Final Water Resources Management Plan 2019

August 2019

NORTHUMBRIAN WATER *living water*

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.

DOCUMENT CONTROL SHEET

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Approved by	Heidi Mottram	Heidi Mottram	31/08/18	Chief Executive Officer

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Board Assurance Statement

Having reviewed the draft final WRMPs, the Northumbrian Water Limited Board made the following statement:

- The Board is satisfied the plan represents the most cost effective and sustainable long term solution;
- The Board believes it has sufficiently collaborated with customers, partners and regulators to develop a strong understanding of future needs, explore every option, and build consensus on delivery plans;
- The Board confirms the integrity of the risk assessment process put in place for all of our water supplies; and
- The Board is satisfied that the WRMPs take account of all statutory drinking water quality obligations, and plans to meet all drinking water quality legislation in full including the Drinking Water Directive.

The Board confirms that Northumbrian Water complies with its duties on drinking water quality matters in its broader resilience and resource planning arrangements.

Date: 30 July 2018

Signed for and on Behalf of the Board:

Ceri Jones
Assets & Assurance Director

Technical Summary

Introduction

Water Resources Management Plan Purpose

This document is our draft final Water Resources Management Plan (WRMP). It demonstrates that we have an efficient, sustainable secure supply of water over our chosen planning period. For this WRMP, we have prepared water demand and supply forecasts for a 40 year planning period from 1st April 2020 to 31st March 2060.

The WRMP covers our entire customer supply area (see Figure 1). For the purposes of our demand forecasts and supply demand balance calculations, the supply area has been split into the following Water Resource Zones (WRZ):

- Kielder WRZ; and
- Berwick & Fowberry WRZ

In addition to these two zones we also report on the Industrial WRZ which supplies untreated water to industry on Teesside. This WRZ is comprised entirely of non-household demand.

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

The Kielder WRZ benefits from Kielder Reservoir and the Kielder Transfer Scheme. Kielder Reservoir, located in Northumberland, is the largest artificial lake in the United Kingdom by capacity holding 200 billion litres (200,000Ml) of water. The reservoir supports flow in the North Tyne to support abstractions of water further downstream. It also supports the Kielder Transfer Scheme which enables water to be transferred to the Wear, Derwent and the Tees rivers. Kielder Reservoir and transfer scheme collectively make the Kielder WRZ one of, if not the most resilient WRZs in the country.

The supply forecast Water Available for Use (WAFU) presented in this draft WRMP is based on updated reservoir control curves that we have agreed with the Environment Agency and the existing raw water pumping station infrastructure. This WAFU provides the WRZ with a significant dry year supply surplus. However, it should be noted, that with different reservoir control curves to call on support from the Kielder Transfer Scheme, the Kielder WAFU and therefore supply surplus could be significantly higher than what we currently report.

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 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 WAFU. WAFU is calculated by quantifying the Deployable Output (DO) of our raw water sources and treatment works within each water resource zone. Outage (e.g. when a treatment works is out of supply due to planned maintenance), process losses (e.g. the water used to back wash treatment works filters) and sustainability reductions (e.g. where our abstraction licences has been reduced to ensure they are sustainable) are then subtracted from DO to give WAFU.

The Kielder WRZ WAFU has reduced by around 100Ml/d (at the end of the planning horizon) due to the updated methodology for calculating DO, the Berwick and Fowberry WAFU remains similar to PR14.

Effect of Climate Change on Future Water Supplies

Climate change was assessed using the i-Think models in our PR14 WRMP, as we have now moved over to using Aquator to carry out our water resource modelling an alternative method of assessing climate change for PR19 to that used for PR14 is required.

As we only have a limited number rainfall-runoff models for the Kielder System and the Kielder WRZ is at low vulnerability to climate change, the WRPG recommends that a tier 1 analysis is carried out, that being the use of Future Flows (FF) Hydrology change factors for the 2080s.

The Kielder WRZ appears to be relatively sensitive to reductions in summer flows, this is due to the fact that under the baseline scenario, during the design drought year, some reservoir levels are already extremely low and the decrease in summer flows means that the reservoirs empty prior to the winter refill period.

For the Berwick and Fowberry WRZ, no groundwater model is available to assess the impact of climate change. In order to provide climate change predictions on groundwater levels in this area, reductions in groundwater level in response to decreasing recharge as a result of climate change (based on UK Climate Projections 2009) are used along with Long Term Average recharge spreadsheet calculations.

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

Environmental Improvements

Each time we update the WRMP (every five years), we agree with the 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 our 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 Periodic Review (PR14) Asset Management Plan (AMP6) National Environment Programme (NEP) (2015 to 2020) includes the following:

- Investigation into sustainable abstraction levels from the Fell Sandstone aquifer in the Berwick area;
- Investigations and trials of variable compensation releases at five impounding reservoirs in the Kielder WRZ.;
- Eight Eel Regulations Implementation Schemes, of which six were to improve intake screening and two to install or improve eel passes;
- Two fish passage installations;
- Water Quality / Drinking Water Protected Areas (DrWPA):
    - A programme of work under the DrWPA driver, implementing catchment schemes to protect raw water quality.

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

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

- Seven Sustainable Change investigations.
- One Eel Screen installation.
- Eight Investigations and Options Appraisals.
- Four Fish Passage Investigations.
- Five No deterioration schemes for catchment management work to protect water quality in some of our surface water catchments

All of the above schemes will go forwards into our 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, we have used Local Plan housing growth evidence from all local authorities and has selected the Plan-based scenario.

The population forecasts for PR19 using the plan-based scenario shows a growth in population over the planning horizon. This has resulted in a 23% increase in population over the 40 year planning horizon. The population is now forecast to be 3.15M by 2059/60. Overall occupancy in the demand forecast reduces from 2.34 to 2.28.

The average annual number of new homes is forecast at 9,307 in AMP7 for our customer supply area.

The per capita consumption (PCC) in our customer supply area is forecast to reduce annually across the planning horizon as a result of our metering policy and water efficiency initiatives. Unmeasured PCC is forecast to reduce to 121.61 l/h/d by 2059/60 with measured properties reducing to 105.28 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.

Water Efficiency

We are able to demonstrate the Company's commitment to encouraging our 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, and in conjunction with smart metering, we will commit to

- deliver a programme of water efficiency activities that will reduce PCC from 138.1 litres per person per day in 2019/20 to 130.5 by 2024/25, representing a 5.6% reduction and equating to 7.7 litres per person per day;
- and reducing PCC to 114.9 in the NW operating area by 2040, representing a 17% reduction.

We 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 our activities in one town at one time. The whole-town approach ensures that we are able to maximise our 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 we are able to engage with future generations. We will continue to focus on housing associations, develop stronger links with their 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. In addition, we will install smart meters and deliver two further programmes that were selected through the options appraisal:

- Work with developers to require new properties to be built to the Building Regulations Part G Optional Requirement, where possible and appropriate.
- Introduce a high efficiency toilet rebate scheme.

It is 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.

- There will be a transition whereby the importance of behaviour change grows exponentially.
- The delivery of home retrofits will need to become more targeted towards only those homes that will truly benefit from the programme. Our 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. We are 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.
- The use of smart metering/technologies will be deemed beneficial to water companies and are an expectation of customers.

In response, we 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 we undertook in conjunction with Oxford University and the University of Chicago, will be implemented to intelligently incentivise customers. We will also deploy a series of smart technologies allowing more frequent and circular customer conversations around water efficiency.

Customer Metering

Our area has a large surplus of supply over demand in its Kielder WRZ and the area is not classed as seriously water stressed. Therefore compulsory metering cannot be considered. In the much smaller Berwick & Fowberry WRZ there is a smaller surplus until the full outcome of the NEP studies in to the sustainability of our ground water abstractions in AMP 6 reports. However we cannot compulsorily meter this area as it is still classed as not being seriously water stressed.

We intend to continue with our current programme of optant metering only for the AMP7 period. However we are keen to explore stimulating the number of optants, by targeted communications with customers, in areas such as Berwick, where higher metered densities would be more beneficial.

Leakage

Our current regulatory leakage performance commitment for 2019/20 is 137Ml/d. Beyond 2020, 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, we estimate that the most probable value for leakage in 2019/20 would increase from 137Ml/d to 138.5Ml/d. For AMP7 (2020 to 2025), we plan to reduce leakage by 15% by 2024/25 to 117.7Ml/d. Beyond 2025, our plans are 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 77.3Ml/d or 56% of current leakage.

