten chance of occurrence). This approach allows the different probabilities of climate change occurring to be examined over the next 25 years.

The look-up table values give the percentage change in demand between 2012 and 2040. As these look-up tables were not updated for PR19 the projections were extended along the same trajectory until 2060 to cover the demand forecasting horizon. This has been applied to the total micro-component consumption to give the most-likely and least likely (maximum) forecasts of climate change impact. The report has advised that the same percentage change in demand can be assumed for both measured and unmeasured properties (UKWIR, 2013). Therefore within the micro-component model the total PCCs have been adjusted by the overall percentage change in demand as found in the look-up tables. It has been assumed that household demand is the only component of demand affected by climate change. Non-household demand is not expected to be effected by climate change. The report also stated that where necessary to allocate the effects of climate change across components of household demand, it would be reasonable to assume that all additional water consumption in hotter or drier weather is for external water uses (UKWIR, 2013).

6.9 Impact on Supply Demand Balance

The impact of climate change on the overall supply demand balance and the sensitivity to climate change scenarios can only be evaluated at the appropriate point in the water resources planning process, after the initial supply demand balance has been constructed. Accordingly the impacts of climate change on the supply demand balance have been described at the end of section 8 on baseline supply demand balance.

6.10 Carbon Emissions from Current Operations

ESW reports annually on the volume of greenhouse gas for which the Company is responsible and has done so since 2008. The trend in these emissions is a falling one though there is some year on year variation in this, mainly due to the impacts of weather and ESW's response to it.

This fall reflects a structured approach to emissions reduction through the implementation of a carbon management plan, initiated in 2009. This Plan has the ambition to reduce emissions by 35% by 2020 against a 2008 baseline. If the emissions linked to grid electricity were to fall as projected by government at that time this should result in a total reduction of 50% in the company-wide operational emissions by 2020.

The plan is based on a combination of actions to improve efficiency in the use of energy and the displacement of grid electricity by the development of renewable energy. This includes hydroelectric generation and solar and in particular the use of biogas from sewage sludge in the Northumbrian area of the Company where NWL provide wastewater services.

The latest estimate of GHG emissions for operational carbon as a result of providing drinking water to customers in the Essex and Suffolk operating area is 44,550 tonnes CO2e (2017 figure in Table 6.14). The emissions intensity of the provision of water services is 284kg CO2e/Ml. This is significantly higher than the emissions intensity of the Company's operations in the Northumbrian operating area. However, it is good in comparison with ESW's neighbours in the lower lying southern half of the country. This emissions intensity is lower than Affinity Water, Anglian Water, Severn Trent, Southern, South West and Wessex Water. Only Thames Water of the larger companies within the south has a lower emissions intensity.

Table 6.14: Drinking Water Emissions Table

Date	2008	2017	2025	2045
Tonnes CO2e	59,962	44,550	21,500	12,200

ESW expects emissions to continue to fall, partly as a result of its own efforts, and partly as a result of falling emissions linked to grid electricity. Most of the Company's emissions result from its use of grid derived power. The proposed closure of the UK's coal powered generation plant by 2023, combined with a growing capacity of renewable energy, means that grid emission factors are likely to fall by half by 2025, then halve again by 2045. The future emissions projections reflect this.

ESW has no projects for the further development of water resources in its Plan, and no consideration of options or the carbon emissions resulting from them has been necessary.

7.0 TARGET HEADROOM

7.1 Background

Actual headroom is the difference between the supply and demand forecasts of the supply demand balance (i.e. the difference between the Water Available For Use (WAFU) and the constrained dry weather demand forecast). A water company would ideally like WAFU to be greater than the demand forecast to allow for uncertainty and ensure it can meet demand.

The 'ideal' amount of actual headroom that a prudent water company should retain is called target headroom. Target headroom can be thought of as a security margin, or more accurately a means of assessing uncertainty in the supply demand balance.

The Agency's WRPG (Environment Agency, 2008 and Environment Agency, 2013) define target headroom as:

"the threshold of minimum acceptable headroom, which would trigger the need for total water management options to increase WAFU or decrease demand"; and

"a buffer between supply and demand designed to cater for specified uncertainties. Water companies should adopt a well-informed approach to determining target headroom. This should balance the costs and risks to customers and the environment of a low headroom allowance against those of a high headroom allowance".

An alternative definition provided by UKWIR and the Agency in 1998 (UKWIR, 1998a) for target headroom is:

"the minimum buffer that a prudent water company should allow between supply (including raw water imports and excluding raw water exports) and demand to cater for specified uncertainties (except those due to outage) in the overall supply-demand balance. Introducing this buffer into the overall supply-demand balance will help to ensure that the Company's chosen level of service can be achieved".

A probabilistic approach to determining target headroom in all four of ESW's resource zones was adopted for the PR09, utilising the industry standard methodology produced in 2002 (UKWIR, 2002). This probabilistic approach was used for PR14 and has been used again for the current periodic review in all four of ESW's resource zones.

A description of the methodology, the results produced and their interpretation has been outlined in an internally produced report. The assessment has already been completed and is summarised below.

7.2 Methodology

The 2002 headroom methodology (UKWIR, 2002) introduces the concept of 'headroom uncertainty', which is defined as:

"a probability distribution that represents a likely range of values for headroom for selected years within the planning period".

Inherent in the definition is the need to make choices from the probability distribution on the level of risk (or degree of uncertainty), that a water Company is prepared to accept in relation to headroom. This is necessary in order to define a value for target headroom for each resource zone for each year across the planning horizon, suitable for incorporation in the supply demand balance. The calculation of headroom uncertainty is required over the planning horizon from 2016/2017 to 2059/2060. However, as headroom uncertainty is forward-looking, the calculation of headroom uncertainty has commenced in 2018/2019.

The basis of the 2002 methodology (UKWIR, 2002) is to apportion target headroom into two main areas; supply side and demand side. For all four resource zones these areas can then be subdivided into respective supply or demand side components indicated as follows:

Supply Side Headroom Components

S3 Uncertainty of renewal of time-limited licences

S4 Bulk imports
S5 Gradual pollution of sources causing a reduction in abstraction
S6 Accuracy of supply side data
S8 Uncertainty of impact of climate change on deployable output
S9 Uncertainty of new sources

Demand Side Headroom Components

D1 Accuracy of sub-component demand data
D2 Demand forecast variation
D3 Uncertainty of impact of climate change on demand
D4 Uncertainty of demand management measures

Two additional supply side components known as S1 (vulnerable surface water licences) and S2 (vulnerable groundwater licences) have not been included at the request of the Agency, and as indicated in the WRPG (Environment Agency, 2017). This is because the Agency has stated that no allowance should be included for uncertainty related to sustainability changes to permanent licences, as they will work with the Company to ensure that these do not impact security of supply (Environment Agency, 2017).

An additional supply side component, S3 (uncertainty of renewal of time-limited licences), has been included since the last periodic review assessment. The Agency has stated that an allowance for uncertainty related to non-replacement of time-limited licences on current terms may be included, which should be based on assessment of environmental risks (Environment Agency, 2017).

All components are associated with sources within ESW's four resource zones, with the exception of the supply side component S4, which considers the bulk supply from TWU.

Supply side components generally require the identification of individual groundwater or surface water sources, which are likely to be impacted. The only exception is the accuracy of supply side data (S6), which groups sources according to the factor constraining DO of the source. Demand side components are considered on a holistic basis for each resource zone.

To formally document all the sources identified under each supply side component and all demand side components, the methodology makes use of 'Headroom Issues Proforma' spreadsheets, which contain details of each identified headroom component for a particular resource zone. The proformas allow each component to be uniquely identified and relationships between components to be defined.

Where a component is not independent, the UKWIR methodology (UKWIR, 2002) and Crystal Ball® allows for overlapping, correlated and dependent relationships to be included in the headroom calculation. These relationships are determined as follows:

- Overlapping or mutually exclusive relationships ensure that it is only possible for the DO of a source to be lost once. Each component is assessed independently before taking the largest value selected from two or more overlapping components.

- Correlating data allows a variety of relationships to be defined between two or more components. For example groundwater sources at different locations may abstract from the same aquifer and therefore face similar sustainability issues or risks from pollution. A correlation coefficient is applied to describe the relationship between the different sources.

- A dependent relationship occurs when a source's headroom uncertainty is dependent on the uncertainty at another source. No dependent relationships occur between any headroom components associated with ESW and consequently dependent relationships were not used in any of the headroom uncertainty calculations.

A summary of the assumptions used to assess the uncertainty for each supply side and demand side headroom component is provided below.

<u>Supply Side Components</u>

S3 All ESW time-limited groundwater sources to be investigated as part of the Water Industry National Environment Programme (WINEP), where the DO would be reduced should there be a sustainability reduction imposed, have been included in S3. This uncertainty has been included from 2027/28 onwards as this is the first year that any reduction in DO would apply.

S4 The Chigwell bulk import was split into two sub-components. This was to enable the inclusion of two key points within the agreement between TWU and ESW:

- Should TWU enforce a temporary water use ban but ESW does not, the quantity supplied to ESW is reduced by 25%;
- Should both water companies have a temporary use ban in place and TWU enforces a drought order ban, a fair apportionment of supply would take place.

The levels of service for both water companies were used to determine the risk of loss of DO from the Chigwell bulk import, across the whole planning horizon.

S5 All ESW groundwater sources were included as being at risk from pollution, with the headroom uncertainty for each source separated into point and diffuse pollution. Catchment risk assessment work undertaken by ESW was used determine the uncertainty of point and diffuse pollution at all of ESW's groundwater sources. The calculation of the uncertainty of point pollution additionally made use of the number of petrol and diesel storage sites within the total groundwater protection zone of each groundwater source.

The uncertainty of dead storage in reservoirs and risk of saline intrusion was also accounted for within S5.

S6 All ESW groundwater and surface water sources and the Chigwell bulk supply were grouped according to the factor constraining DO. The accuracy of supply side data was determined for each of the following:

- aquifer constrained sources, using the combined accuracy of abstraction meters and water level transducers;
- licence constrained sources, using the accuracy of abstraction meters;
- infrastructure constrained sources, subdivided into pump capacity and Water Treatment Works accuracy, using accuracy of pumps and Water Treatment Works output meters, respectively.

S8 The DO for all ESW surface water sources was assessed for the impact of climate change. There has been no further information made available to determine the impact of climate change on the DO of ESW's groundwater sources, therefore the same methodology as the last periodic review was used. All sources determined as being potentially impacted were included in the uncertainty of impact of climate change on DO. The uncertainty surrounding surface water and groundwater DO was defined around the climate change average scenario, and mean of 75% and 119% recharge scenarios. The climate change scaling factor was extended to 2059/60 to calculate uncertainty figures to the end of the planning horizon. Further information on climate change can be found in chapter 6 of this report.

S9 All potential new groundwater and surface water sources would be included to ensure sufficient resources within each resource zone over the planning horizon. This component was not relevant for the four ESW water resource zones.

Demand Side Components

D1 The accuracy of distribution meters was used to determine the accuracy of sub-component demand data for each ESW resource zone, on a holistic basis.

D2 DI was subjected to a statistical technique known as the MLE, which took into account the difference between recorded DI and the sum of all its components, with the aim to make these figures reconcile as closely as possible. The uncertainty surrounding the dry year distribution input for each of the four resource zones was used to determine the demand forecast variation.

D3 The 'Impact of Climate Change on Demand' project results and report (UKWIR, 2013) were used to calculate forecasts of climate change impacts on household water demand and to quantify the impact of climate change on demand. The uncertainty of impact of climate change on demand was defined using 50th and 90th percentile to determine the best estimate and maximum values, and the minimum uncertainty assigned as zero. Further information on climate change can be found in chapter 6 of this report.

D4 The uncertainty of demand management measures for each ESW water resource zone was determined for each of the following:

- delivering the meter strategy, using the number of meters forecast to be installed;
- leakage, using historical data to determine the expectancy of meeting the leakage targets;
- water efficiency, using the likelihood of ESW's current water efficiency targets.

Further Elements of Methodology

Uncertainties have been assessed for every year within the planning horizon.

Once information on the sources of uncertainty for each headroom component had been collated, a probability distribution was defined for each of the components uniquely identified in the Issues Proforma spreadsheets. To define the probability distribution, information was sought from relevant reports, data and expert knowledge within ESW as to the most appropriate type to best fit the data and situation.

Probability distribution profiles can be continuous or non-continuous. In many circumstances continuous distributions will be more appropriate for assessing headroom uncertainty. These allow any value between the stipulated values to be applied to the probability, whereas a non-continuous distribution only allows probability to be determined for the particular values stipulated.

An 'Input Proforma' spreadsheet was completed for each individual headroom component identified within the Issues Proforma spreadsheets, in order to allow the data, probability distributions and specific parameters to be documented and the decisions for these choices to be transparent and auditable. The sheets include specific sections to document meetings and discussions used to progress the particular component, relevant reports and data applied.

The individual headroom components were grouped on a resource zone basis and inserted into a purpose-built spreadsheet produced by Mott MacDonald as part of the UKWIR project (UKWIR, 2002). The probability distributions, parameters and relationships between components form the basis of the Monte Carlo simulation, which determines the overall Headroom Uncertainty by adding the individual headroom components together. The software package Crystal Ball (Release 11.1.2.4.850) was used within the spreadsheet environment to allow the Monte Carlo simulations to be run. When run, Monte Carlo randomly selects numbers from the probability distribution assigned to each component, effectively simulating a 'what if' scenario. The Monte Carlo simulation derives headroom uncertainty for each year within the planning horizon. The simulation was run through 10,000 iterations for each of the four ESW resource zones, in order to gain a suitable level of consistency in the results.

The Monte Carlo simulation was re-run excluding the climate change components S8 (uncertainty of impact of climate change on DO) and D3 (uncertainty of impact of climate change on demand) for each of the four ESW resource zones. The headroom uncertainty figures with and without climate change were compared for every year within the planning horizon to analyse the significance of climate change.

The data and assumptions made for each of the elements of headroom are discussed further in the Company's Headroom Calculations report (Essex & Suffolk Water, 2017f), and should be referred to for additional information. Due to its importance, climate change, which is covered by headroom components S8 for supply side and D3 for demand side, is worthy of specific mention and is discussed in chapter 6.

7.3 Form of Output – Trend Charts and Sensitivity Analysis

The results from the Monte Carlo simulation are expressed in terms of percentiles for every year within the planning horizon, for each of the four resource zones.