Our Plan for Reducing Leakage

Our current leakage performance commitment is to keep leakage to an average level of 137 million litres of treated water per day (Ml/d). This is about 21% of water supplied each day and is a combination of leakage from both our, and our customer's pipes. This is one of the higher leakage levels of all water companies but reflects the economics of operating in a relatively water rich environment. However, our customers have told us it is too high, and we agree. We talked to our customers about why leakage occurs and how some of it comes from pipes that burst but most of the leakage comes through tiny invisible leaks all along our vast network and this is very challenging to address. The pipes that connect the customer's properties (supply pipes) to our network also leak and we estimate that these account for one third of the total leakage. These pipes are the customer's responsibility, although we are aware this is often not understood by them.
We are planning an ambitious target to reduce leakage by 15% between 2020 and 2025 and then by a further 10% over each subsequent 5 year period through to 2045. It will get increasingly harder over time to reduce leakage as the leaks become smaller and harder to find. The use of emerging innovative techniques that aid in the detection and repair of leaks, the management of pressures and the continuous replacement of old iron pipes with modern polyethylene pipes, gives us confidence that we can achieve these targets.

Final Plan Distribution Input Forecast

The overall effect on the forecast of DI is that in 2059/60, Kielder WRZ will have a demand of around 65 Ml/d less than today, with a population increase of 589,589 people. Berwick and Fowberry WRZ demand is also forecast to slightly decrease by 0.98Ml/d.

Target Headroom Forecast

Actual headroom is the difference between the supply and demand forecasts of the supply demand balance (i.e. the difference between WAFU and the constrained dry weather demand forecast). WAFU should 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. As a percentage of Distribution Input (DI) (the demand for water), target headroom is 5.3% in the Kielder WRZ and 11.3% in the Berwick and Fowberry WRZ in 2059/60

Supply Demand Balance Forecast

A supply demand balance is best illustrated as a graph showing supply 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.

We have re-assessed our supply and demand forecasts for this draft WRMP. These assessments have confirmed that both of our 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.

Drought Resilience

We have tested the resilience of our water supply system to a very severe drought which is calculated to occur once in every 200 years on average. We have not observed a drought of this intensity and so have used models to simulate the effects of such a drought on DO. Our modelling confirms that both of our WRZ are very resilient as a supply surplus would still be maintained during such an extreme drought.

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1.0 INTRODUCTION

1.1 Overview

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

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

The WRMP covers our entire customer supply area. For the purposes of the demand forecasts and supply demand balance calculations, the supply area has been split into the following Water Resource Zones (WRZ):

- Kielder WRZ; and
- Berwick and Fowberry WRZ.

In addition to these two zones we also report on the Industrial WRZ which supplies untreated water to industry on Teesside. This WRZ is comprised entirely of non-household demand and is described in more detail in Section 2.2.8.

The Kielder WRZ benefits from Kielder Reservoir and the Kielder Transfer Scheme. Kielder Reservoir, located in Northumberland, is the largest artificial lake in the United Kingdom by capacity holding 200 billion litres (200,000Ml) of water. The reservoir supports flow in the North Tyne to support abstractions of water further downstream. It also supports the Kielder Transfer Scheme which enables water to be transferred to the Wear, Derwent and Tees rivers. Kielder Reservoir and transfer scheme collectively make the Kielder WRZ one of, if not the most resilient WRZs in the country.

The supply forecast Water Available for Use (WAFU) presented in this draft WRMP is based on updated reservoir control curves that we have agreed with the Agency and the existing raw water pumping station infrastructure. This WAFU provides the WRZ with a significant dry year supply surplus. However, it should be noted, that with different reservoir control curves to call on support from the Kielder Transfer Scheme, the Kielder WAFU and therefore supply surplus could be significantly higher than what we currently report.

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, 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 our Drought Plan (www.nwl.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 both WRZs have a surplus of water across the planning horizon, 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

We recognised the value of early communication with the many stakeholders potentially affected by and involved in the water resources planning process. We sent pre-consultation letters to statutory consultees and have:

- Communicated with neighbouring water companies seeking their views on what should be included in our draft WRMP.
- Held regular Environment Agency Liaison meetings where different elements of the draft WRMP have been discussed.
- Presented to our 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.
- Presented to Ofwat and to the Consumer Council for Water.

Output from the above engagement has been taken into consideration in the development of this draft WRMP. As we were forecasting all of our Water Resource Zones to be in surplus, the key areas of feedback from the Environment Agency, Natural England and our Water Forum were in relation to development of our part of the Water Industry National Environment Programme (this was successfully agreed) and with regard to the level of our ambition for demand management options including metering, leakage reduction and water efficiency (see Section 5).

Direction from the Secretary of State was in the form of the Water Resources Management Plan Direction 2017.

1.3.2 Engaging our Water Forum in the development of our WRMP

When we started developing the draft Water Resources Management Plan (WRMP) we presented sections and gave details to the Northumbrian Water Water Forum. The Forum then reviewed and discussed the draft WRMP and provided a number of challenges in their formal consultation response. At the Forum's Water Quality sub-group meeting on 28 June 2018, they discussed our response to the WRMP consultation responses made by the EA, Ofwat and the Water Forum and concluded that they were happy with what had been done.

1.3.3 Engaging our customers in the development of our WRMP

Our customers are at the heart of everything we do and every decision we make. We carry out an ongoing and comprehensive programme of bespoke activity around short-, medium- and long-term strategic aspects of service, including operational service, inclusivity, charges and the future.

This section provides more information about the research, participation and engagement activities that have shaped our WRMP plan. Our plan is shaped upon insight derived from several of our qualitative and quantitative customer research and engagement projects into areas which influence water resource management and water efficiency. Our rationale for this approach is founded in our 'Defining the Conversation' and 'Communicating Risk' research projects, which took place in late 2016 and early 2017.

Defining the Conversation (2016 and 2017) explored what matters most to our customers about the services we provide and which areas of service they most want to influence. Our customers told us that we should engage with them to understand their views on customer service, value for money and trust. In regards to other areas of service, the majority viewpoint was that we should ‘just deal with it’, meaning that they trusted us to deliver the service, using our internal expertise without having to consult customers or external specialists. The areas of service participants most frequently stated we should 'just deal with’ relate to water resource management and included ‘supplying a reliable and sufficient supply of water’ and ‘providing clean, clear drinking water that tastes good’. Customers also told us that we should engage with other expert organisations when considering how to manage our performance in the wider environment.

Our Communicating Risk (2017) research was about engaging our customers around how they prefer probability, chance and risk to be communicated. We conducted this research for two reasons; firstly because we knew that some of our customers, who are less comfortable with numbers, struggle to interpret numerical presentations of risk. This includes the types of ratios typically used to indicate the likelihood of drought or appeal for restraint (e.g. a 1 in 200 year drought). During the research we presented participants with different numeric options (i.e. percentages, ratios, fractions, and visual formats) and asked them to order them from the most to least likely to happen. A considerable minority instantly switched off, perturbed by their belief that they struggle with numbers. This disengagement impacts on the reliability of any data resulting from customer research into risk management.

Many customers have had no personal experience of water-related service failure, or know anyone who has. This means that they perceive the risk of experiencing a failure to be very low, especially for rarer events such as a drought or hosepipe ban. Customers who have experienced a more common water-related service failure, such as discoloured tap water, highway flooding or leakage from pipes in the street perceive a greater likelihood of these reoccurring. Hence, these more common service failures tend to be prioritised higher than addressing longer term strategic issues, such as water resource management.

Our Communicating Risk research findings supported the findings of Defining the Conversation in that participants told us that there are some complex aspects of service which they expect us to manage and plan for without the need for consultation. The most often cited areas of population increases, climate change and ageing infrastructure all relate to our approach to water resource management.

Over 2017 and 2018 we engaged our customers on water resource management options, as part of the shaping of our plan. Informed from our engagement and risk research findings we chose to concentrate on demand management options, rather than the more complex and poorly understood levels of service, such as hose pipe ban frequency.

We also explored the views of our customers via an online survey, on leakage, metering, tariffs, consumption and preferences for managing the supply demand balance. Participants were asked how they would allocate a £10 budget across five potential water resource management investment options, in order to understand their priorities.

1. Highest Priority	Build more reservoirs, water treatment works and pipes
2.	Reduce consumption with compulsory water meters at all customers' homes
3.	Inform customers about water meters for optional meters
4.	Reducing leaks
5.Lowest Priority	Installing water meters whenever someone moves house

In addition to this research we have gone on an extensive journey to understand the views of our customers and have conducted several other projects which touch on elements of water resource management planning including:

- Trust & Value (2017)
- Service Measures (2017)
- Communicating Risk (2017)
- Behaviour change and funds (2017)
- Tariff Structures (2017)
- Resilience, Asset Health and Long-Term Affordability (2017)
- Long-Term Strategy Consultation (2018)

The key messages from customers, from these projects, which have influenced the design of our WRMP are:

Customer research finding	How the research influenced our WRMP
1. Increasing supply capacity is prioritised over demand management	We understand customers to be saying that they want us to plan ahead and develop new resources rather than pursue an aggressive demand management policy We do not have a supply deficit in either operating area which requires us to invest in new water resources at this time. However, we do plan to reduce demand further in order to reduce the amount of water that is lost through leakage and also in the way it is used by customers. We want to respect what our customers have told us and our ambitions relating to water consumption are shaped accordingly.
2. Customers prefer water meters to be optional	We are introducing 'whole area metering' with opt-in measured billing to replace change of occupier metering.
3. Customers take individual responsibility for levels of water consumption but also expect us to do more to encourage water efficiency in future.	We commit to sustained gradual reductions in consumption which will enable us to put customer experience first. We will invest in both existing and new approaches to incentivise water efficiency.

Our independent Water Forum, whose role it is to challenge us to always make sure we put our customers at the heart of our future plans and pricing, were updated on the development of our WRMP in November 2017. Members challenged the presentation of return periods, suggesting that percentage chance of restrictions would be much more meaningful (e.g. 5% chance in 20 years as opposed to a 1 in 20 year restriction). We noted in response that the use of return periods, expressed as annual ratio (e.g. 1 in 20 years) was explicitly required by DEFRA. Members also agreed that our selective metering strategy was a good scheme.

These views have shaped our draft WRMP plan, which is currently going through a final round of testing as part of our PR19 Acceptability Research. A representative sample of our customers are being given the opportunity to look at a summary of our whole PR19 Business Plan and to tell us whether or not they accept it. A section of the summary specifically relates to water resource management. Here participants can read about how from 2020 we will focus on:

- Improving how we can move water around our regions to reduce the chance of customers' water supplies being interrupted
- Always making sure that local communities have sufficient water to meet their needs
- Reducing the risks of hazards like climate change and extremes of weather impacting on our ability to maintain water and wastewater services to customers
- Increasing our ability to respond to and recover from long-term interruptions to the water supply which could impact up to 100,000 customers
- We will continue to make sure that none of our customers are at risk of supply restrictions in a 1 in 200 year drought
- We will reduce interruptions to water supply lasting longer than twelve hours
- Offering our customers smart water meters

Our customers are asked one 'killer question' to measure their acceptability of our whole business plan:

To summarise, in our proposed plan we will make improvements to the services you receive between 2020 and 2025, and will also reduce the risk of more serious problems happening in the future. Our plan is built on what customers have already said is important to them and will be delivered for a lower bill than you pay today.

On the basis of this information, do you accept Northumbrian Water's plan?

Yes – I accept the plan

No – I don't accept the plan

Don't know

The acceptability research has not concluded at the time of preparing this summary, however initial results on acceptability is high.

1.3.4 Draft Water Resources Management Plan Consultation

We ran a public consultation on our draft WRMP between Monday 5th March and Sunday 27th May 2018. The start of the consultation coincided with publication of the document on our website (http://www.nwl.co.uk/wrmp)

We invited the following statutory consultees 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
- Natural England
- The Historic Buildings and Monuments Commission for England.
- Any navigation authority in the area of the plan.
- United Utilities
- Yorkshire Water Services
- The Consumer Council for Water

We also welcomed comments and representations from the wider community, including customers and any other interest groups.

We have since reviewed the feedback received during the consultation and have prepared a Statement of Response which details any changes we have made to the draft WRP19 as a result of the feedback received during the public consultation. We will publish our Statement of Response on our website on 31 August 2018. We will also submit our Statement of Response and our draft final WRMP to Defra on 31 August 2018.

Subject to approval by the Secretary of State, our final Water Resources Management Plan will then be adopted and published in 2018/2019.

1.4 Reliable and Resilience Supplies

The importance we place on delivering reliable and resilient water supplies is demonstrated through our commitment to the following three customer outcomes:

- We are resilient and provide clean drinking water now and for future generations;
- We always provide a reliable supply of water; and
- Our drinking water is clean, clear and tastes good.

We have a strong track record in this area. This WRMP confirms we are very secure with a demonstrable supply surplus in each of our Water Resource Zones (WRZ). It confirms we can provide resilient water supplies for customers without harming the environment, over a minimum of a 40-year horizon, even during a severe drought with a 1 in 200 year return period.

We are not complacent about the future and we have created a Resilience Framework that cuts across the entire business, encompassing corporate, financial and operational resilience, so that we are able to consider and address ‘resilience in the round’. Our new Chief Resilience and Sustainability Officer will be responsible for managing this framework, and will lead our partnership approach to support and build regional resilience.

Even in areas where we are very resilient we will go above and beyond so our customers can have trust in our resilience position. Our ambitious goals for reliable and resilient services are to:

- Significantly lower our levels of leakage;
- Have a per capita consumption for water use in our regions of 118 litres per person per day by 2040;
- Promote confidence in our drinking water so that nine out of ten of our customers choose tap water over bottled water;

Our customer research confirms that they support us investing in resilient networks and planning ahead for impacts, such as from climate change, regional population growth and major incidents impacting the operation of our sites and networks. They also expect our systems to have connectivity and back-up. However, they also understand that we cannot remove all risks (Resilience, Asset Health and Long Term Affordability, 2018). Nevertheless, they do expect us to plan for the future by updating and modernising our infrastructure and systems, and to learn from past events and to put in place the right strategies to prepare for similar events in the future.

To further increase resilience, in addition to the demand management options (see Section 5) and catchment management schemes (see Section 3.4) included in our final plan, we will improve the interconnectivity and transfer capability across our strategic raw and potable water networks. Following our appraisal of risks and current system resilience across our water service, we have identified a number of discretionary investment schemes which start to address this and deliver customers improvement to the reliability and resilience of their water service.

In the North East, we have abundant water resources backed up by our Kielder reservoir. We can transfer water between the main rivers across the region to ensure availability of raw water at treatment works. Only around 3% of the population, in the Berwick water resource zone cannot benefit from Kielder. Between 2015 and 2020 we are investing significantly to improve the reliability and resilience of the Berwick borehole abstraction and treatment systems to provide resilient water supplies to this rural area.

For the Kielder resource zone, although we have plenty of raw water and sufficient treatment capacity the river valley based nature of our operational networks often limits our ability to transfer surplus treated water across our networks. This lack of transfer capability increases our vulnerability to a loss of supply scenario in the event of a catastrophic loss of a strategic asset. Our ambition is to create a fully integrated potable water grid system across our NW operating area by 2045. This grid will complement the current resource resilience we have within the Kielder Raw Water Transfer system, and address the current restrictions in water transfer capability across the region.

From 2020-25, we will invest £128m to deliver our water resilience plan for this area. This includes 18 ‘enhanced’ resilience schemes at a cost of £97m with the remaining £31m funded from our 2020-25 base capital plan. This will improve security of supply and reduce risks of interruptions to supply for more than 447,000 properties. We will:

- Improve treatment capability, including full ‘run to waste’ functionality at Mosswood WTW to manage increasing cryptosporidium risk from raw water sources and protect against asset failure risks. This will provide a more secure source of supply where no alternative currently exists and will directly benefit over 100,000 properties.
- Construct new storage capacity at Springwell, Gateshead, and improve the interconnectivity of our Wearside network. This will reduce the risk of an interruption to supply following an issue at a treatment works, a failure of a strategic water main or a supply restriction due to changing raw water quality. This investment will directly benefit over 52,000 properties currently not supplied from strategic storage as well as providing additional long term security of supply to a further 200,000 properties in the wider Wearside area. This scheme is supported by the DWI.
- Construct a new 55Ml/day pumping station at Shildon service reservoir to provide a secondary supply source from Teesside into our Central zone. This will provide a secondary source of supply to over 50,000 properties currently fed from a single treatment works and trunk main.
- Lay 53km of new main to reduce the risk of a trunk main failure impacting water supply and also improving our water transfer capability between Tees and Central zones. This will directly benefit over 200,000 properties in Teesside. We will also install a number of additional strategic mains reinforcement schemes, including automated flow control, as part of our long term operational plan for the Tees network. The DWI have supported the elements of this scheme that will improve drinking water quality.
- Provide a secondary source of supply to 80,000 properties in Darlington and Whitley Bay currently supplied from single trunk mains.
- Improve overall site and system resilience to natural and manmade hazards at 36 of our water sites deemed as ‘too critical to fail’. These sites provide water supply to over 447,000 properties in total.

1.5 Innovation

Our customer research has shown us that customers expect the quality of the services they receive to continually improve. They do not have specific views on how we should innovate, but they expect us to be forward looking and to 'move with the times'.

Our customers also expect innovation to deliver better value for money and less waste. They expect us to be able to measure how good we are at innovation and the impact it is having. As part of our openness we will publish information on our innovations and will track the changes in our performance that arise from the new activities we undertake.

For AMP7 (2020 to 2025), we have set ourselves an ambitious innovation goal which is to"...**be leading in innovation within the utilities sector and beyond".**

We already innovate openly, working with partners from across a multitude of sectors. This is exemplified by our widely-acclaimed NWG Innovation Festivals (https://innovationfestival.org/). This attracted 1,000 people from across the country and from 140 different organisations in its first year and was even bigger in 2018. We have also established an external Innovation Panel to challenge and support us in developing our Innovation Strategy, which brings together innovation leaders from within and outside the industry.

We use data hacks to help us to find solutions to data-rich problems. Data scientists with fresh eyes use novel tools and techniques to consider challenging questions. We also work with universities and technology companies to provide data and subject matter expertise.