7.3.1 Trend Charts

The percentile envelopes of headroom uncertainty can be plotted in Crystal Ball® as a 'headroom uncertainty trend chart', which indicates how the uncertainty in headroom varies throughout the planning horizon, under the analysis for each resource zone. The headroom uncertainty trend chart for the Essex WRZ is provided below by way of an example.

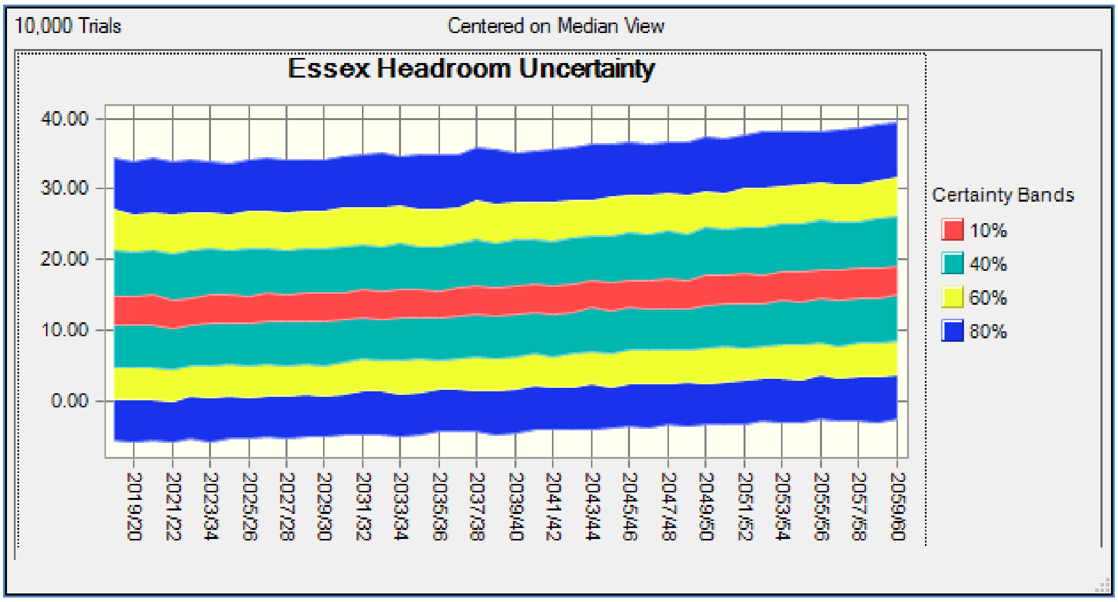


Figure 7.1: Headroom uncertainty trend chart for the Essex WRZ

When interpreting such Crystal Ball® trend charts it should be recognised that, as in the above example:

- Headroom uncertainty has been defined for all years within the planning horizon;
- The various certainty bands indicated are represented by <u>all</u> the range of values between and including the indicated upper and lower bounds;
- The certainty bands above are not the same as percentiles but are related as follows:
    - The 10% certainty band in red equates to the difference between the 45th and 55th percentile (i.e. 5% either side of the median value);
    - Similarly the junction between the yellow and blue shaded areas is the 80th percentile at the top of the chart and the 20th percentile and the bottom of the chart;
- Upper percentiles have been considered as choices for target headroom.

When determining which of the upper percentiles of headroom uncertainty should be used for target headroom, ESW has recognised that this choice is important given that it reflects the level of risk the Company is willing to accept. It should be recognised that this choice may directly affect investment decisions and the driving supply demand balance scenario. The upper percentiles reflect return periods as indicated in the following table:

Table 7.1: Upper percentiles and return periods

Percentile	Return Period
50	1 in 2
75	1 in 4
80	1 in 5
90	1 in 10
95	1 in 20
96	1 in 25
98	1 in 50

The return periods can be viewed as the probability for each year of headroom uncertainty not falling within a respective defined envelope.

ESW has chosen to adopt the 90th percentile until 2024/25 and then a decreasing percentile throughout the planning horizon to the 55th percentile in 2059/60. The Company therefore accepts an increasing risk over the time period that required headroom falls outside the range of values indicated in the headroom uncertainty trend chart. This is in accordance with the Agency's 2017 WRPG which states that water companies 'should accept a higher level of risk further into the future than in the early years because as time progresses the uncertainties for which headroom allows will reduce' and the water company will be able to adapt to any changes (Environment Agency, 2017).

7.3.2 Sensitivity Analysis

The UKWIR methodology includes an inherent assumption that all components identified are of an equal weighting unless related through overlapping, correlations or dependency. The creation of sensitivity charts from the Monte Carlo simulation allows sensitivity analysis to be performed for each component through the use of correlation coefficients. An individual sensitivity chart has been created for the end of each AMP over the planning horizon, for each resource zone. The sensitivity chart for Essex WRZ in 2044/45 is presented below by way of an example.

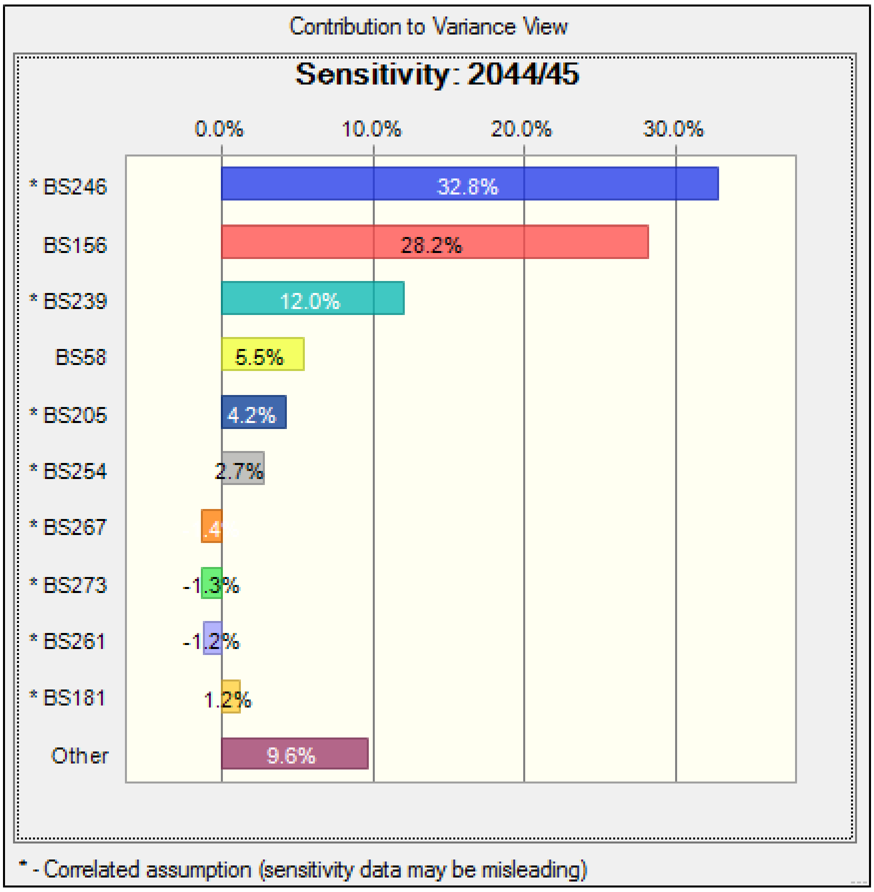


Figure 7.2: Sensitivity 2044/45

The components (e.g. BS246) identified in the sensitivity charts in Crystal Ball® refer to the specific cell reference number in the Monte Carlo spreadsheet used for the particular resource zone being considered.

The UKWIR 2002 methodology (UKWIR, 2002) suggests the checking of headroom components contributing to over 25% of overall uncertainty, to ensure they are realistic. Where sensitivity analysis has highlighted such components, stringent checking has occurred and it has been determined that the parameters input to the probability distributions are realistic. Where a headroom component contributes over 50% to overall headroom uncertainty, the methodology suggests that further investigations to confirm or refine estimates may be justified. This does not apply to any of the four ESW resource zones investigated as the sensitivity charts do not highlight any contributions over 45.8%.

The sensitivity charts created for the last year of each AMP (i.e. end of each five year period) throughout the planning horizon have been analysed for each resource zone. The ten most significant components in each sensitivity chart have been identified, and their variation in contribution across the planning horizon assessed. These results are displayed as tables within this section.

7.4 Headroom Uncertainty Results

The results of the headroom assessment for each resource zone are indicated on the following pages, along with explanatory text. In understanding this assessment the following should be taken into account:

(i) The assessment of headroom uncertainty has been a major undertaking for ESW and represents a significant body of work.

(ii) S1 (vulnerable surface water licences) and S2 (vulnerable groundwater licences) have not been included in the assessment. This is because the Agency has stated that no allowance should be included for uncertainty related to sustainability changes to permanent licences, as they will work with the Company to ensure that these do not impact security of supply (Environment Agency, 2017).

(iii) To some extent the headroom assessment anticipates the likely water resource management options to be employed in the final planning scenario. This is unavoidable since element S9 of the headroom assessment specifically relates to quantifying uncertainty of new sources. This has previously been identified by ESW as a potential weakness of the current UKWIR headroom uncertainty methodology. However S9 was not relevant for the draft Final PR19 target headroom assessment as no water resource management options are anticipated within ESW's four WRZs over the planning horizon.

(iv) The following pages give a general overview, and the Company's PR19 Headroom Calculations report (Essex & Suffolk Water, 2017f) should be consulted in order to obtain the complete picture.

7.4.1 Headroom Uncertainty Results – Essex Resource Zone

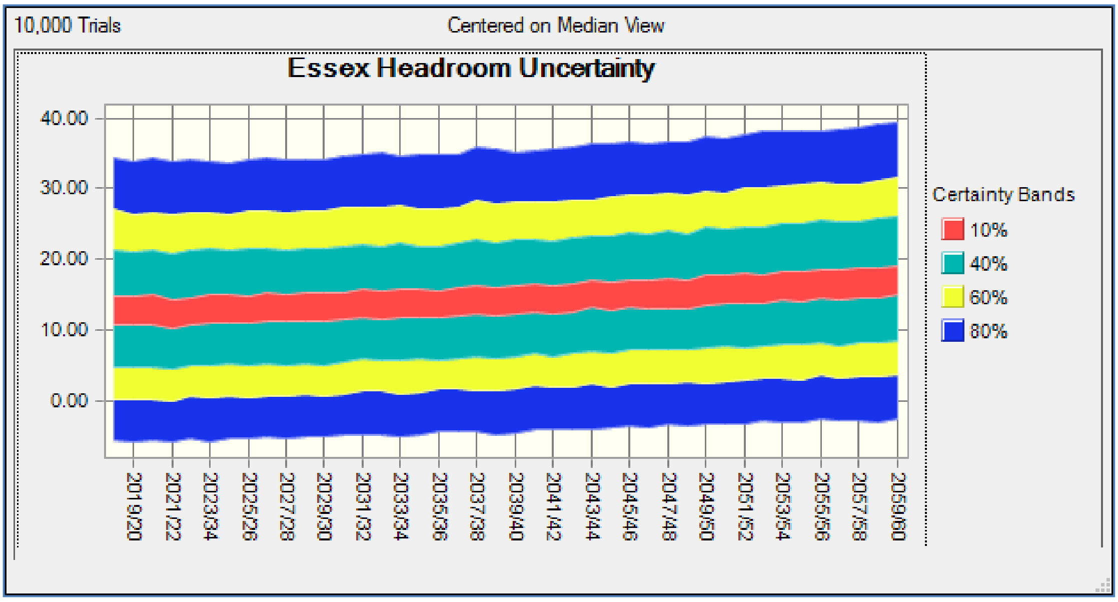


Figure 7.3: Essex headroom uncertainty

Explanatory Text

By reference to the upper 80%, 60% and 40% certainty bands:

- The gradual rise from 2018/19 to 2059/60 is largely due to the impact of demand forecast variation and also the uncertainty of distribution input arising from meter inaccuracy.

Target Headroom Range

Using the chosen percentiles the target headroom accepted ranges from 34.36Ml/d in 2018/19 to 19.12Ml//d in 2059/60. This represents 7.81% and 4.14% of WAFU in 2018/19 and 2059/60, respectively.

Sensitivity Analysis – Essex Resource Zone

Essex: Percentage Significance of Components

Table 7.2: Essex Resource Zone Percentage Significance of Components

Component Reference	Component/Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
D2/1	Demand forecast variation	36.9	35.0	34.6	33.9	32.8	32.8	34.2
S6/2	Meter uncertainty for licence constrained sources	28.1	29.4	28.7	28.4	29.4	28.2	25.9
D1/1	Uncertainty of distribution input arising from meter inaccuracy	13.7	12.8	12.7	12.1	12.3	12.0	11.7
S4/1	Chigwell Bulk Supply (Temporary Use Ban)	5.6	5.7	5.6	6.4	5.7	5.5	5.1
D4/1(ii)	Uncertainty of impact of demand management - Leakage	-2.1	-1.6	-1.3	-1.6	-1.6	-1.4	-1.1
S8/7	Uncertainty of impact of climate change on Essex System	1.6	2.0	2.8	3.0	4.0	4.2	5.5
D4/1(iii)	Uncertainty of impact of demand management - Water Efficiency	-1.3	-1.8	-1.5	-1.6	-1.2	-1.3	
D4/1(i)	Uncertainty of impact of demand management - Metering	-1.3	-1.5	-1.3	-1.3	-1.0	-1.2	-1.1
D3/1	Uncertainty of impact of climate change on demand	0.9	1.0	1.4	2.0	2.3	2.7	3.6
S8/3	Uncertainty of impact of climate change on South Essex Well 1	0.4	0.5				1.2	1.4
S8/1	Uncertainty of impact of climate change on South Essex Well 2			0.7	1.0	1.1		1.6

N.B. The ten most significant components in each year were analysed.

Key

<=5%	
>5 - 15%	
>15 - 25%	
>25%	

Explanatory Text

- Throughout the planning horizon demand forecast variation contributes the greatest proportion of overall uncertainty, with the significance of this component gradually decreasing from 36.9% in 2019/20 to 34.2% in 2059/60. It is considered realistic that demand forecast variation is a significant factor of uncertainty in the Essex resource zone.
- The significance of meter uncertainty for licence constrained sources varies from 28.1Ml/d in 2019/20 to 25.9Ml/d in 2059/60. This is considered realistic considering that the Essex System, which is licence constrained forms a significant proportion of the total Essex WRZ DO.
- The significance of the uncertainty of supply and demand climate change components gradually increases over the planning horizon. The uncertainty of the impact of climate change on the Essex System uncertainty increases over the planning horizon, from 1.6% in 2019/20 to 5.5% in 2059/60.