We will continue to build on and invest in our capabilities, leveraging our connections within our shareholder group to promote innovation within our region and beyond.

In this WRMP, we have set out how we will reduce our leakage by 15%, how we will start to use smart metering and how we will help our customers to be more water efficient. Further details of how we will innovate and use technology to reduce demand is set out in Section 5 of this report.

1.6 Our Approach to Assurance

We have used a three line of defence model for assurance, similar to that used for our other regulatory returns. Each piece of data has been provided by someone of appropriate skill and experience and has been peer reviewed.

The key approach, assumptions and strategy have been approved by key directors (principally the former Water Director and the Assets and Assurance Director) a summary paper which included a high level approach and strategy was approved by the Board.

In addition to the above, external assurance and consultancy was sought in areas of highest risk. Edge Analytics were used to calculate the population and property forecasts which is key data underpinning much of the plan.

PwC were our principal external assurance provider and were engaged to provide the principal assurance over our WRMPs, their scope included:

- Gaining an understanding of the overall approach to the production of the WRMPs;
- Gaining an understanding of the detailed underlying processes and assumptions made which were then used to prepare the WRMPs;
- Tracing a sample of these non-financial and investment data points to a mix of source documentation and the outputs of detailed calculations and models;
- Testing a sample of inputs into the calculations and models by tracing these back to source systems and documentation;
- Performing a critical strategic assessment of the WRMPs, specifically assessing their content against the requirements and guidance published by Defra and the Environment Agency; and
- Assessing the extent to which the data in the WRMPs has been accurately extracted into the Water Resource Market Information data tables.

Any recommendations made have been incorporated into the plan.

Our approach to assurance is described in *Our Assurance Plan 2018/19*. The plan identifies areas of risk and planned assurance activity in 2018/19. The Periodic Review 2019 (PR19) is identified as a risk and the WRMPs have been produced and assured in line with the PR19 process. Given the critical importance of PR19, the Board has formed a dedicated Board Sub-group to provide integrated support to both the Board and management in driving forward and assuring preparation of our PR19 plan. The Board Sub-Group has overseen the production and assurance of the WRMP.

1.7 Water Resources Plan Structure

Subsequent sections of this WRMP are as follows:

Section 2 Background Information: This section provides background information including a description of each of our WRZs, progress made in implementing our 2015 WRMP, confirmation of the base year and planning period and confirms our 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 our 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, our baseline supply demand balance confirms both WRZs are in surplus over the whole planning horizon and so options appraisal is not required.

Section 10 Final Water Resources Strategy: This section confirms our final water resources strategy.

2.0 BACKGROUND INFORMATION

2.1 Water Resource Zones

The Water Resource Zone (WRZ) is the basic building block of a Water Resource Management Plan (WRMP). Companies will have a variable number of WRZs making up their total supply area. A WRZ is the largest area of a company's supply area where supply infrastructure and demand centres are generally integrated to the extent that customers in the WRZ should experience the same risk of supply failure due to climatic conditions.

We have two potable WRZs covering our supply area. These are the Berwick and Fowberry WRZ in the far north of the supply area and covering about 1% of the customers and the Kielder WRZ covering the remaining 99% of customers. The Berwick and Fowberry WRZ has two well fields centred around Berwick and Fowberry.

The Industrial WRZ was originally constructed in the 1940's to meet a growing demand for non-potable water on Teesside. Water can be abstracted from the River Tees at three locations to support the Industrial WRZ.

2.2 Water Resource Zone Integrity

A Kielder and Berwick and Fowberry WRZ Integrity Assessment was the subject of dialogue in our previous WRMP with the Environment Agency (the Agency) as they required us to demonstrate more fully how it is a single WRZ. We were able to demonstrate that water is integrated to such an extent over the whole WRZ, mainly by being supported by Kielder Reservoir and the Tyne-Tees Transfer (TTT), that it is a single WRZ and complies with the definition of a WRZ. There have been no major changes to this position and no area of the company has ever been subject to restrictions on their use of water due to drought conditions.

We recognise that the Kielder WRZ and Berwick and Fowberry WRZ are completely separate from each other although our Level of Service (LoS) to both WRZs is the same. There is a considerable surplus of supply within the Kielder WRZ that, as demonstrated in previous WRMPs can be adequately moved across all of the major customer centres.

The use of three WRZs remains appropriate. Figure 2.1 below shows the three WRZs.

2.2.1 The Kielder Water Resource Zone

There are three main supply zones within the Kielder WRZ, these being the "Northern", "Central", and "Southern", which incorporate the major urban conurbations of Tyneside, Wearside and Teesside respectively. They are virtually discrete in terms of treatment capacity, but they can all be supported from Kielder. As such they all have the same theoretical risk on restrictions of use and are considered as a single water resource zone.

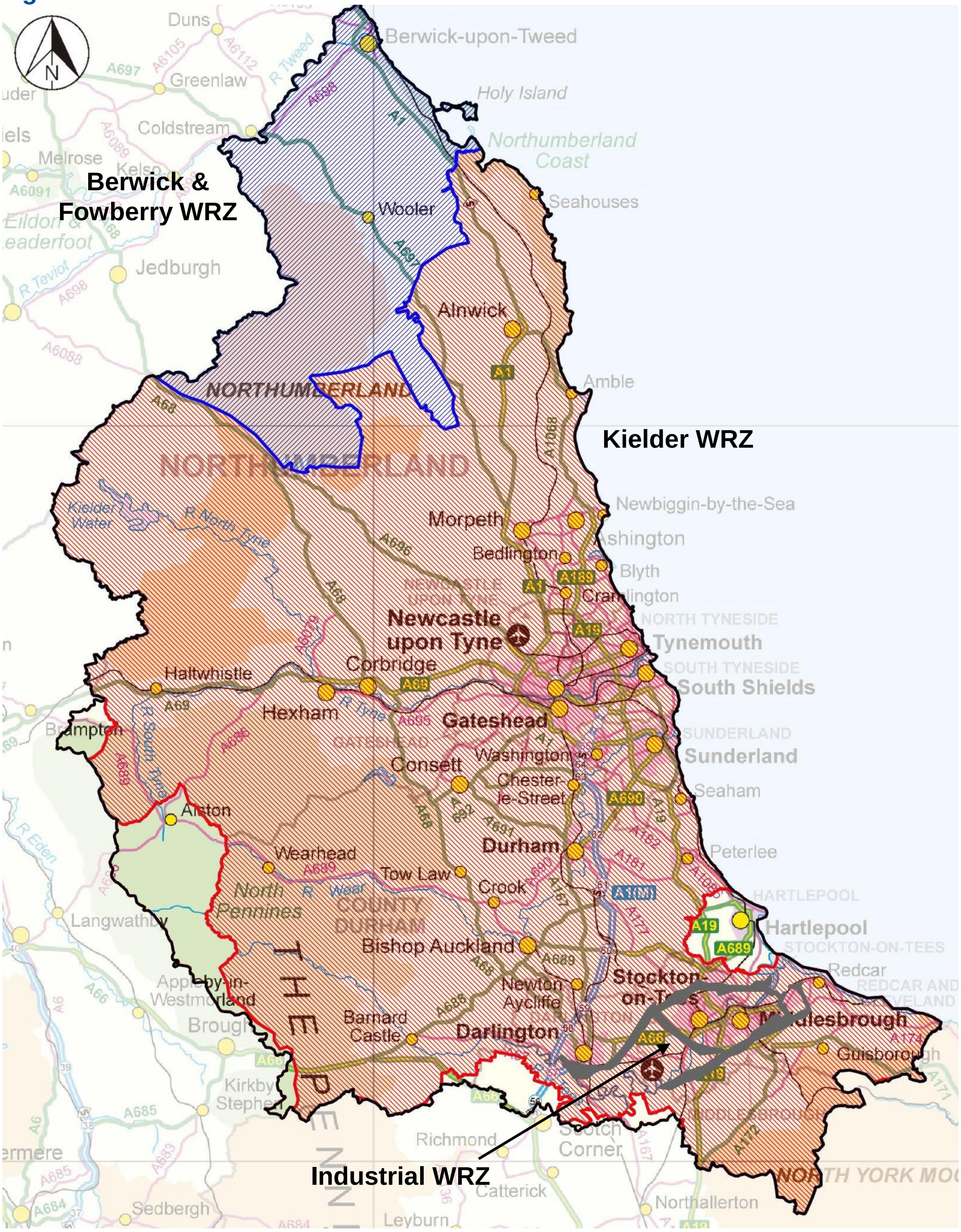
2.2.2 The Kielder Water Supported Systems

The scheme consists of the Kielder Reservoir and Dam (associated headworks including release valves and hydropower plant), Bakethin Dam (a weir upstream of Kielder Reservoir) and a pumping station at Riding Mill on the River Tyne. The pumps deliver into a rising main from Riding Mill to Letch House. A gravity pressurised tunnel flows from Letch House into Airy Holm Reservoir, onto Frosterley discharge into the River Wear and to Eggleston discharge into the River Tees. Licensed abstractions from the tunnel allow support to Mosswood Water Treatment Works (WTW) and to Honey Hill WTW.

2.2.3 Associated Water Resources

Associated water resources include those that may be deficient in times of drought to meet demands, and may therefore be required to call upon the strategic resource provided by the Kielder Water Scheme. These resources have been grouped as follows:

Figure 2.1 Water Resource Zones



- North Tyne and Northumberland Resources
- River Wear and Associated Mid Durham Resources
- Tees Resources

These groups are described as follows:

North Tyne and Northumberland Resources

The northern part of this system is supplied from Warkworth WTW, Fontburn Reservoir and treatment works and Tosson Springs and treatment works. These are linked to the Tyne system with a potable water trunk main and full flow from Warkworth can be replaced with potable water from the Tyne WTWs.

Fontburn Reservoir is silted at its upper levels due to pine needles falling and trapping the sands and silts which do not migrate to the treatment works. Previously the amount of storage lost at Fontburn Reservoir due to siltation had been estimated to be 489 Million litres (Ml). Following a recent bathymetric survey the overall storage lost due to siltation has been re- assessed as 80Ml and confined to the area around the inlet of the reservoir.

In addition there is a linear sequence of reservoirs supplying raw water to Gunnerton, Whittle Dene and Horsley WTWs.

Catcleugh Reservoir in Redesdale feeds Hallington Reservoirs by gravity which in turn connects to the Whittle Dene group of reservoirs. Two additional reservoirs, Colt Crag and Little Swinburne contribute flow to the Hallington Reservoirs. These direct supply reservoirs cannot reliably meet the raw water requirements and river abstractions are made at Barrasford on the North Tyne and Ovingham on the Tyne. The pumped abstraction at Ovingham is used to supply Horsley WTW or to support the Whittle Dene Reservoirs, whilst the abstraction from Barrasford is pumped into the Hallington Reservoirs. Kielder releases are made to regulate the River North Tyne or River Tyne when required.

Storage at other reservoirs is balanced to ensure that water is not wasted through spillage, especially at Whittle Dene, whilst higher level reservoirs are still drawn down.

Water treatment is provided at six works, three very small works, Otterburn, Rochester and Byrness, supplying the Redesdale area and Gunnerton supplying the area west of Hexham. The remaining treatment works at Whittle Dene and Horsley jointly meet the majority of Tyneside and SE Northumberland demands.

Catcleugh Reservoir Operation

The treatment works at Otterburn, Rochester and Byrness are dependent on Catcleugh Reservoir for sole supply and theoretically the needs of this demand zone should limit the rate of transfer to Hallington and Whittle Dene.

However, in practice, the capacity of the Rede pipeline restricts the rate of drawdown such that, even in extreme drought the needs of Redesdale do not act as a constraint. Transfers from Catcleugh to the Hallingtons can therefore operate continuously at full pipeline capacity. The Rede pipeline from Catcleugh to Hallington is limited (by construction) to 55 Million litres per day (Ml/d) when the reservoir is full, and therefore normally operates at full capacity.

Colt Crag, Hallington and Whittle Dene Reservoir Operation

The linear configuration of the remaining reservoirs permits them to be considered as one, with the total storage balanced between reservoirs under our control within the constraints imposed by the licence. The aim should be to avoid unnecessary losses by spillage, whilst maintaining throughput for treatment. Control rules for the group of reservoirs have been agreed between the Agency and ourselves.

2.2.4 The Tyne – Tees Transfer System

The TTT system comprises a pumping station at Riding Mill on the River Tyne, a rising main and gravity tunnel carrying water (when required) to Airy Holm Reservoir, the River Derwent, Mosswood WTW, Waskerley airshaft, the River Wear and the River Tees.

At Riding Mill pumping station six pump units, each with a nominal fixed capacity of 1.05 cumecs (90 Ml/d), are installed. However an agreed supply capacity with Central Electricity Generating Board (CEGB) limits maximum abstraction flow to three pumps, about 270 Ml/d. All six pumps remain in commission and are tested periodically.

The rising main and tunnel are designed to remain charged and have a capacity of 230,000 m^3 Airy Holm Reservoir forms a header tank on the tunnel system to correct any imbalance between rates of pumping and outlet discharge. Airy Holm will normally be maintained near to full level in order to provide a reserve for releases. However, no spillway discharge should occur as a direct result of pumping at Riding Mill.

A direct connection links the tunnel with Mosswood WTW and can provide full substitution for the Derwent Reservoir resource and thus support the water resources for mid-Durham.

Provision has been made for a licensed abstraction from Waskerley airshaft with an annual total of not more than 3,200 Ml. This water can be abstracted from the TTT into Waskerley northern catchwater.

The Tyne-Tees transfer system also supports the Rivers Wear and Tees to ensure that prescribed minimum maintained flow conditions are met and the system operation is set out in the Kielder Operating Manual.

2.2.5 River Wear and Associated mid-Durham Resources

The strategy for operating to the River Wear and mid-Durham resources is:

- To regulate the River Wear to maintain flow rates above a prescribed minimum flow rate as measured at Chester-le-Street gauging station.
- To regulate the River Wear to support abstractions, including the public water supply abstraction at Lumley.
- To provide water in emergency for flushing the Rivers Derwent and Wear, following major pollution incidents.
- To support associated water resources in mid-Durham in times of drought by making direct transfers from the Tyne-Tees tunnel to Mosswood treatment works and from Waskerley airshaft to support Honey Hill treatment works.

River Regulation for Prescribed Flow and Abstraction

The outlet from the TTT System to the River Wear is located near Frosterley. The maximum discharge capacity of the outlet valves is 2 cumecs. (173 Ml/d). Tunstall Reservoir now acts as a regulatory reservoir following the abandonment of the treatment works at this site.

Water for public water supply is abstracted from the River Wear at Chester-le-Street to Lumley WTW the maximum licensed daily abstraction is 45.4 Ml/d.

A prescribed minimum maintained flow is set at Chester-le-Street gauging station of 2.0cumecs (173 Ml/d). Both the Agency and ourselves has access by telemetry to levels and flows measured at the station.

Mine water discharges to the River Wear and tributaries cause small variations in flow. However, eventually minewater pumped discharges are expected to cease.
An outlet close to Derwent Reservoir allows releases to be made from the TTT in the River Derwent. However, as there are no public water supply abstractions or prescribed flows on the River Derwent, releases are reserved for use in supporting compensation flows and alleviating pollution.

Waskerley Air Shaft allows licensed abstractions of 24 Ml/d or 3200 Ml/year to be abstracted from the TTT into Waskerley.

Mid –Durham Associated Water Resources and Support.

An operating policy for the timing and magnitude of Kielder support is agreed to provide guidance in ensuring that public water supply requirements can be met in a drought in all parts of the mid-Durham demand area.

System Assumptions

Given the complex interlinked network linking sources and demands a large number of options exist for operating the system. The control policies described later are based on the following key assumptions:

- Priority is given to meeting public water supply requirements and the needs of the rivers, as reflected by minimum maintained flows and compensation flows.
- Where either of the requirements above can be met only from a single source, sufficient water has to be retained in the relevant storage to supply these without reduction except under severe droughts, until the anticipated end of a drought.
- Other uses of water, such as for fisheries, recreation and amenity are recognised and provided for where appropriate.
- The policies provide a broad but well defined framework within which the undertaker may operate the system to meet their own needs and interests.
- The policies have been defined to minimise the operating costs for the Agency and ourselves within the constraints above.

Water Resources System Structure

The key mid-Durham resources are:-

The abstraction from the River Wear at Lumley, two main reservoirs Derwent and Burnhope, three smaller reservoirs Smiddy Shaw, Hisehope and Waskerley, Tunstall river regulatory reservoir, groundwater sources (mainly from the Magnesian limestone aquifer in the Sunderland area), and two small spring sources, and the TTT system as previously described.

Derwent Reservoir:-

Mosswood WTW supplies its demand centres by abstracting raw water from Derwent Reservoir or from the TTT scheme. Abstraction from the tunnel to Derwent/Mosswood is licensed to an annual total of 21900 Ml and a peak daily rate of 164 Ml/d.

Smiddy Shaw, Hisehope and Waskerley Reservoirs:-

Smiddy Shaw, Hisehope and Waskerley Reservoirs, nearby small spring sources, Waskerley air shaft and associated Honey Hill WTW are treated as a group. Water can be transferred under gravity from Waskerley, Hisehope and Smiddy Shaw to Honey Hill WTW. The required output of Honey Hill WTW cannot be fully met from these reservoirs year round but support is available from Burnhope Reservoir. Burnhope raw water may be transferred under gravity to Waskerley, Smiddy Shaw or direct to Honey Hill at a maximum rate which depends on the level in Burnhope.

In addition water can be pumped into Waskerley Reservoir from the Waskerley airshaft (part of the TTT). A maximum of 24 Ml/d can be pumped from the airshaft while the total annual abstraction may not exceed 3200 Ml.