7.4.2 Headroom Uncertainty Results – Suffolk Blyth Resource Zone

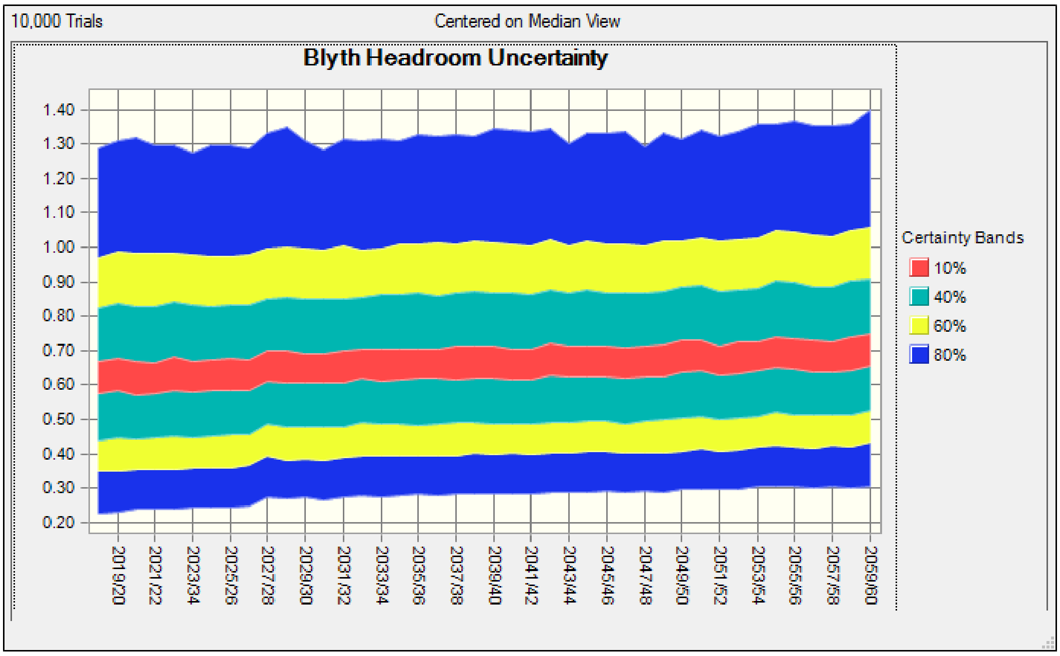


Figure 7.4: Blyth Headroom Uncertainty

Explanatory Text

By reference to the upper 80%, 60% and 40% certainty bands:

- There is general trend of a small gradual increase in headroom uncertainty over the planning horizon. This is largely due to demand forecast variation and the risk of loss of DO due to gradual pollution.

Target Headroom Range

Using the chosen percentiles the target headroom accepted ranges from 1.29Ml/d in 2018/19 to 0.75Ml/d in 2059/60. This represents 9.83% and 5.72% of WAFU in 2018/19 and 2059/60, respectively.

Sensitivity Analysis – Suffolk Blyth Resource Zone

Suffolk Blyth: Percentage Significance of Components

Table 7.3: Suffolk Blyth Resource Zone Percentage Significance of Components

Component Reference	Component/Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
D2/2b	Demand forecast variation	35.0	33.7	33.9	32.8	32.5	32.3	33.1
D1/2b	Uncertainty of distribution input arising from meter inaccuracy	12.7	12.8	12.7	12.5	12.0	11.4	12.8
S5/20b	Risk of loss of DO due to diffuse pollution at Blyth Borehole 4	7.3	8.1	7.7	8.0	8.1	8.1	7.8
S5/15b	Risk of loss of DO due to diffuse pollution at Blyth Borehole 1	6.8	7.7	8.3	7.6	7.5	7.8	7.2
S5/15a	Risk of loss of DO due to point pollution at Blyth Borehole 1	4.5	4.0	4.4	4.3	4.8	4.4	4.6
S5/20a	Risk of loss of DO due to point pollution at Blyth Borehole 4	4.4	4.2	4.4	4.1	4.8	4.3	4.2
S5/18a	Risk of loss of DO due to point pollution at Blyth Borehole 2	4.2	4.1	3.2	3.4	3.4	3.2	3.6
S5/14a	Risk of loss of DO due to point pollution at Blyth Borehole 7	3.5	3.6	3.6	3.9	3.8	3.9	4.1
S5/19a	Risk of loss of DO due to point pollution at Blyth Borehole 3	3.5	3.7	3.3	3.5	3.4	3.9	3.6
S6/6b	Meter uncertainty for licence constrained sources	3.2		2.8	2.5	3.1		2.7
S5/14b	Risk of loss of DO due to diffuse pollution at Blyth Borehole 7		2.7				2.7	

N.B. The ten most significant components in each year were analysed.

Key

<=5%	
>5 - 15%	
>15 - 25%	
>25%	

Explanatory Text

- Throughout the planning horizon demand forecast variation contributes the greatest proportion of overall uncertainty, with the significance of this component generally reducing across the planning horizon from 35.0% in 2019/20 to 33.1% in 2059/60. It is considered realistic that demand forecast variation is a significant factor of uncertainty in the Blyth resource zone.
- The combined uncertainty of risk of loss of DO due to gradual pollution is a significant component throughout the planning horizon. This is considered realistic due to the Blyth being purely a groundwater fed water resource zone.

7.4.3 Headroom Uncertainty Results – Suffolk Hartismere Resource Zone

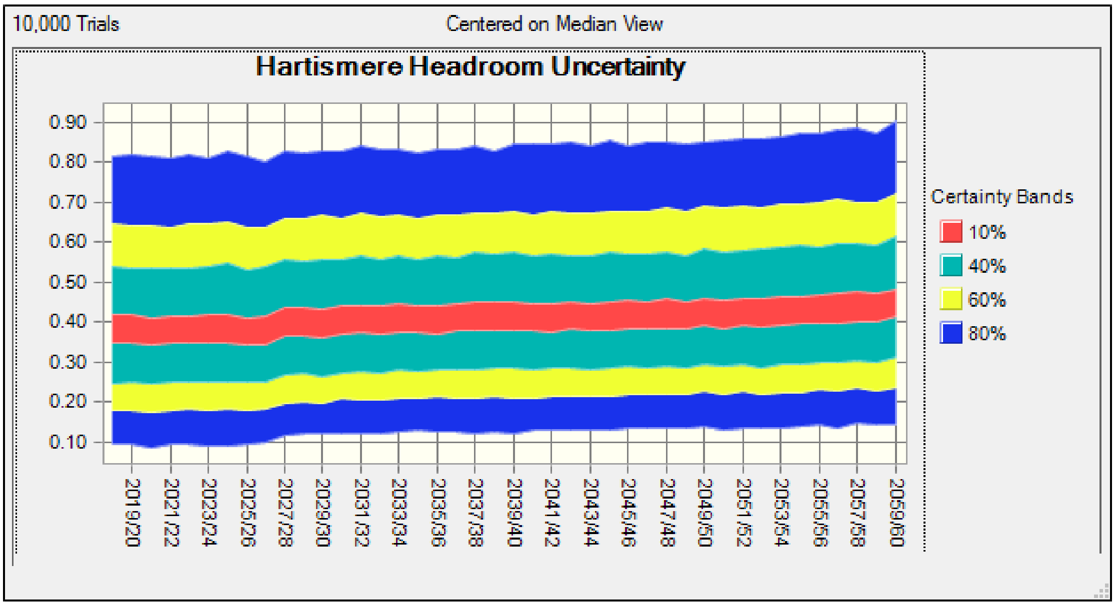


Figure 7.5: Hartismere Headroom Uncertainty

Explanatory Text

By reference to the upper 80%, 60% and 40% certainty bands:

- Generally there is a small gradual increase over the planning horizon, which is largely due to the uncertainty of demand forecast variation, and also due to uncertainty of distribution input arising from meter inaccuracy and risk of loss of DO due to gradual pollution.

Target Headroom Range

Using the chosen percentiles the target headroom accepted ranges from 0.82Ml/d in 2018/19 to 0.48Ml/d in 2059/60. This represents 8.48% and 5.02% of WAFU in 2018/19 and 2059/60, respectively.

Sensitivity Analysis – Suffolk Hartismere Resource Zone

Suffolk Hartismere: Percentage Significance of Components

Table 7.4: Suffolk Hartismere Resource Zone Percentage Significance of Components

Component Reference	Component/Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
D2/2a	Demand forecast variation	45.3	43.8	44.9	45.8	44.8	45.0	45.1
D1/2a	Uncertainty of distribution input arising from meter inaccuracy	15.7	17.0	16.6	16.0	16.0	16.2	16.6
S5/8a	Risk of loss of DO due to point pollution at Hartismere Borehole 5	4.9	4.9	4.3	4.4	4.4	4.4	4.4
S5/8b	Risk of loss of DO due to diffuse pollution at Hartismere Borehole 5	4.8	4.9	5.1	5.1	5.5	5.3	4.7
S5/10a	Risk of loss of DO due to point pollution at Hartismere Borehole 7	4.6	4.3	4.1	4.5	4.4	4.3	4.5
S5/13a	Risk of loss of DO due to point pollution at Hartismere Borehole 8	3.7	4.4	3.5	3.3	3.8	3.8	3.6
S6/6a	Meter uncertainty for licence constrained sources	3.5	3.4	3.5	3.0	3.0	3.1	2.6
S6/5a	Infrastructure constrained sources - Uncertainty for WTW capacity	3.5	3.0	3.3	2.7	3.1	3.1	2.9
D4/2a (iii)	TBC Uncertainty of impact of demand management - Water Efficiency	-1.7	-2.1	-1.6			-1.7	-2.2
D4/2a(i)	Uncertainty of impact of demand management - Metering	-1.6		-1.6	-1.8	-2.3		-2.0
D4/2a(ii)	TBC Uncertainty of impact of demand management - Leakage		-1.6		-1.7	-1.7	-1.7	

N.B. The ten most significant components in each year were analysed.

Key

<=5%	
>5 - 15%	
>15 - 25%	
>25%	

Explanatory Text

- Throughout the planning horizon demand forecast variation contributes the greatest proportion of overall uncertainty, with the significance of this component remaining fairly constant at 45.3% in 2019/20 and 45.1% in 2059/60. It is considered realistic that demand forecast variation is a significant factor of uncertainty in the Hartismere resource zone.
- The significance of uncertainty of distribution input arising from meter inaccuracy and risk of loss of DO due to gradual pollution remains almost constant over the planning horizon.

7.4.4 Headroom Uncertainty Results – Suffolk Northern Central Resource Zone

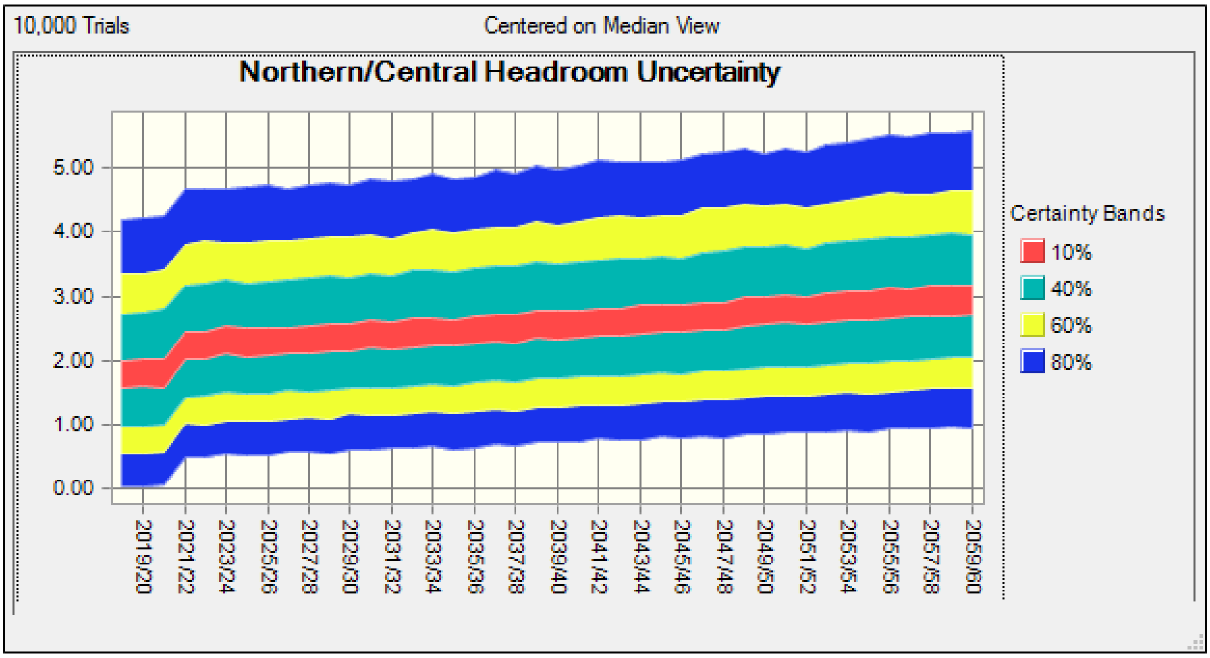


Figure 7.6: Northern Central Headroom Uncertainty

Explanatory Text

By reference to the upper 80%, 60% and 40% certainty bands:

- There is a step increase in 2020/21 due to the inclusion of uncertainty surrounding saline intrusion at Northern Central Borehole 11 from this year onwards;
- From 2021/22 to the end of the planning horizon there is a gradual increasing trend, partly due to the increasing significance of the uncertainty of the impact of climate change on supply and demand.

Target Headroom Range

Using the chosen percentiles the target headroom accepted ranges from 4.18Ml/d in 2018/19 to 3.17Ml/d in 2059/60. This represents 6.79% and 5.37% of WAFU in 2018/19 and 2059/60, respectively.