Burnhope Reservoir:-

Water from Burnhope can be used to supply Wear Valley WTW and the raw water pipeline to the Waskerley, Smiddy Shaw or Honey Hill WTW. Wear Valley treatment works and compensation water can only be provided from Burnhope and therefore, sufficient resources are retained at all times to provide for these two demands. Burnhope Reservoir is small for the catchment area and can be resource restricted in the summer months.

Groundwater Supply

The coastal ground water sources and shafts supplying groundwater towards Sunderland have their pump low level protection set conservatively to alleviate the problem of disturbing sediment at the lower levels. Sediment creates turbidity, which is used as a surrogate for possible cryptosporidium pollution and results in pump shut down. There is a project currently underway which involves the addition of filtration at each of the groundwater stations to control turbidity and allow groundwater to be put back into supply with shorter run-to-waste times. This investigation looks at the physical (particle size distribution) and chemical (chemical analyses of different particle size ranges) nature of particles making up turbidity. This will help identify the potential source of turbidity and the specification of filters at each groundwater station.

In addition there is also a programme of groundwater source cleaning in progress to ensure supplies can be maintained.

We will also carry out the following investigations regarding the Sunderland Groundwater abstractions.

Saline Intrusion: There are concerns that there is not an evaluation of the impact of abstractions on possible saline intrusion into the Magnesian Limestone aquifer and therefore as part of WINEP we will work with the Agency using the groundwater model to assess the potential for saline intrusion.

Coal Measures: Impact of rising groundwater in Coal Measures on the water quality within the Magnesian Limestone. This includes investigation with Coal Authority on the depth of the separation zone between the top of the Coal Measures and the bottom of the Magnesian Limestone which is a key mechanism to protect Magnesian Limestone aquifer and ensures the hydraulic gradient between the two aquifers is from the Magnesian Limestone to the Coal measures and sharing this information with the Agency. This also includes the proposal to develop the existing Magnesian Limestone groundwater model to include predictive modelling of the interaction between the Magnesian Limestone and Coal Measure groundwaters.

2.2.6 River Tees and Associated Tees Resources Objectives

Within the general framework of ensuring proper use of resources, objectives for the River Tees and the operation of local resources within the Tees catchment are:

- To regulate the River Tees to maintain flow rates above a prescribed minimum flow rate as measured at Broken Scar gauging station.
- To regulate the River Tees to support at Broken Scar, Blackwell and Low Worsall and hence to support associated water resources in the Tees catchment in times of drought.

- To provide water in emergency for flushing the River Tees, following major pollution incidents.

River Regulation and Prescribed Flows and Abstractions

The principal regulating reservoir on the Tees catchment is Cow Green providing the full support required for prescribed flows and abstractions under normal conditions. In conditions of dry weather or future higher abstractions, releases may be made from Balderhead Reservoir or the TTT system.

Associated Tees Water Resources and Support

The principal objective in the design of the Kielder Scheme was to augment the water resources of the Tees basin to meet the then rapidly increasing demand for water, primarily for industrial use. Although the forecast industrial demands have not materialised, recent droughts have illustrated the advantages of a strategic regional resource. Whilst the volume of transfer through the tunnel to the Tees has been limited to small amounts, the availability of support has enabled the cheaper local sources to be used more effectively, and to be drawn down further, without the necessity to place restrictions on water use.

System Assumptions

Given an inter-linked network linking sources and demands, a large number of options exist for operating the system. The control policies described below are based on the following key assumptions.

- Priority is given to meeting public water supply requirements and the needs of the river are reflected by the minimum maintained flow and compensation flows from reservoirs.
- Other uses of water such as for fisheries, recreation and amenity are recognised and provided for where appropriate.
- The policies provide a broad but well defined framework within which we may operate the system to suit our own needs.

Cow Green Reservoir:-

Cow Green is the principal river regulating reservoir on the River Tees, and is used to support the minimum maintained flows in the River Tees to allow abstractions from the river downstream. River regulation demand can normally be met from Cow Green but can be augmented when necessary by releases from Lune and Balder Reservoirs or the Kielder transfer system.

In-river needs in the upper Tees are met by the compensation flow and by the requirement to reserve water such that at least one third of regulation releases at a given time come from Cow Green, when additional regulation releases are being made from the Lune and Balder Reservoirs, as specified in the Tees Valley and Cleveland Water Act 1967. That Act also requires that 1818 Ml be reserved in the reservoir for freshet releases for fishery purposes, at a maximum additional discharge rate of 45.45 Ml/d.

Cow Green has a flood control role during winter months with the level of the reservoir being drawn down to provide flood storage.

Lune and Balder Reservoirs:-

The Lune and Balder Reservoirs consist of Selset, Selset Weir and Grassholme on the River Lune and Balderhead, Blackton, Hury Subsidiary and Hury on the River Balder. The two cascades of reservoirs are used conjunctively by means of a tunnel connecting Selset Reservoir to Hury Reservoir.

The Lune and Balder Reservoirs directly support Lartington WTW. Water may be available for regulation releases to support the River Tees when the reservoirs are in the surplus zone. The normal minimum release to the River from these reservoirs is compensation water (44 Ml/d) and the flow to meet the requirement of Lartington WTW.

In-stream flow needs for the Lune and Balder Rivers are met by the compensation releases from Grassholme and Hury Reservoirs respectfully. There is significant recreational use of some of the reservoirs.

2.2.7 Berwick and Fowberry Water Resource Zone

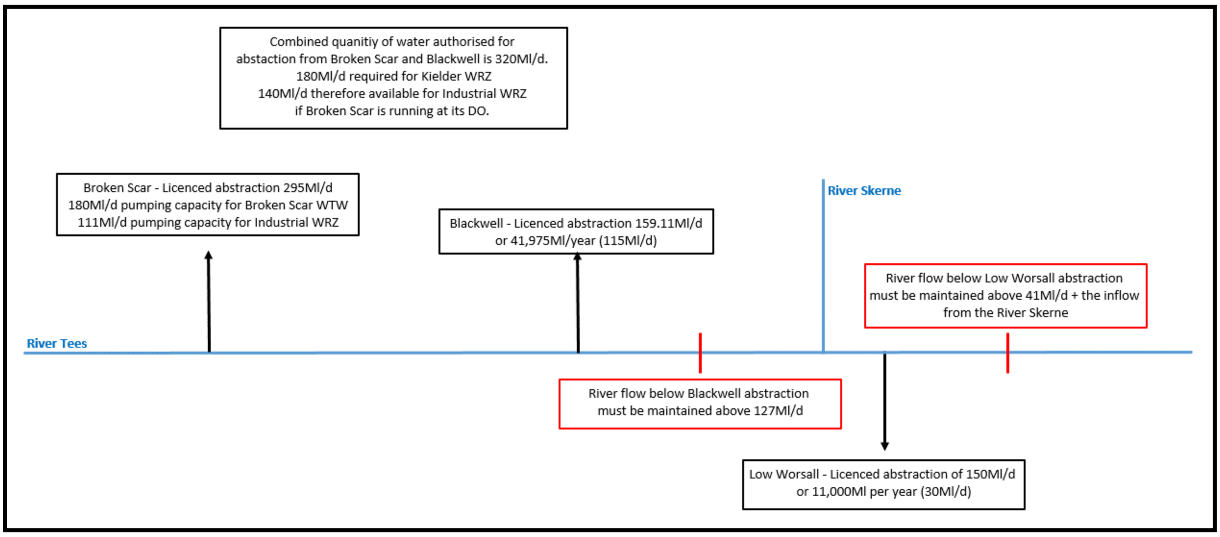
The Berwick and Fowberry WRZ is a small zone in the North East of Northumberland serving the towns of Berwick-upon-Tweed and Wooler. The area has a small indigenous population of about 25,000 people but is a very popular tourist area. It is a discrete zone in terms of both water resources and treatment capacity and cannot be supported from Kielder. The resources comprise a number of groundwater sources, sunk into different layers of the Fell Sandstone Aquifers.

2.2.8 Industrial Water Resource Zone

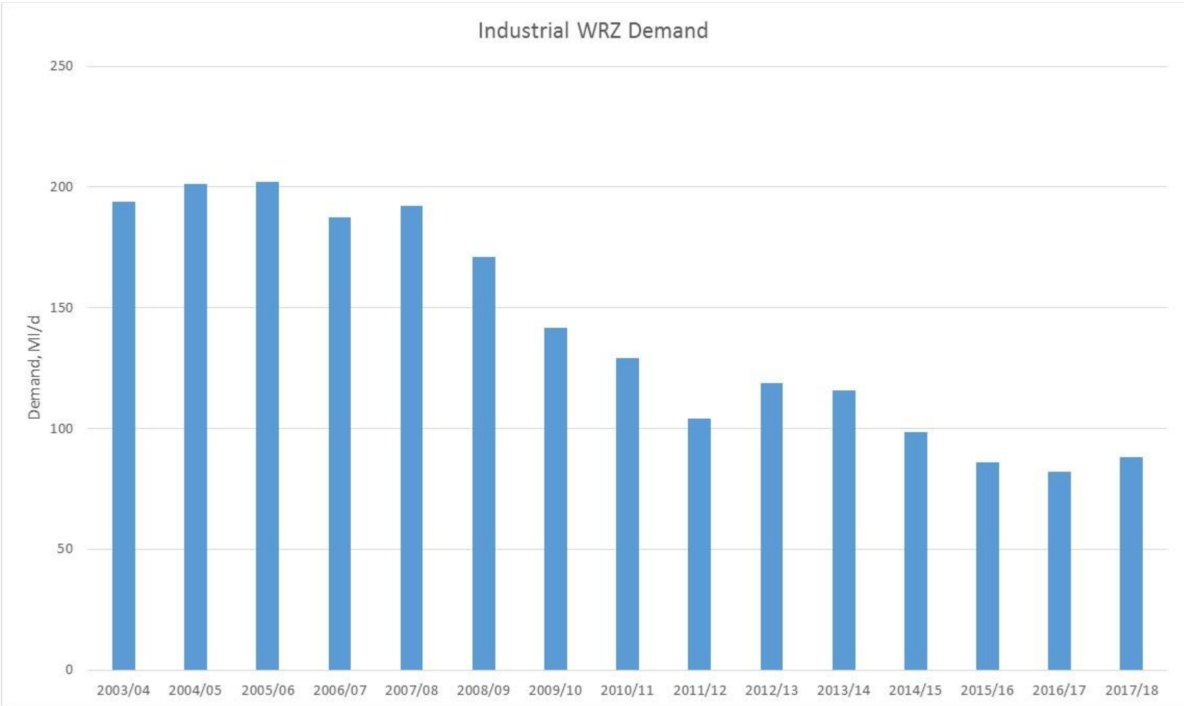
The Industrial WRZ was originally constructed in the 1940's to meet a growing demand for non-potable water on Teesside. Water can be abstracted from the River Tees at three locations to support the Industrial WRZ.

The Industrial WRZ, comprises two connected networks referred to as the Gately and Low Worsall systems. The Gately network takes its supply from Blackwell RWPS and Broken Scar RWPS. Under normal operation Blackwell RWPS provides the supply to the Gately Moor Reservoirs with Broken Scar RWPS providing emergency backup if required. The Low Worsall network takes its supply from Low Worsall RWPS.

Below is a description of how the various abstraction licences on the River Tees interact and the volume of water available for the Kielder WRZ and the Industrial WRZ.



Demand in the Industrial WRZ has dropped significantly over the course of the past 15 years from 200Ml/d to 85Ml/d, a reduction of 57% since the early 2000's. The demand has remained ~85Ml/d over the past 3 years.



As a result of this significant reduction in demand, going forwards, we are forecasting to supply the Industrial WRZ wholly from Blackwell RWPS with standby pumping capacity available at Broken Scar RWPS.

For clarity, the demand in the Industrial WRZ is treated independently from the demand in the Kielder WRZ albeit both demands are included in the Aquator model. All non-potable demand is within the Industrial WRZ and all non-household demand is within the Kielder WRZ. All demand forecasting mentioned elsewhere in this document is only applicable to the two potable WRZs. Due to the nature of demand in the Industrial WRZ (i.e. for industrial process as opposed to traditional demand profiles), the standard demand forecasting techniques are not appropriate. For planning purposes we have assumed a consistent demand forecast for the Industrial WRZ of 82Ml/d based on the demand experienced in the past 3 years. We feel this is appropriate as any increase in annual average demand will only be experienced if new industry is developed on Teesside. Given the current economic climate, this does not currently look likely. Additionally, any new industry that develops in Teesside will inevitably be designed with more water efficient processes than has been seen historically.

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 both WRZs across the full planning horizon.

Our 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 3.7 while progress with our leakage, metering and Water Efficiency programmes are presented in Section 5.

2.4 Sharing Surplus Water Resources

WRZ supply/demand balance calculations were prepared in early 2017. These showed that there was a significant surplus of water in the Kielder WRZ that would be available for trading. However, there was considerable uncertainty as to what the surplus for the Berwick and Fowberry WRZ would be as at that point, our groundwater abstraction sustainability investigations had not concluded. Consequently, it was concluded that there was no surplus of water to trade from the Berwick and Fowberry WRZ.

As with previous periodic reviews, we have held discussions with regional companies, specifically with Yorkshire Water (YWS), United Utilities (UU) and Hartlepool Water.

YWS

We have previously met with YWS to discuss what options could be available as new water resource schemes for YWS using transfers of surplus water from our current licensed resources. Only two options were considered suitable for consideration of further thought.

The first was to look at a potable water supply from our Broken Scar WTW being piped by new pipelines into the Whitby area of YWS. A supply of 25 Ml/d would be required by YWS and Broken Scar has sufficient spare dry year DO to make this supply. We provided YWS with its Large User Tariff rate as a likely charge it would make for the water. YWS, should they choose to look at the option in its appraisal process, would have to look at costing to lay the pipeline between the two places and estimate the pumping (energy) costs.

The second option was to look at transferring raw water into YWS area by transferring River Tees water into the existing pipeline running from the Tees almost to the River Wiske, and extending this pipeline to the River Swale. YWS asked us to cost and model two different volumes of 50 Ml/d and 140 Ml/d, noting that the 140Ml/d would require the electrical service capacity at Riding Mill to be upgraded and an additional pump installed.

YWS has not asked to progress agreements regarding trading of water from the Kielder WRZ. Consequently, no allowances have been made in either our baseline or final plan supply demand balance calculations.

UU

We have previously met with UU to explore any options that could be available for transferring surplus water from our Kielder WRZ into UU's area. A number of options and volumes were considered.

We currently make a ~1.0 Ml/d bulk potable supply from Burnhope Reservoir into UU's North Eden WRZ. UU forecast this WRZ to remain in surplus but would like to understand any potential for increasing the current volume of the bulk supply. We estimated that there was sufficient raw water and treatment capacity (by substituting water within the Kielder WRZ) for a bulk supply of 5 – 6 Ml/d to be available. However after investigating the capacity of the current bulk supply infrastructure, we later informed UU that the current infrastructure delivering 1.0Ml/d is at full capacity and the cost of upgrading the pipelines and intermediate pumping stages is likely to make this option unviable. UU has not ask for any further information.

Cow Green Reservoir is geographically the nearest of our resources to where UU may need water in the future. An option could be considered where a pipeline from Cow Green, crossing the Pennines, could connect into a tributary of the River Eden for the Carlisle WRZ or into Haweswater for the Integrated WRZ. UU has previously asked us to look at the cost and availability of 25, 50, 100 and 180 Ml/d being supplied from Cow Green to UU. These costs were provided to UU in October 2012 but the following information to note was also given:-

- A supply above 100 Ml/d is unlikely to be available without a large change to our current operating regime
- Cow Green is a SSSI and any new abstraction from the reservoir would require a full Environmental Impact Assessment and we would not be sure of the outcome.
- Cow Green is in a remote location without suitable roads or power supplies.

UU requested similar costings for 25, 50,100 and 180 Ml/d supplies into UU from Kielder Reservoir. Taking water from Kielder is likely to have less environmental impact on the water body but does require the water to be transferred longer distances. Transfers from Kielder into UU's Carlisle or Integrated WRZ and into its West Cumbria WRZ have been previously considered. However, the latter was discarded on cost grounds compared to other options for the WRZ.

UU has not asked to progress agreements regarding trading of water from the Kielder WRZ. Consequently, no allowances have been made in either our baseline or final plan supply demand balance calculations.

We will continue to explore trades both directly with other water companies and through Water Resources North.

2.5 Water UK Water Resources Long-term Planning Framework

The primary aim of this project was to develop a strategy and framework for the long-term planning of water resources at a national level, and in doing so to assess the long-term water needs and the available options to meet them.

The project considered droughts worse than those within the historic record and worse than current levels of service plan for. It looked ahead 50 years and undertook new modelling of droughts, assessed climate change impacts and provided conclusions on the national scale resilience of water supplies.

The project:

i. took a sector-wide view of future resilience and options for improving that resilience;
ii. Assessment of variation in levels of service and potential minimum levels of service for customers and the environment, accounting for costs and benefits at a national, regional and sub-regional level, which includes the wider social impacts of drought and drought resilience;
iii. Exploration of opportunities to integrate investment (WRMPs) & operational management (Drought Plans);
iv. Qualitative identification of potential implications of drought failure on other sectors Identification of the potential barriers that are represented by current and future arrangements that might exist between water companies, including potential trading arrangements, the implications of competition etc.
v. Identification of the likely nature of resilience infrastructure and preferred levels of service to inform discussions relating to national infrastructure planning and the development of a national policy statement on water resources.