Sensitivity Analysis – Suffolk Northern Central Resource Zone

Suffolk Northern Central: Percentage Significance of Components

Table 7.5: Suffolk Northern Central Resource Zone Percentage Significance of Components

Component Reference	Component/Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
D2/2c	Demand forecast variation	41.7	40.3	41.4	40.2	39.8	39.4	38.0
D1/2c	Uncertainty of distribution input arising from meter inaccuracy	14.7	13.8	14.1	14.3	14.4	14.4	14.1
S5/28a	Risk of loss of DO due to point pollution at Northern Central Borehole 2	3.6	3.2	3.0	3.1	3.0	2.9	2.8
S8/35	Uncertainty of impact of climate change on Lound Lakes	3.4	4.0	3.6	4.2	4.4	4.3	5.2
S5/26a	Risk of loss of DO due to point pollution at Northern Central Borehole 1	3.3	3.5	3.3	2.8	3.1	2.8	2.4
S5/31a	Risk of loss of DO due to point pollution at Northern Central Borehole 10	2.7	2.4	2.3	2.2	2.4	2.3	2.1
D3/2c	Uncertainty of impact of climate change on demand	2.6	2.9	2.4	3.3	3.5	3.9	4.9
S5/27a	Risk of loss of DO due to point pollution at Northern Central Borehole 9	2.2	2.4	2.2	2.0	2.1	2.0	
S5/26b	Risk of loss of DO due to diffuse pollution at Northern Central Borehole 1	2.2						
S8/33	Uncertainty of impact of climate change on Ormesby Broad	1.9	2.2	2.3	2.9	2.9	3.5	4.2
S6/6c	Meter uncertainty for licence constrained sources		2.1	2.1	2.0	1.8	2.1	1.9
S8/36	Uncertainty of impact of climate change on River Waveney							2.1

N.B. The ten most significant components in each year were analysed.

Key

<=5%	yellow
>5 - 15%	light blue
>15 - 25%	light green
>25%	lavender

Explanatory Text

- At the beginning of the planning horizon demand forecast variation contributes the greatest proportion of overall uncertainty, at 41.7%. The significance of this component gradually decreases over the planning horizon, to 38.0% in 2059/60;
- The significance of the risk of loss of DO due to gradual pollution generally decreases between 2019/20 and 2059/60;
- The contribution of uncertainty of impact of climate change on supply and demand gradually increases over the planning horizon. For example, the significance of uncertainty of impact of climate change on the Lound Lakes increases from 3.4% in 2019/20 to 5.2% in 2059/60.

7.5 Sensitivity Analysis of Climate Change

The difference between the headroom figures with and without the climate change components in the Essex and Northern Central WRZs were found to be much lower than the contribution of climate change determined during the sensitivity analysis for headroom with climate change. This is because it is not possible to make deterministic interpretations with target headroom results due to the probabilistic approach of Monte Carlo analysis. Therefore if a component is removed from the calculation, it does not mean that target headroom will reduce by a similar amount. If there are fewer components, the random selection of values in the simulation increases the likelihood that more extreme values will be selected, and ultimately a completely different distribution will result.

The difference between the headroom figures with and without the climate change components in the Blyth and Hartismere resource zone was found to be similar to the contribution of climate change determined during the sensitivity analysis for headroom with climate change. This was because only the uncertainty of the impact of climate change on demand was included in the original calculation as there was no uncertainty relating to the impact of climate change on supply components. Therefore only one component was removed prior to calculating target headroom without climate change components, so a similar number of components were included to be selected during the probabilistic approach of the simulation.

The impact of climate change on the baseline supply demand balance is explained in more detail in chapter 8.

7.6 Comparison with 2009 Periodic Review (PR09)

The following table provides comparison between the above results (for PR19) and those determined for PR14:

Table 7.6: Comparison of Headroom Uncertainty PR14 and PR19

Zone	Headroom Uncertainty (Ml/d)				
	PR14 base year	PR19 base year	PR14 end of planning horizon	PR19 2044/45	PR19 end of planning horizon
Essex	29.52	34.36	33.02	23.42	19.12
Blyth	1.33	1.29	1.39	0.88	0.75
Hartismere	0.62	0.82	0.66	0.57	0.48
Northern Central	4.10	4.18	5.70	3.62	3.17

The target headroom in the base year for each resource zone is higher for PR19 than PR14 for all water resource zones except Blyth WRZ. The target headroom determined at the end of the 25-year planning horizon (2044/45 for PR19) is higher for PR14 than PR19 for all WRZs.

The target headroom has changed between PR14 and PR19 due to completing a new calculation for each resource zone, which included different sources of uncertainty and assumptions. In addition ESW has chosen a reducing percentage percentile profile across the planning horizon to allow for increasing risk across the planning horizon, in accordance with the WRPG (Environment Agency, 2017).

8.0 BASELINE SUPPLY-DEMAND BALANCE

8.1 Background

The baseline dry year supply and demand data determined in the previous chapters has been used to produce a Baseline Dry Year Supply Demand Balance for each of the four Water Resource Zones (WRZ). All the known changes to Water Available For Use (WAFU) and the known baseline demand management policies have been included in these calculations.

The baseline supply demand balance calculation is to identify whether a WRZ is predicted to have a supply deficit at any point over the planning horizon. For each WRZ, as supply demand balance graph has been prepared. The key features on each of the graphs are:

- The 'target headroom' profile which has been added to the constrained dry weather demand forecast. Target headroom is calculated using the 90th percentile until the end of AMP6 which then reduces to the 55th percentile by 2060. Consequently, target headroom declines over the planning horizon;
- The demand forecasts include the assumptions on water efficiency savings from the Company's baseline demand management; and

- Climate change has been built into the supply, demand and target headroom forecasts as outlined earlier in this document.

The initial supply demand balance graphs for each WRZ are presented in the following sections along with commentary on the key features of interest.

8.2 Essex Resource Zone

Figure 8.1 below presents a baseline supply demand balance for the Essex WRZ. The Abberton Scheme, delivered in AMP5, provided an increase in deployable output in the Essex WRZ of 67Ml/d. This has provided sufficient water supplies to ensure a supply surplus is maintained until 2060.

The supply demand balance graph below shows WAFU a gentle increasing trend in WAFU. This is due to climate change which may increase winter rainfall and therefore river flows and the ability to store this extra water in the now enlarged Abberton Reservoir.

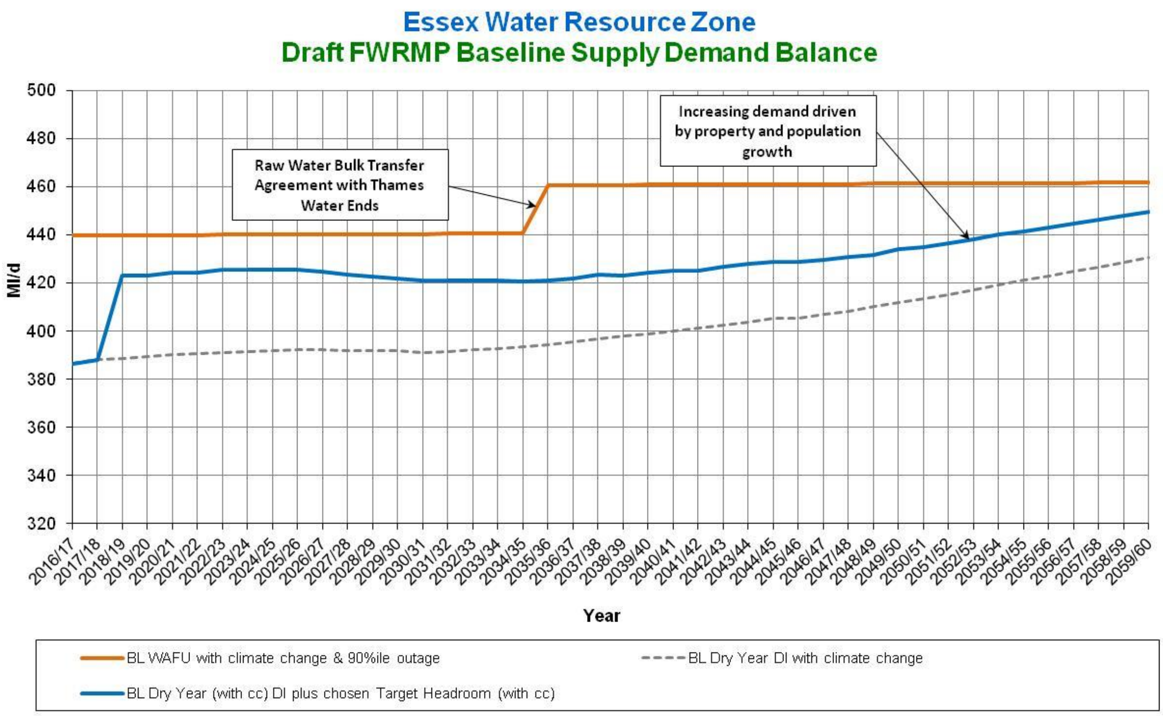


Figure 8.1: Essex WRZ baseline supply demand balance

The balance of supply in Ml/d is illustrated in Table 8.1 below and can be summarised as follows:

Table 8.1: Essex WRZ balance of supply

Essex WRZ	End of AMP6	End of AMP7	End of AMP8	End of AMP9	End of AMP10	End of Planning Horizon	End of 40 Year Planning Horizon
Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
Balance of Supply (excluding headroom)	50.51	48.07	48.56	47.01	61.84	55.68	31.16
Balance of Supply (including headroom)	16.68	14.39	18.54	19.81	36.43	32.25	12.04

The balance of supply with target headroom ranges from 16.68Ml/d at the end of AMP6 to 32.25Ml/d at the end of the statutory 25 year planning period (2045). This increase is due to a bulk raw water export agreement with Thames Water ending. Balance of supply then reduces to 12.04Ml/d by 2060 due to an increase in customer demand.

Given the supply surplus, no supply schemes will be required. ESW has offered other water companies a temporary trade of 5Ml/d until 2035 and then up to 25Ml/d from 2045 to 2060. This is discussed further in section 10 of this report (Final Water Resources Planning Strategy).

8.3 Suffolk Blyth Resource Zone

Figure 8.2 presents a baseline Supply Demand Balance for the Blyth WRZ.

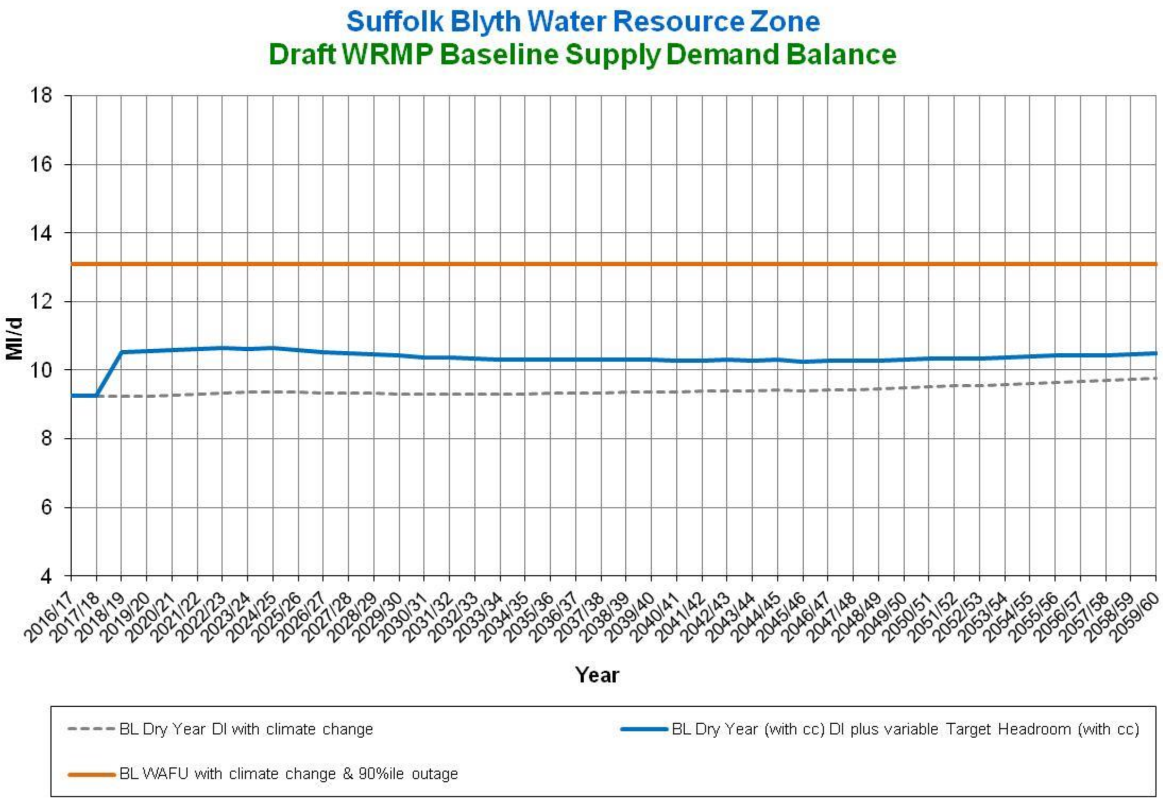


Figure 8.2: Suffolk Blyth WRZ baseline supply demand balance

WAFU remains constant while DI increases slightly over the planning horizon. The balance of supply for in Ml/d is summarised as follows.

Table 8.2: Suffolk Blyth WRZ balance of supply

Blyth WRZ	End of AMP6	End of AMP7	End of AMP8	End of AMP9	End of AMP10	End of Planning Horizon	End of 40 Year Planning Horizon
Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
Balance of Supply (exc. headroom)	3.86	3.75	3.79	3.80	3.75	3.69	3.35
Balance of Supply (inc. headroom)	2.55	2.45	2.69	2.79	2.81	2.81	2.60

The balance of supply with target headroom ranges from 2.55Ml/d at the end of AMP6 to 2.81Ml/d at the end of the 25 year planning horizon and 2.60Ml/d at the end of the 40 year planning horizon.

Given the supply surplus, no supply or demand schemes will be required.

8.4 Suffolk Hartismere Resource Zone

Figure 8.3 below presents a baseline supply demand balance for the Hartismere WRZ.

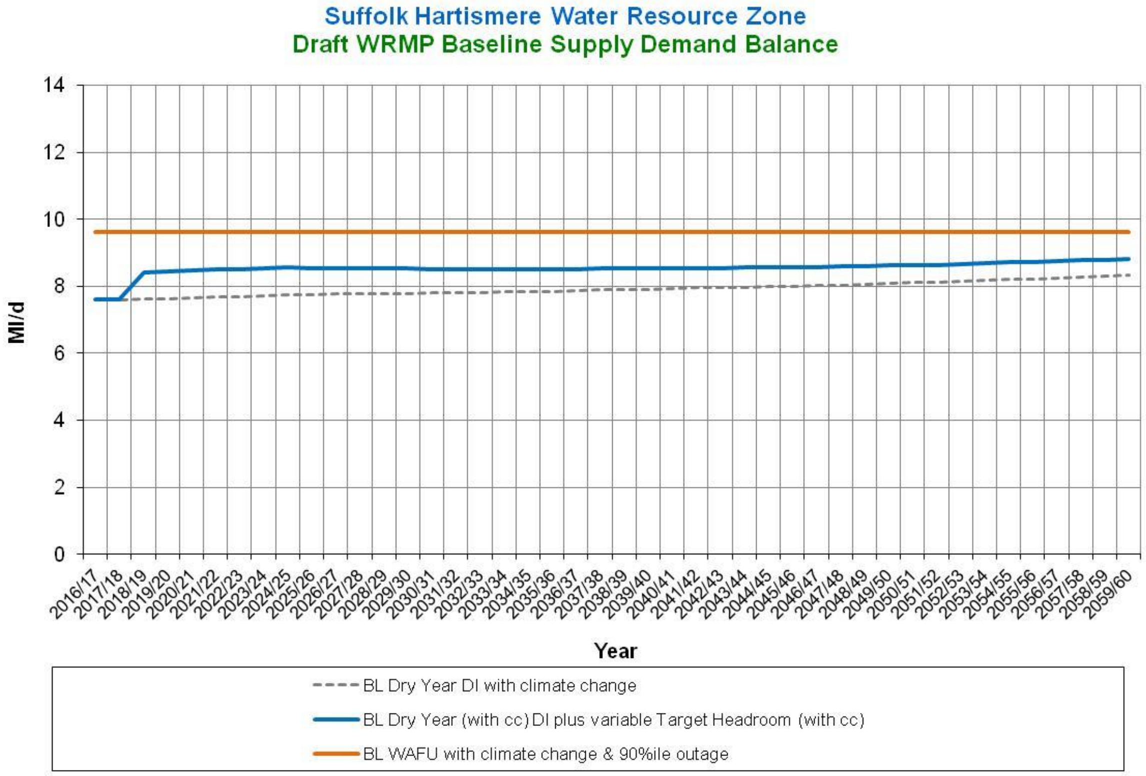


Figure 8.3: Suffolk Hartismere WRZ baseline supply demand balance

WAFU remains constant over the planning horizon while DI increases slightly over the planning horizon. The balance of supply in Ml/d is illustrated in Table 8.3 below and can be summarised as follows:

Hartismere WRZ	End of AMP6	End of AMP7	End of AMP8	End of AMP9	End of AMP10	End of Planning Horizon	End of 40 Year Planning Horizon
Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
Balance of Supply (excluding headroom)	2.01	1.89	1.85	1.80	1.72	1.63	1.30
Balance of Supply (including headroom)	1.19	1.07	1.11	1.14	1.10	1.06	0.81

Table 8.3: Suffolk Hartismere balance of supply

The balance of supply with target headroom ranges from 1.19Ml/d at the end of AMP6 to 1.07Ml/d at the end of the 25 year planning horizon to 0.81Ml/d at the end of the 40 year planning horizon.

Given the supply surplus, no supply or demand schemes will be required.

8.5 Suffolk Northern Central Resource Zone

Figure 8.4 below presents a baseline supply demand balance for the Northern Central WRZ.

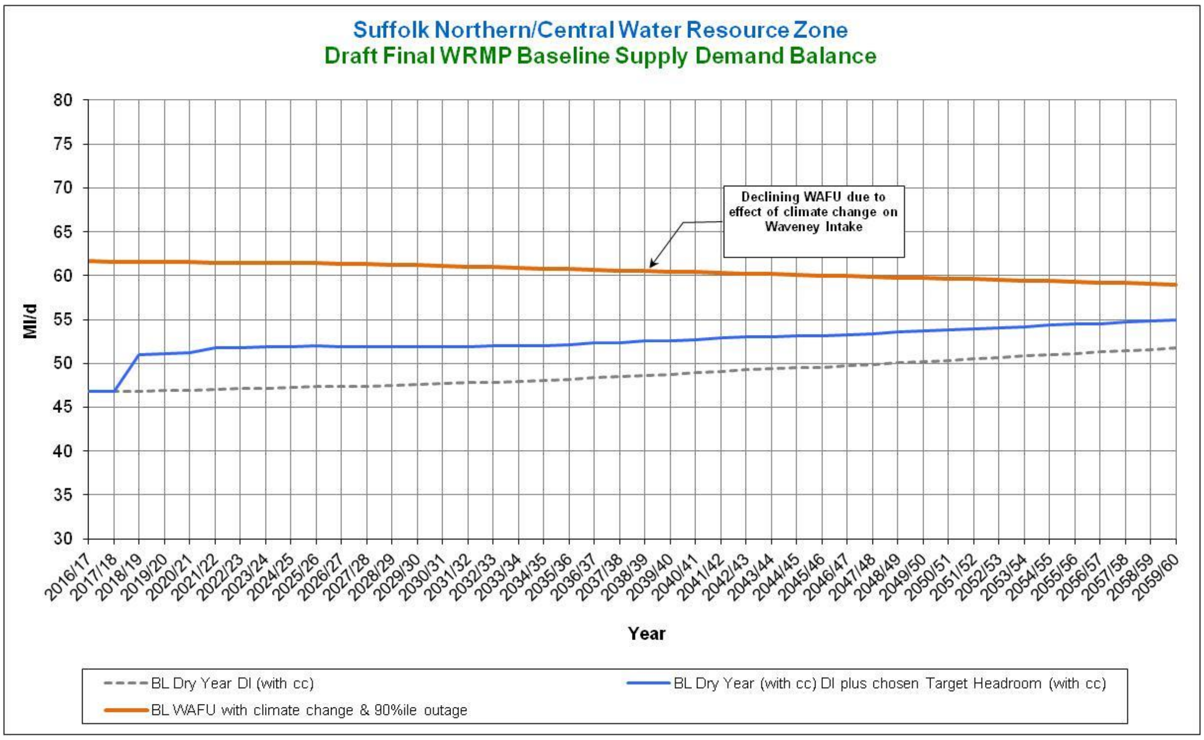


Figure 8.4: Suffolk Northern Central WRZ baseline supply demand balance

WAFU decreases over the planning horizon due to the implications of climate change on the DO of the River Waveney abstraction. DI increases over the planning horizon. The balance of supply for in Ml/d can be summarised as follows:

Northern Central WRZ	End of AMP6	End of AMP7	End of AMP8	End of AMP9	End of AMP10	End of Planning Horizon	End of 40 Year Planning Horizon
Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
Balance of Supply (excluding headroom)	14.63	14.21	13.59	12.77	11.67	10.53	7.27
Balance of Supply (including headroom)	10.42	9.52	9.32	8.79	7.86	6.91	4.10

Table 8.4: Suffolk Northern Central balance of supply

The balance of supply with target headroom ranges from 10.42Ml/d at the end of AMP6 to 6.91Ml/d at the end of the 25 year planning horizon and 4.10Ml/d at the end of the 40year planning horizon.

Given the supply surplus, no supply or demand schemes will be required.

8.6 Impact of Climate Change on the Overall Supply Demand Balance

8.6.1 Background

The effect of climate change on both supply and demand forecasts has been described in section 6 of this report. Subsequent to the calculation of target headroom and the development of initial supply demand balances for each of the ESW WRZs, the impact of climate change on the balance is summarised in this section.

A comparison has been made between the supply demand balance with and without climate change. This has been enabled by re-running the target headroom calculations through Monte Carlo simulation but with the relevant climate change components (on both supply and demand) having been removed.

The results of the assessment for each water resource zone are illustrated in the following sections. In each section a graph is presented which compares the supply demand balance in a particular zone for both with and without climate change scenarios. The “with climate change” scenarios are illustrated in orange and the “without climate change” scenarios are illustrated in blue.

8.6.2 Essex Resource Zone

The with and without climate change baseline dry year supply demand graph is illustrated below.

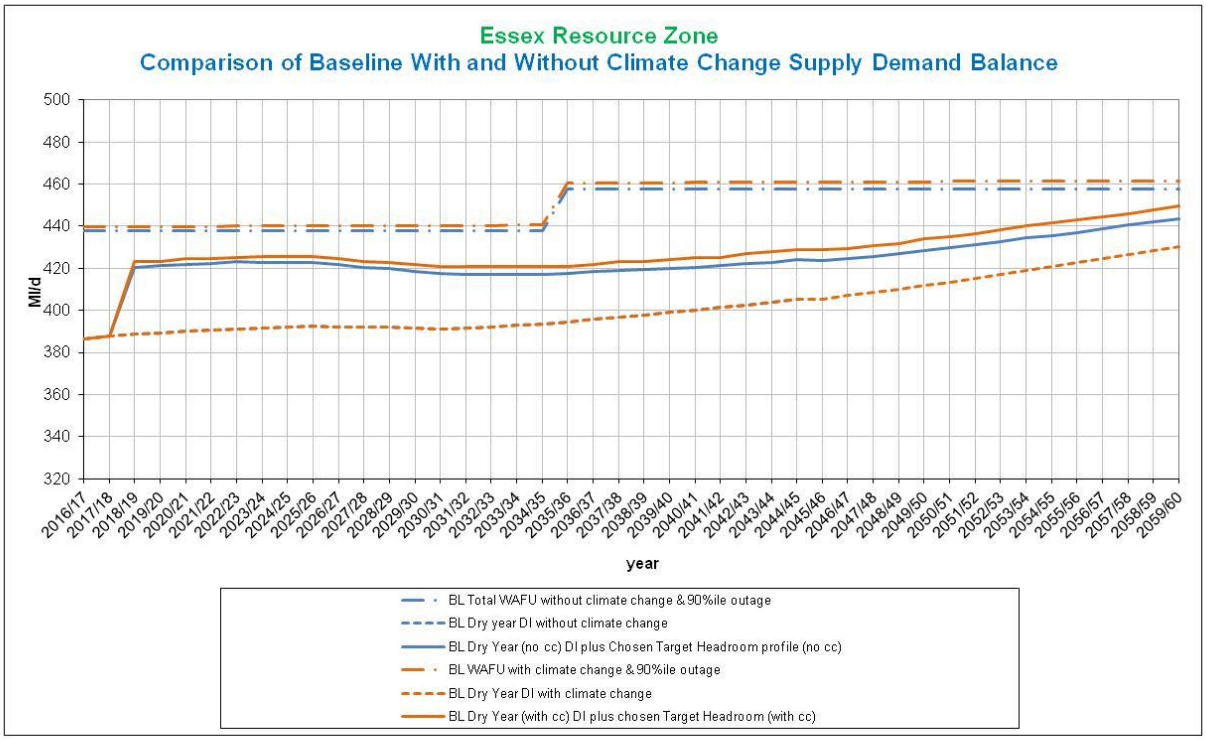


Figure 8.5: Essex WRZ baseline dry year supply demand with and without climate change

The difference in the Essex WRZ balance of supply (including target headroom) according to the two scenarios is summarised below.

Table 8.5: Essex WRZ balance of supply with and without climate change

Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
with climate change BoS (Ml/d)	16.67	14.38	18.53	19.80	36.43	32.25	13.74
without climate change BoS (Ml/d)	16.41	14.96	19.27	20.87	37.93	33.92	15.83

As there is a supply surplus under both scenarios, it can be concluded that climate change is not driving any investment in either supply or demand schemes.

8.6.3 Suffolk Blyth Resource Zone

The with and without climate change baseline dry year supply demand graph is illustrated below.

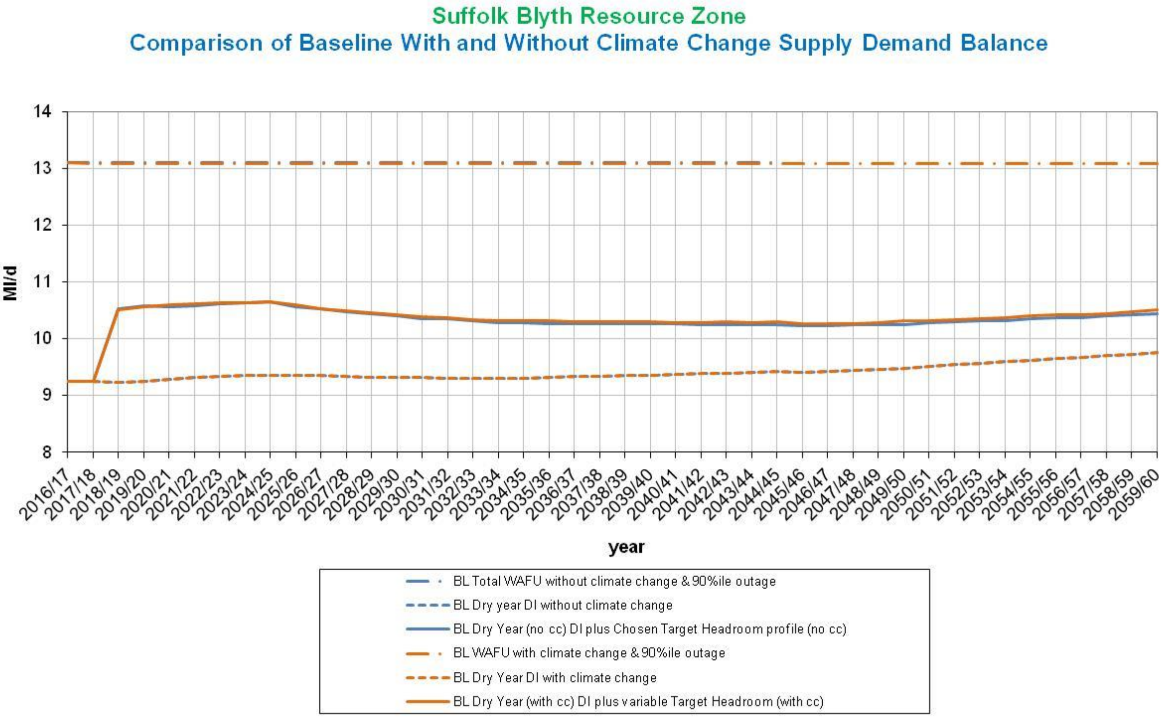


Figure 8.6: Suffolk Blyth WRZ baseline dry year supply demand with and without climate change

The difference in the Blyth WRZ balance of supply (including target headroom) according to the two scenarios is summarised below.

Table 8.6: Suffolk Blyth WRZ balance of supply with and without climate change

Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
with climate change BoS (Ml/d)	2.55	2.45	2.69	2.79	2.81	2.81	2.60
without climate change BoS (Ml/d)	2.53	2.45	2.70	2.83	2.85	2.86	2.66

As there is a supply surplus under both scenarios, it can be concluded that climate change is not driving any investment in either supply or demand schemes.

8.6.4 Suffolk Hartismere Resource Zone

The with and without climate change baseline dry year supply demand graph is illustrated below.

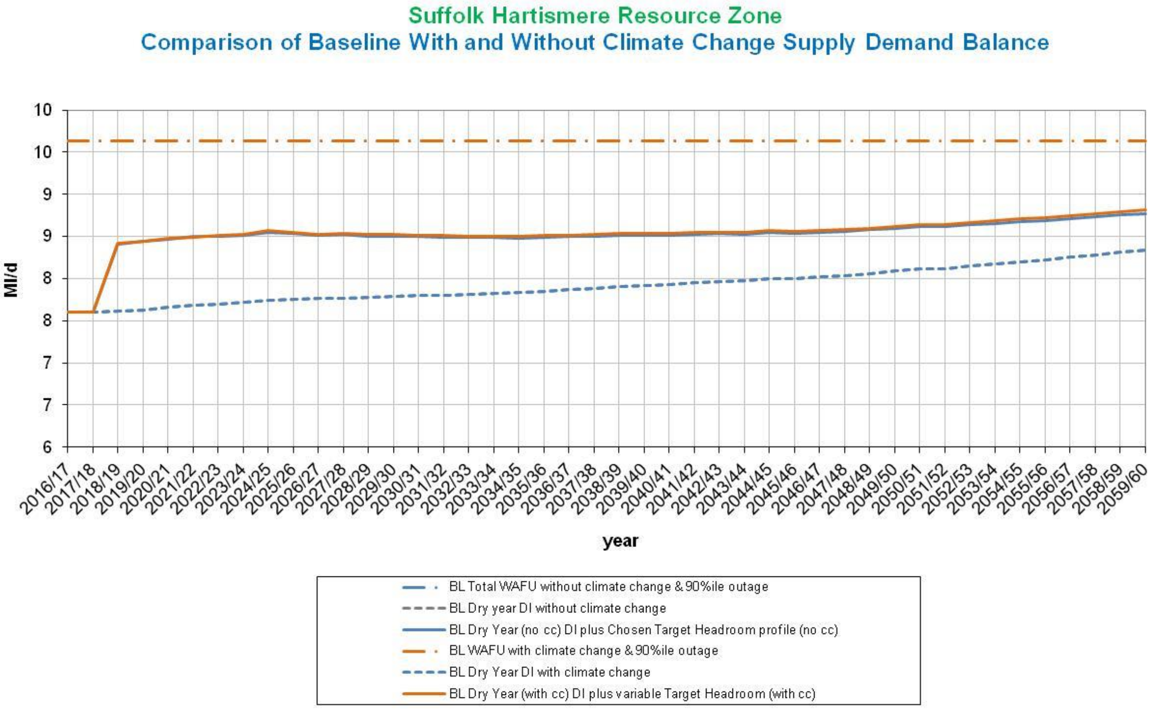


Figure 8.7: Suffolk Hartismere WRZ baseline dry year supply demand with and without climate change

The difference in the Hartismere WRZ balance of supply (including target headroom) according to the two scenarios is summarised below.

Table 8.7: Suffolk Hartismere WRZ balance of supply with and without climate change

Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
with climate change BoS (Ml/d)	1.19	1.07	1.11	1.14	1.10	1.06	0.81
without climate change BoS (Ml/d)	1.19	1.08	1.13	1.15	1.13	1.08	0.86

As there is a supply surplus under both scenarios, it can be concluded that climate change is not driving any investment in either supply or demand schemes.

8.6.5 Suffolk Northern Central Resource Zone

The with and without climate change baseline dry year supply demand graph is illustrated below.

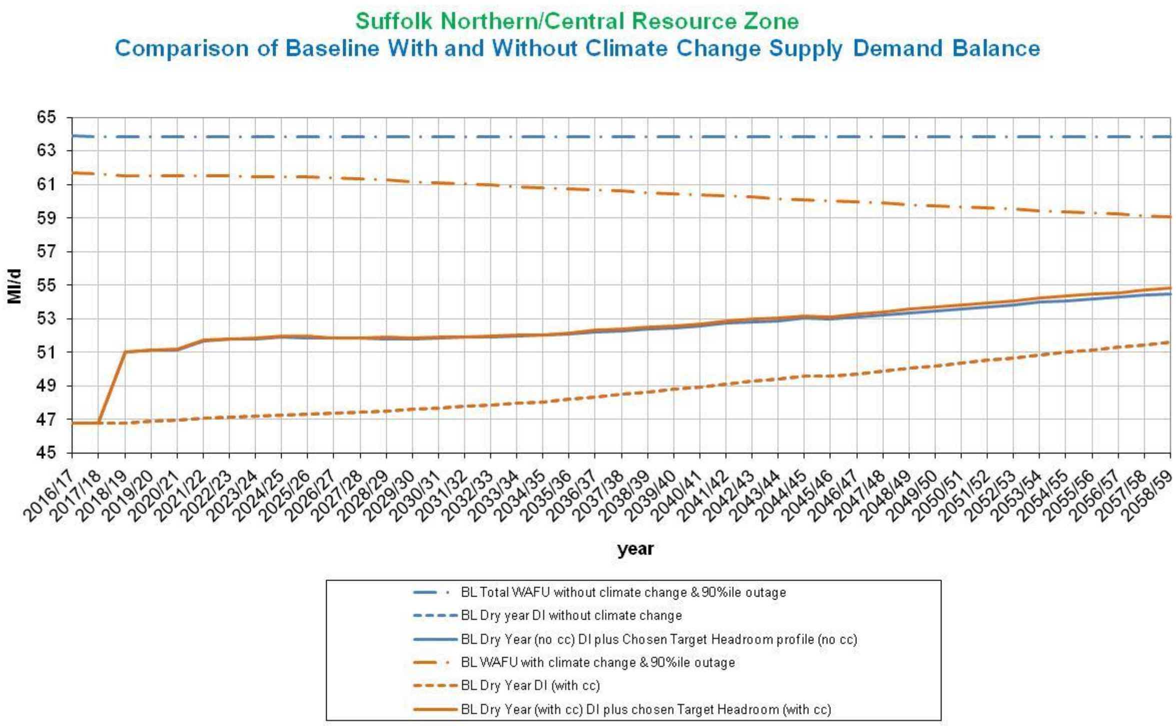


Figure 8.8: Suffolk Northern Central WRZ baseline dry year supply demand with and without climate change

The difference in the Northern Central WRZ balance of supply (including target headroom) according to the two scenarios is summarised below.

Table 8.8: Suffolk Northern Central balance of supply with and without climate change

Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
with climate change BoS (Ml/d)	10.42	9.52	9.32	8.79	7.86	6.91	4.10
without climate change BoS (Ml/d)	12.71	11.93	12.07	11.86	11.39	10.81	9.19

As there is a supply surplus under both scenarios, it can be concluded that climate change is not driving any investment in either supply or demand schemes.

8.7 Sensitivity to Unconfirmed Non-household Demand

ESW is aware of proposed non-household development in the Suffolk Blyth WRZ although planning applications for the proposed development have not been submitted. Consequently, the potential demand from this proposed development has not been included in the baseline Distribution Input Forecast.

However, for scenario testing, ESW has prepared the supply demand balance graph below in which the Distribution Input forecast includes the potential demand of ~2Ml/d from the proposed development.

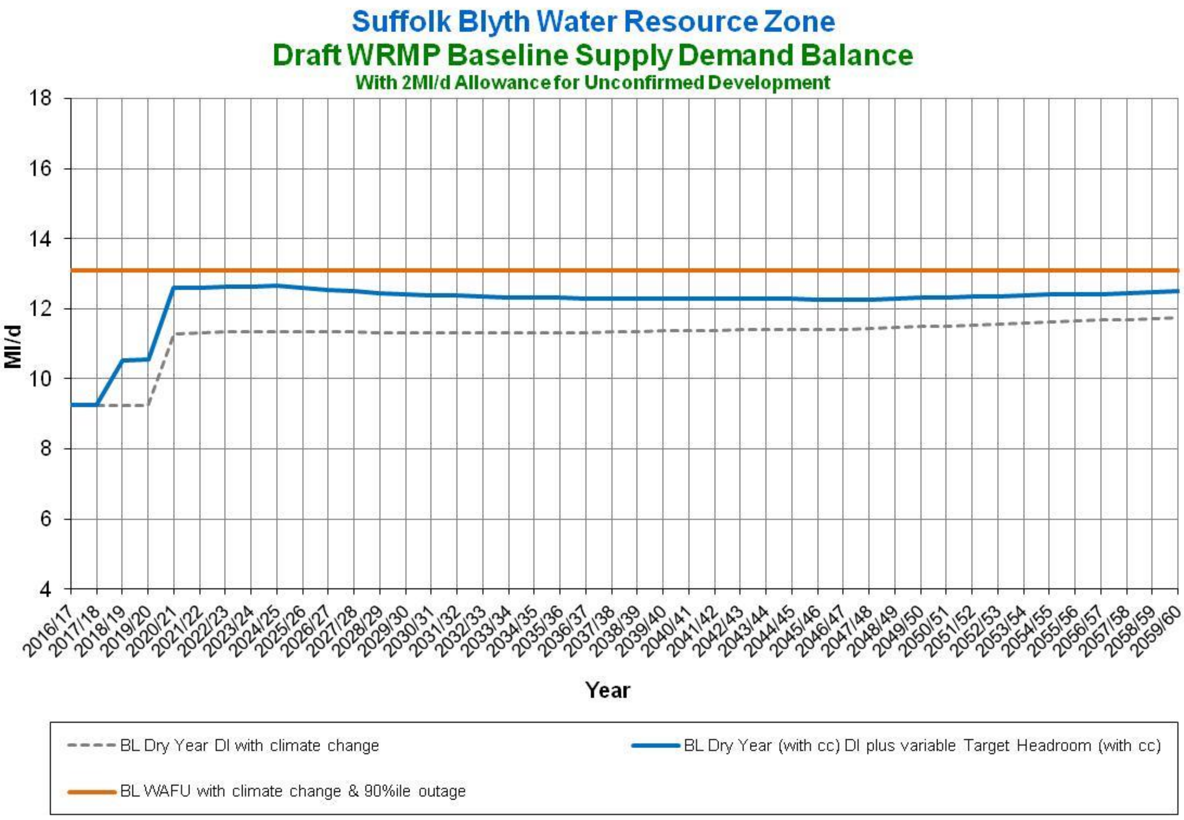


Figure 8.9: Suffolk Blyth WRZ baselince supply demand balance with proposed development

This shows that a supply surplus is still maintained across the full 40 year statutory planning period.

8.8 Sensitivity to Sustainability Reductions

The WRPG states that water companies should work out the impact of possible sustainability changes identified in the PR19 Water Industry National Environment Programme (WINEP) on WRZ deployable output through scenario testing.

ESW's WINEP (Version 2) includes:

- 24 WFD groundwater abstraction investigations and options appraisals; and

- One sustainability change implementation scheme for a groundwater sources that may affect flows in the River Brett.

No sustainability reductions have been defined for the 24 WFD schemes and so it has not been possible to present a revised deployable output assessment for these sources.

A sustainability reduction has been defined for an emergency use groundwater source that may affect the River Brett. This would effectively reduce the source's abstraction licence daily licensed quantity from 22.73Ml/d to 15.57Ml/d. ESW has not allowed for this sustainability reduction in the baseline DO assessment. This is because there is insufficient evidence regarding what the total sustainability reduction for all abstraction licence holders should be in order for the River Brett to reach good status. Additionally, there is insufficient evidence to confirm what the apportionment of effect should be. ESW will work with the Agency, Anglian Water and Affinity Water on a joint investigation and if required, options appraisal, in AMP7. Any required option would be implemented in AMP8.

To establish the sensitivity of the Essex WRZ's deployable output to the sustainability reduction, a version of the Essex WRZ Aquator model has been run which takes account of the sustainability reduction. This reduces the Essex WRZ deployable output by less than 1Ml/d as the emergency use boreholes are rarely used in the Essex model as they are controlled by the control curve for triggering use of the Stour Augmentation Groundwater Scheme (SAGS) boreholes. Consequently, the sustainability reduction would not cause a supply deficit.

8.9 Water Framework Directive Water Body Deterioration Risk

8.9.1 Background

An objective of the Water Framework Directive is to prevent deterioration of the status of all surface water and groundwater bodies. The WRPG requires water companies to show in their WRMPs how they will manage the risk of deterioration due to the increased utilisation of abstraction licence annual licensed quantities.

The WRPG confirms that a planned increase in abstraction should be used as the trigger to assess whether increased abstraction poses a deterioration risk to the status of water bodies. The Environment Agency's approach allows full licensed quantities to be used to meet inter-annual fluctuations in demand that may arise between dry, normal and wet years. However, a sustained increase in abstraction to meet growth in demand could be considered to pose a deterioration risk where, for example, river flow falls consistently below an Environment Agency defined threshold called the Environmental Flow Indicator (EFI).

It is therefore possible to undertake a risk assessment to provide an indication of the level of deterioration risk in each of ESW's water resource zones in the first instance simply by reviewing the baseline distribution input forecast. This along with previous risk of deterioration assessments are considered for each of the WRZs below.

8.9.2 Essex WRZ

The Essex wells provide a constant base load into the WRZ and there are no plans to increase abstraction above recent actual in the near future. The Chigwell bulk supply licensed quantity is often fully utilised and so there is no scope to increase abstraction from the Lea Valley reservoirs. The remainder of the Essex WRZ is covered by the Essex System which covers abstractions from the Rivers Stour, Blackwater and Chelmer and from Abberton and Hanningfield reservoirs. As part of the Abberton Scheme, Black and Veatch consultants undertook a WFD assessment for ESW to ensure that there would be no deterioration on either the donor (Ely Ouse rivers) or receiving rivers (Essex System rivers). The assessment was based on full licensed quantities and concluded that there would be no deterioration of water body status.

ESW's dry year distribution input in 2020/21 is forecast to be 385Ml/d. However, due to demand management strategies (see section 5), distribution input is forecast to reduce from 2020/21 to 2034/35 and is not forecast to exceed the 2020/21 level until 2052/53.

Given the above points, ESW concludes that there is not a risk of WFD water bodies deteriorating as a result of abstraction from the Essex and Ely Ouse rivers over the statutory 25 year planning horizon from 2020 to 2045.

8.9.3 Suffolk Blyth WRZ

ESW's dry year distribution input in 2020/21 is forecast to be 9.25Ml/d. However, due to demand management strategies (see section 5), distribution input is forecast to increase by less than 1.7% by 2045. Consequently, ESW concludes that there is not a risk of WFD water bodies deteriorating as a result of abstraction from the Chalk and Crag aquifers over the statutory 25 year planning horizon from 2020 to 2045.

8.9.4 Suffolk Hartismere WRZ

ESW's dry year distribution input in 2020/21 is forecast to be 7.46Ml/d. However, due to demand management strategies (see section 5), distribution input is forecast to reduce from 2020/21 to 2035/36 and is not forecast to exceed the 2020/21 level until 2049/50. Consequently, ESW concludes that there is not a risk of WFD water bodies deteriorating as a result of abstraction from the Chalk and Crag aquifers over the statutory 25 year planning horizon from 2020 to 2045.

8.9.5 Suffolk Northern Central WRZ

ESW's dry year distribution input in 2020/21 is forecast to be 46.42Ml/d. However, due to demand management strategies (see section 5), distribution input is forecast to reduce from 2020/21 to 2024/24 and is not forecast to exceed the 2020/21 level until 2031/32. Consequently, ESW concludes that there is not a risk of WFD water bodies deteriorating as a result of abstraction until at least 2031/32.

By 2045, the end of the statutory 25 year planning horizon, dry year distribution input is forecast to have increased by less than 3.1%. An assessment of the risk of deterioration from 2031/32 is described below.

The Northern Central WRZ is largely supplied by surface water abstracted from the River Bure and Ormesby Broad (Ormesby Licence), Fritton and Lound Lakes (Lound Licence) and the River Waveney. Groundwater is also abstracted from a series of boreholes near to Beccles in Suffolk.

Fritton and Lound Lakes
The Lound annual licensed quantity has previously been utilised and so it is not possible to increase abstraction.

Beccles Area Chalk Boreholes
ESW abstracts from a series of Chalk boreholes near to Beccles in Suffolk. These boreholes are included in WINEP for investigation in AMP7. Once these investigations have been completed, the results can be used to repeat the no deterioration assessment for the Northern Central WRZ in time to feed into the PR24 WRMP.

River Waveney
The River Waveney is supported by a series of boreholes which collectively form the Environment Agency owned and operated Waveney Augmentation Groundwater Scheme (WAGS). It is currently thought that the reliable yield of the WAGS scheme can always provide a net gain in flow at ESW's River Waveney intake so that:

i. The full daily licensed quantity can always be met; and
ii. A minimum flow is maintained downstream of the River Waveney intake to prevent the saline interface from moving upstream during low river flows.

The sustainability of the WAGS scheme along with an assessment of its net gain at ESW's intake will be undertaken by the Environment Agency and ESW in 2018 and if required as part of AMP7 groundwater sustainability investigations. Once completed, a no deterioration assessment of the River Waveney abstraction can be repeated in time to feed into the PR24 WRMP.

River Bure and Ormesby Broad
Both the River Bure and Ormesby Broad abstractions have previously been investigated by ESW (AMP NEP) and the Agency (Review of Consents (RoC)). The Agency modelled the effect of abstracting the full licensed quantity (10,000Ml/annum) from the River Bure and concluded no likely significant effects. Historically, ESW abstracts about 6,000Ml/annum from the River Bure although this might increase in the future to reduce abstraction from Ormesby Broad. This should not cause deterioration in water body status as abstraction would still be less than 10,000Ml/annum which was assessed not to cause significant likely effects.

For ESW’s Ormesby Broad abstraction, RoC was not able to conclude ‘no likely significant effects’ because a minimum water depth of 30cm was not always maintained in drought years across the extent of the Broad. Consequently, the abstraction licence has now been modified to include a Broad abstraction cessation level of -0.44mAOD and ESW has undertaken a programme of sediment removal to ensure that a minimum water depth is always maintained across the full extent of the Broad. This work means that the abstraction licence is now considered sustainable.

8.9.6 Summary

Baseline distribution input forecasts for the Essex, Blyth and Hartismere WRZs indicate that distribution input will fall and then not increase above baseline levels during the statutory minimum 25 year planning period. Consequently, ESW concludes that there is not a risk of WFD water bodies in these WRZs deteriorating as a result of ESW’s abstraction.

The baseline distribution input forecast for the Northern Central WRZ indicates that distribution input will fall and then not increase above baseline level until 2031/32. Consequently, ESW concludes that there is not a risk of WFD water bodies deteriorating as a result of abstraction until at least 2031/32. By 2045, the end of the statutory 25 year planning horizon, dry year distribution input is forecast to have increased by less than 3.1%. The Ormesby and Lound abstraction licences are considered sustainable when fully utilised. The sustainability of the Waveney Augmentation Groundwater Scheme along with Beccles area Chalk groundwater abstractions will be assessed as part of AMP7 WINEP investigations. The output from these investigations will be used to inform PR24 WRMP. As the risk of deterioration does not start until 2030/31, then there is no need for any interim risk reduction or mitigation measures.

9.0 OPTION APPRAISAL

For all four Water Resource Zones, the baseline scenario supply demand balance demonstrates a supply surplus over the full planning period from 2020/21 to 2059/60. Consequently, there is not a requirement to develop new water resources and so there are no resource schemes to appraise in this section. Additionally, there are no new demand actions beyond those described in the metering, leakage and water efficiency strategies described in section 5.

10.0 FINAL WATER RESOURCES STRATEGY

10.1 Final Planning Supply Demand Balance

10.1.1 Overview

ESW has carefully followed the WRPG and believes it has prepared a robust draft WRMP. The baseline supply demand balance in section 8 of this report has confirmed the nature of the balance of supply for each WRZ. A final planning scenario supply demand balance calculation has been prepared for each of the WRZ's which includes a final plan DI forecast based on the Company's leakage, metering and water efficiency strategies (see section 5) going forwards.

A final planning scenario supply demand balance graph and tabled summary data (with and without target headroom) is presented for each WRZ in the following sections.

10.1.2 Essex WRZ

The baseline supply demand balance graph for the Essex WRZ showed that a supply surplus was maintained until across the full planning period.

The final planning supply demand balance graph below shows a greater supply surplus across the planning period from 2020 to 2060. This is because while household property and population increases, water demand is reduced as a result of the Company's final planning water efficiency and leakage strategies. The graph also shows a 20Ml/d increase in WAFU in 2035 which is a consequence of a bulk supply agreement with Thames Water coming to an end.

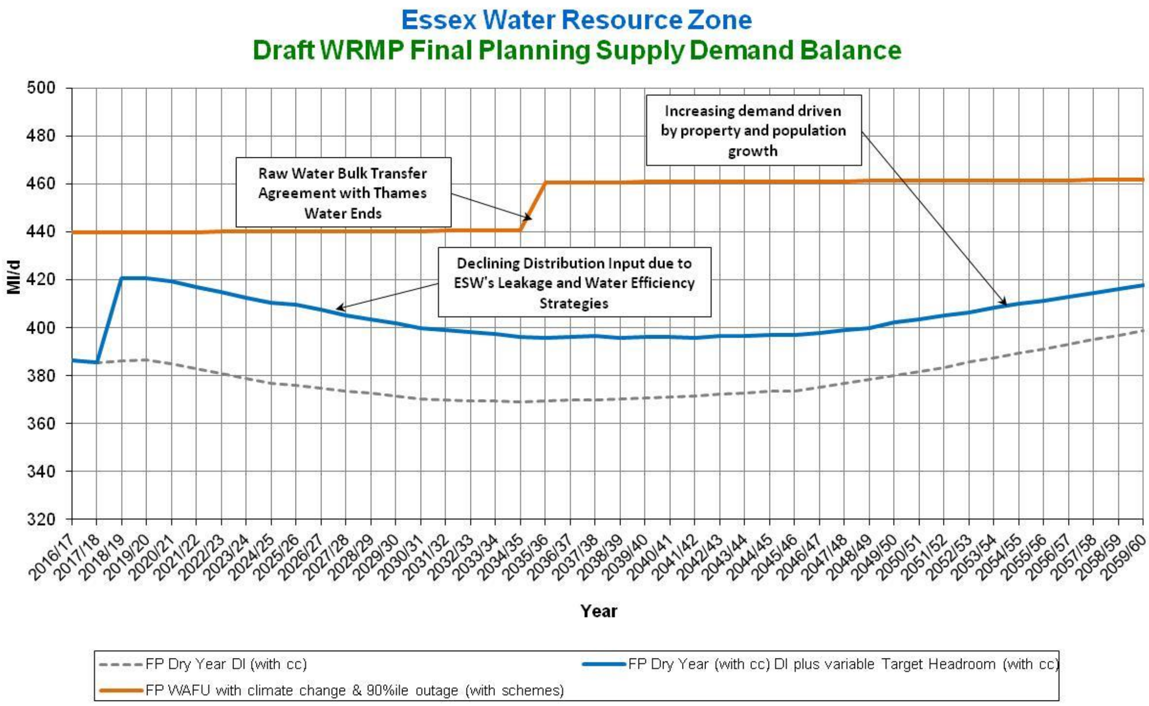


Figure 10.1: Essex WRZ draft WRMP final planning supply demand balance

Table 10.1: Essex WRZ draft WRMP final balance of supply

Essex WRZ	End of AMP6	End of AMP7	End of AMP8	End of AMP9	End of AMP10	End of Planning Horizon	End of 40 Year Planning Horizon
Year	**2019/20**	**2024/25**	**2029/30**	**2034/35**	**2039/40**	**2044/45**	**2059/60**
Balance of Supply (excluding headroom)	53.12	63.39	68.65	71.40	90.08	87.38	62.83
Balance of Supply (including headroom)	19.28	29.71	38.63	44.19	64.67	63.96	43.71

ESW is promoting a new scheme in the Company's PR19 Business Plan called the Abberton to Hanningfield Pipeline. It is being promoted in the Business Plan as it will not increase deployable output in the Essex WRZ and is being promoted under resilience and cost benefit of future water treatment requirement drivers. If supported by ESW's economic regulator Ofwat, a new pipeline would be constructed that would allow water from Abberton Reservoir to be pumped to Hanningfield Reservoir. The scheme would also make use of an existing operational pipeline.

The Company believes that the pipeline will provide greater water resources resilience as it will allow water from Abberton Reservoir to be pumped across to Hanningfield Reservoir should an imbalance in reservoir storage occur for reasons outside of the Company's control. This PR19 WRMP has planned for higher unplanned-outage in the Essex WRZ than that allowed for in the previous PR14 WRMP. This is in part due to the levels of algae observed in Abberton Reservoir in 2016/17 which constrained Layer WTW output. The increase in PR19 un-planned outage that has been allowed for in the Essex WRZ has not caused a supply deficit at any point across the planning period. However, since the enlargement of Abberton Reservoir as part of the Abberton Scheme, there still remains uncertainty regarding how water quality, particularly algae, will out-turn in future years. This may be a consequence of different reservoir dynamics (water depth, water temperature, mixing, leaching of nutrients from soil) due to the enlargement of Abberton Reservoir, or because of external climatic changes. The latter should not be ruled out as other water companies have noted similar challenges relating to algae. If constructed, the pipeline would reduce actual un-planned outage as the Company would then be able to plan to increase Hanningfield WTW output, which has spare capacity, when poor water quality in Abberton Reservoir constrains Layer WTW output. The Company could only plan to do this once the proposed pipeline has been installed. If it were to do it now, this would cause a storage imbalance between Abberton and Hanningfield Reservoirs.

A further driver for the pipeline is that it would defer or even negate the need for an upgrade of Layer WTW. Previous WRMPs have confirmed the need for Layer treatment works to be upgraded to increase its deployable output from 145Ml/d to 165Ml/d and eventually 210Ml/d. However ESW has concluded that, rather than upgrade Layer WTW, Hanningfield WTW, which has spare capacity, could be used to meet future increases in customer demand. However, this is only possible with the proposed pipeline. This makes sense from a cost benefit perspective as the pipeline is likely to be significantly cheaper than upgrading Layer WTW.

The proposed pipeline scheme will be included in ESW's PR19 Business Plan, prior to which appropriate environmental assessments will be undertaken. This includes Water Framework Directive "No Deterioration" assessments which will cover, among other aspects, the risk of transferring Invasive Non-native Species (INNS) and a Habitats Regulation Assessment (HRA).

10.1.3 Blyth WRZ

The baseline supply demand balance graph for the Blyth WRZ showed that a supply surplus was maintained across the full planning period. The supply surplus in the final planning supply demand balance graph below is slightly higher reflecting the Company's final planning water efficiency and leakage strategies.

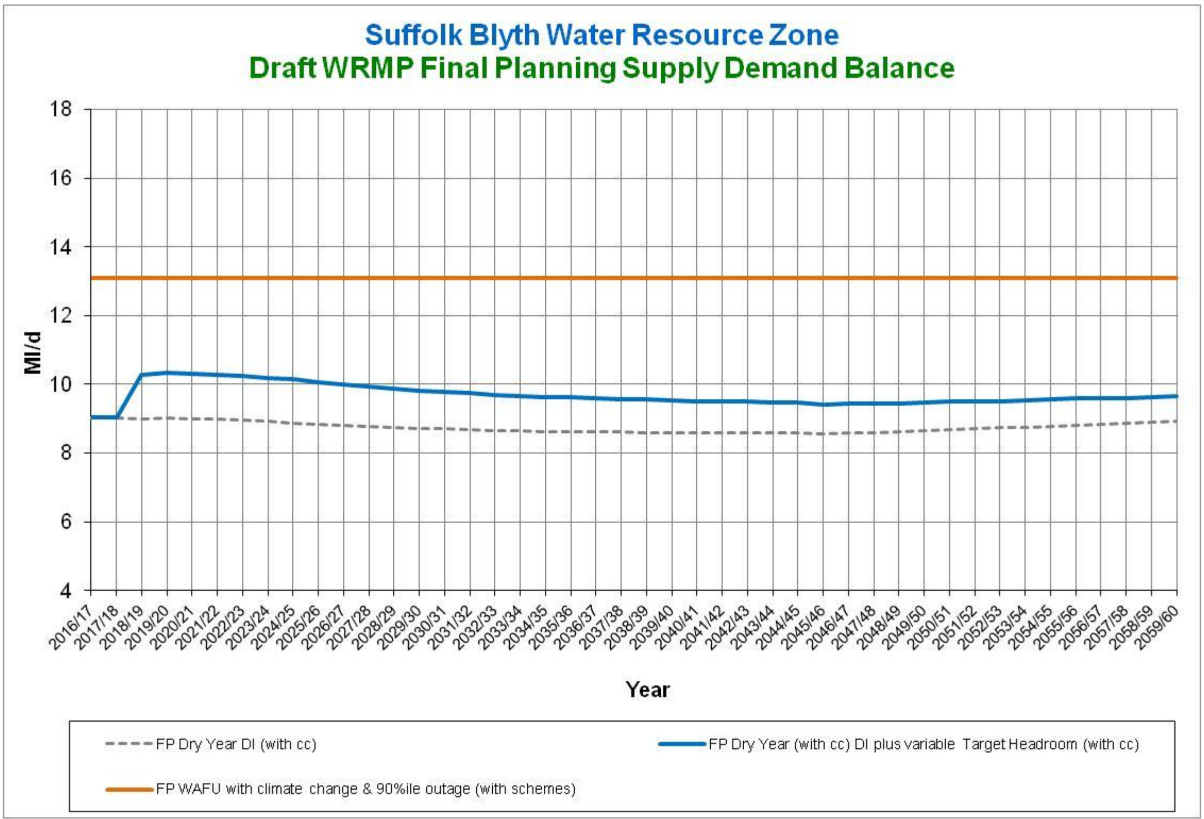


Figure 10.2: Suffolk Blyth WRZ draft WRMP final planning supply demand balance

Table 10.2: Suffolk Blyth WRZ draft WRMP final balance of supply

Blyth WRZ	End of AMP6	End of AMP7	End of AMP8	End of AMP9	End of AMP10	End of Planning Horizon	End of 40 Year Planning Horizon
Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
Balance of Supply (excluding headroom)	4.09	4.25	4.39	4.48	4.51	4.52	4.19
Balance of Supply (including headroom)	2.78	2.95	3.28	3.48	3.58	3.65	3.44

10.1.4 Hartismere WRZ

The baseline supply demand balance graph for the Hartismere WRZ showed that a supply surplus was maintained across the full planning period. The supply surplus in the final planning supply demand balance graph below is slightly higher reflecting the Company's final planning water efficiency and leakage strategies.

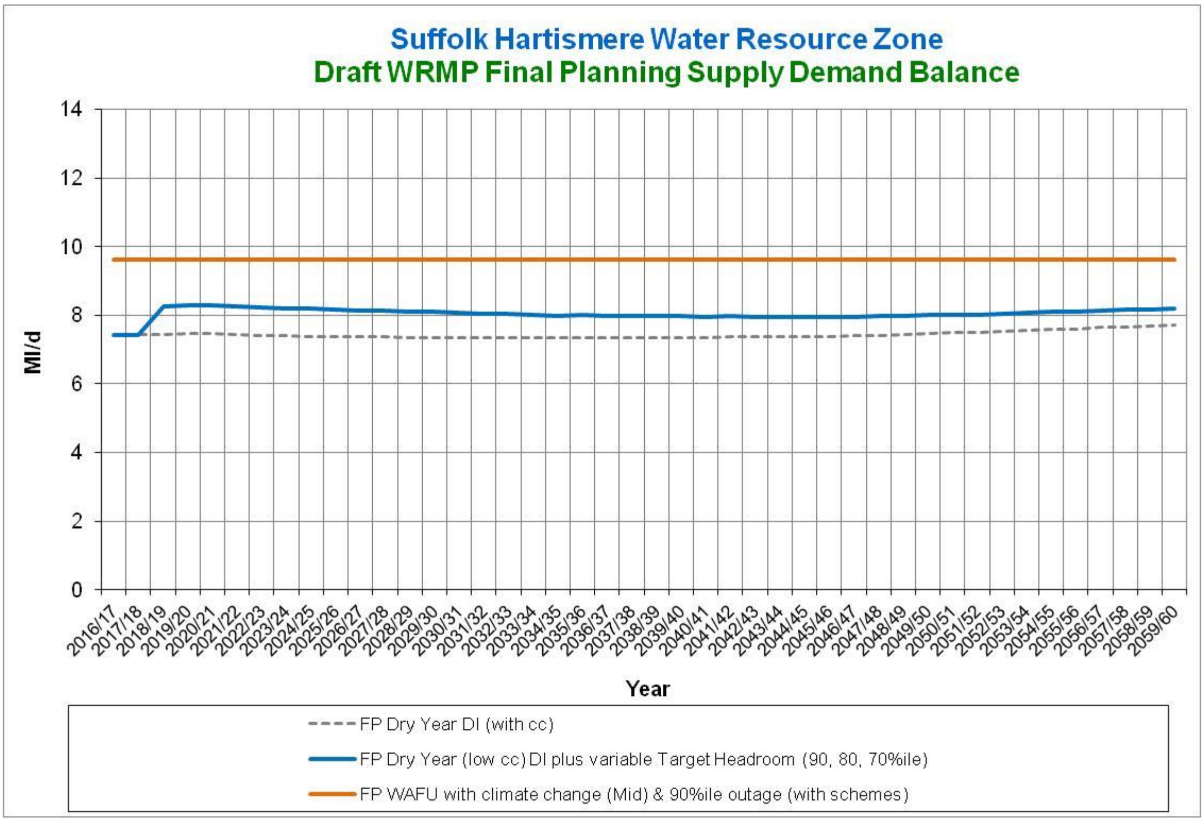


Figure 10.3: Suffolk Hartismere WRZ draft WRMP final planning supply demand balance

Table 10.3: Suffolk Hartismere WRZ draft WRMP final balance of supply

Hartismere WRZ	End of AMP6	End of AMP7	End of AMP8	End of AMP9	End of AMP10	End of Planning Horizon	End of 40 Year Planning Horizon
Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
Balance of Supply (excluding headroom)	2.17	2.25	2.28	2.30	2.28	2.25	1.92
Balance of Supply (including headroom)	1.35	1.43	1.54	1.64	1.66	1.68	1.43

10.1.5 Northern Central WRZ

The baseline supply demand balance graph for the Northern Central WRZ showed that a supply surplus was maintained across the full planning period. The supply surplus in the final planning supply demand balance graph below is slightly higher reflecting the Company's final planning water efficiency and leakage strategies.

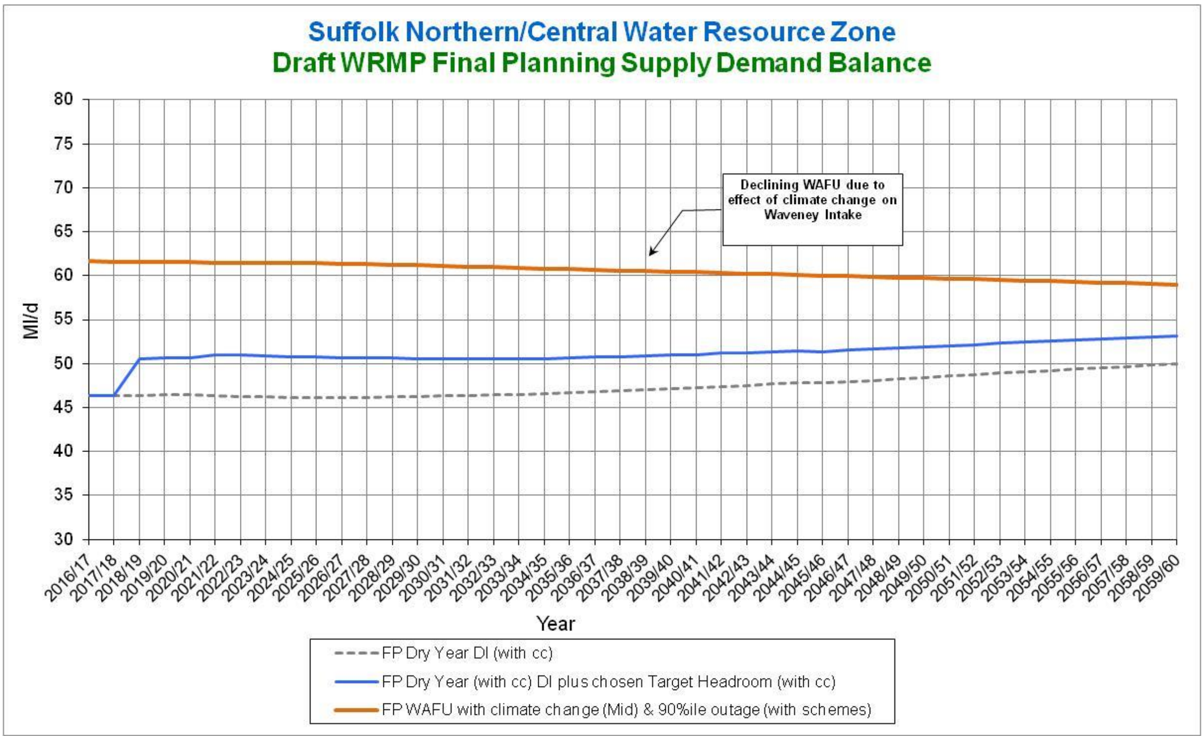


Figure 10.4: Suffolk Northern Central WRZ draft WRMP final planning supply demand balance

Table 10.4: Suffolk Northern Central WRZ draft WRMP final balance of supply

Northern Central WRZ	End of AMP6	End of AMP7	End of AMP8	End of AMP9	End of AMP10	End of Planning Horizon	End of 40 Year Planning Horizon
Year	2019/20	2024/25	2029/30	2034/35	2039/40	2044/45	2059/60
Balance of Supply (excluding headroom)	15.25	15.05	15.34	14.91	14.27	13.31	12.30
Balance of Supply (including headroom)	15.25	10.83	10.66	10.64	10.28	9.50	8.69

11.0 SUMMARY

11.1 Summary

A supply and demand forecast has been prepared for each of the Company's Water Resource Zones (WRZ) for the following scenarios:

- Worst historic drought; and
- A drought with a return period of 1 in 200 Years.

ESW's final plan confirms that a supply surplus will be maintained under both scenarios in all four of the Company's WRZs across both the statutory minimum planning period (25 years to 2045) and the full planning period (40 years to 2060) which have been considered in this plan. This is achieved without the need to implement Level 4 restrictions and demonstrates the resilience of the WRZs to future droughts.

ESW has concluded that the volume of water the Company forecasts it will need to abstract over the planning period will not deteriorate the status of the water bodies from which it abstracts. This is in part due to the demand savings and reductions in network losses that ESW's water efficiency and leakage strategies will respectively bring.

11.2 Annual Review of this Water Resources Management Plan

Once published, this WRMP will be reviewed annually in line with the Environment Agency's WRPG. All appropriate out turn data (for example, leakage, metering, abstraction and progress with implementing the WINEP) will be reported. ESW will consult with the Environment Agency should it wish to make any material changes to this plan.

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13.0 APPENDICES

APPENDIX 1: FIGURES

Figure 1: Essex & Suffolk Water's Supply Areas and Transfer Scheme Infrastructure

Figure 2: Essex WRZ and associated infrastructure.

Figure 3: Suffolk WRZs and associated infrastructure.

APPENDIX 2: WATER RESOURCES PLANNING TABLES

Completed Tables

A series of Water Resources Planning (WRP) tables represent the supply demand balance of the plan for each of the Company’s WRZs and also provide information for organisations to understand and appraise the WRMP.

A suite of tables is available in an individual workbook for each water resource zone.

The fundamental basis of the tables is the dry year annual average scenario and both baseline and final planning data are presented within the same workbook for each resource zone.

No critical period scenarios were appropriate for any of the ESW resource zones. The tables have been provided electronically to regulators in the first instance.

Copies of these tables are available on request.

APPENDIX 3: SECURITY INFORMATION

This draft WRMP has been independently security checked for ESW by the Company's Security Certifier from ch2m and will also be subject to final approval by Defra prior to release into the public domain. No information has been redacted from this draft WRMP.

APPENDIX 4: ACRONYMS AND ABBREVIATIONS

Active Leakage Control	ALC
Anglian Water Service	AWS
Average Day Peak Week	ADPW
Climate Change and Demand for Water	CCDeW
Deepest Advisable Pumping Water Level	DAPWL
Deployable Output	DO
Distribution Input	DI
District Meter Area	DMA
Ely Ouse to Essex Transfer Scheme	EOETS
Environment Agency	the Agency
Essex & Suffolk Water	ESW
Future Flows	FF
Great Ouse Groundwater Scheme	GOGS
Internal Drainage Board	IDB
Latin Hypercube Sampling	LHS
Levels of Service	LoS
Local Authority	LA
Maximum Likelihood Estimation	MLE
Minimum Residual Flow	MRF
National Environment Programme	NEP
Per Capita Consumption	PCC
Periodic Review 2009	PR09
Periodic Review 2014	PR14
Periodic Review 2019	PR19
Rateable Value	RV
Recent Actual	RA
Regional Spatial Strategy	RSS
Review of Consents	RoC
Site of Special Scientific Interest	SSSI
Stour Augmentation Groundwater Scheme	SAGS
Strategic Environmental Assessment	SEA
Study of Water Use	SWU
Supply Demand Balance	SDB
Sustainable Economic Level of Leakage	SELL
Thames Water Utilities	TWU
Treatment Works Operational Use	TWOU
UK Climate Projections	UKCP09
Water Available for Use	WAFU
Waveney Augmentation Groundwater Scheme	WAGS
Water Closet	WC
Water Resource Management Plan	WRMP
Water Resource Zone	WRZ
Water Resources Planning Guideline	WRPG
Water Resources Planning Guideline (Environment Agency, April 2017)	the WRPG
Water Treatment Works	WTW