The study concluded that:

i. there is a significant and growing risk arising from drought, climate change, population growth and sustainability reductions;
ii. there is a strong case for government to promote a consistent national minimum level of resilience for water resources;
iii. there is an economic benefit of increased resilience because the investment needed to increase resilience is 'modest' compared to the potential reactive costs to drought and flood;

iv. companies should continue to seek a twin-track approach which includes demand management and supply enhancement including transfers between companies; and
v. there is a strong case for 'adaptive planning' to support company WRMPs. While individual companies will need to make investment in the next 25 year planning period, nationally, 2040 and 2065 were identified as key points in time to make investment.

The report considered NW within a group called the North East. The report concluded that this group is currently running a large surplus and is highly unlikely to experience significant drought detriment. Our WRMP19 continues to support this. Indeed, the Kielder WRZ deployable output is infrastructure and licence constrained and not resource constrained. We believe that Kielder Reservoir can be used to improve the resilience of other water companies. Kielder water can easily be transferred to the south of our WRZ using the existing Tyne Tees Transfer (TTT). Our ability to move Kielder water within our area means that water can then be exported into the northern WRZs of neighbouring water companies which by substitution, would then free up water to trade further south. We are a lead water company in Water Resources North and have confirmed through this group and through our Water Resources Market Information data published on our website, that we have water to trade to increase the resilience of other water companies. We updated our WRMP to include a dedicated section on the WaterUK project.

2.6 Regional Water Resources (Water Resources North)

A new group called Water Resources North (WRN) has been formed with initial membership comprising NW, YW, UU, Hartlepool Water and the Agency. The group anticipates opening up to other relevant stakeholders (abstractors and regulators) once water companies have gained a clear understanding of their joint long term water resources position and aspirations. It may be appropriate to have a number of levels of engagement – from those directly involved in the group, through to those who are consulted, or informed, about the group's discussions.

The purpose of WRN is to provide leadership and coordination to support the delivery of long term water resource resilience in the north of England, and to support activity aimed at ensuring national water resource resilience. The primary objectives of the group are to:

i. Contribute to securing the long-term resilience of water supplies and the water environment in the north, across all stakeholders, and
ii. Facilitate a co-ordinated approach across northern water companies to cross-boundary trading that may contribute to enhancing national water resource resilience.

The group will help to achieve these objectives by:

i. Providing a strategic forum to bring together representatives from each of the water companies in the north of England, their regulators and other relevant industries, to facilitate an effective and co-ordinated approach to water resources management;

ii. Enhancing understanding of the long-term challenges for water resource resilience, both within the north and across the whole country;

iii. Contributing to joint working on future water resource options, both to inform individual companies' WRMPs and to inform long term investment needs which may include joint investment activity;

iv. Helping the industry to articulate future challenges with a consistent voice, to assist with customer and stakeholder engagement and understanding of investment priorities; and

v. Sharing approaches and best practice in water resources planning.

We fully support the WRN project. Kielder Reservoir provides us with a significant supply surplus which, with additional infrastructure, could be used to support both neighbouring water companies and also water companies further south. For example, a neighbouring water company could take a raw water supply into one of its WRZ from a Kielder Reservoir supported river. This could then allow that company to release water from another of its WRZ to one of its neighbouring water companies and so on. This theoretical transfer scheme has previously been highlighted by the Water Resources Long Term Planning Framework project and could be considered by WRN going forwards.

We share the ambition of government and regulators that greater focus be given to regional water resource planning through bodies such as WRN. We are determined to play a leading role in this process and to ensure that a fully integrated regional planning approach is adopted for the 2024 planning cycle.

2.7 Planning Period

The statutory planning period for WRMPs is a minimum of 25 years from 1 April 2020 to 31 March 2045. However, the Water Resources Planning Guideline (WRPG) encourages water companies to plan over a longer planning horizon. For the purposes of this Plan, our 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 we have out-turn data for and is also in line with the WRPG.

2.8 Planning Scenarios

Our baseline and final plan supply forecasts for each WRZ are based on a 'dry year' which is defined by the worst historical drought we have on record. The design drought years are described in the DO 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 also presented in Section 3.1.

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).

Our assumptions regarding the impacts of climate change on both Water Available For Use (WAFU) and demand are described in Section 6.

Kielder WRZ has always used the Dry Year Annual Average as the planning scenario. This still remains relevant as no high peak demand is driving investment in the WRZ.

2.9 Problem Characterisation and Risk Composition.

Problem Characterisation

Problem Characterisation requires water companies to assess the vulnerability of each of their WRZs to various strategic issues, uncertainties, and risks. We undertook a problem characterisation assessment in 2016 and submitted the resulting report to the Agency. The assessment was completed following the method outlined in the 2016 UKWIR report entitled WRMP 2019 Methods – Risk Based Planning.

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. Both of our 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 LoS 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 both of our WRZs, there were no significant concerns about understanding of near term supply system performance and we continue to meet 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 both of our WRZs had a "low vulnerability" score. The results of this assessment were then carried forward to the risk composition stage detailed below.

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 WRPG provides a summary description of the approaches and techniques for each approach for developing supply and demand forecasts and is re-produced in table 2.1 below.

Table 2.1 Risk Composition Guidance

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 LoS commitments and resilience to droughts outside of the historic

Risk Composition	What is it?	Specifics of what is Involved (supply, demand, investment)
		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 our stated LoS and drought resilience.

The WRPG 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.

Our early (2016) supply and demand forecasts indicated that both of our WRZs would have a supply surplus across the full planning period. As such, the problem characterisation assessment concluded that the WRZs had a low vulnerability to supply deficits. Consequently, the conventional methods (i.e. Risk Composition 1) have been used to forecast 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.

In line with the WRPG, we have applied some Risk Composition 2 approaches in that each water resource zone has been tested against a theoretical drought event which could occur one year in every 200 years on average.

2.10 Resilience to Droughts More Severe than those used to test this WRMP

For each of our water resource zones, we have completed deployable output assessments both against our worst drought on record and for Kielder WRZ a drought with a return period of 1 in 200 years on average. It has not been possible to complete a 1 in 200 year drought assessment for our Berwick WRZ due to the lack of a model. However, we have gained through our AMP6 National Environment Programme investigations a conceptual understanding of the Berwick Fell Sandstone hydrogeology. This has allowed us to start developing a model with British Geological Survey, which we can then use to undertake such drought resilience assessments.

The resulting deployable outputs ensure that there is a supply surplus across the 40 year planning period without the need for Level 2 customer restrictions (i.e. we only need to make appeals for restraint once in every 20 years on average). Based upon these assessments, we have followed Ofwat's Drought Resilience Metric guidance to develop a Certainty Grade for Kielder WRZ, outlined in section 2.10.1.

In line with the Defra Guiding Principles and with the revised Water Resources Planning Guideline (July 2018), we will be testing our deployable output against even more extreme droughts including those with a return period of 1 in 500 years and 1 in 1,000 years on average. This work will be completed using the Drought Resilience Framework method and will be reported in the first Annual Review of our published WRMP19.

If a more severe drought than those we have tested our plan against were to occur, the actions we would take are outlined in our Drought Plan (www.nwl.co.uk/droughtplan). The next action would be to impose a level 2 temporary use ban which would include restrictions on the use of hosepipes. Our drought plan does not contain any drought permits which would provide additional supplies of water.

2.10.1 Drought Resilience Common Performance Commitments

Ofwat has developed a common performance commitment for drought resilience. The measure is, "the percentage of the population the company serves that would experience severe supply restrictions (e.g. standpipes or rota cuts) in a 1 in 200 year drought".

As described above, our PR19 modelling has confirmed that 0% of our customers would experience severe supply restrictions (e.g. standpipes or rota cuts) in a 1 in 200 year drought. This is due to the Company having invested for the long term in Kielder Reservoir.

Ofwat note that due to uncertainties surrounding data reliability and inconsistent methodologies, it is not possible to assign a quantitative level of certainty to the drought metric. As an alternative, a semi-qualitative 'Certainty Grade' has been suggested, adapted from the established Ofwat Confidence Grade process.

The first step is to assign a grade to the sophistication of the methodology used to derive a 1 in 200 year drought event. Table 2.2 outlines the criteria proposed, and Table 2.3 shows the grade assigned to Kielder WRZ in this process.

Table 0.2: Methodology grading criteria

Method Grade	Description
A	Use of drought event data from latest research outputs that have employed global climate model ensemble runs to simulate droughts, such as those arising from the MaRIUS Project within the NERC Drought and Water Scarcity Programme[1],
B	Use of perturbed data from existing observed weather datasets, using stochastic processes, in a "weather generator" approach used with UKCP09 Regional Climate and Future Flows (2012[2].)
C	Extrapolation from limited sample of historic company data
D	Use of arbitrary or 'yardstick' deviations based on historic observations

Table 2.3: Methodology grading result

WRZ	Methodology	Grade
Kielder	The Kielder Aquator model was run using a historic naturalised river flow series, with incrementally increasing demand, and the model counted the number of failure years in the analysis period for each demand. The return period for each number of failure years was calculated based on the total record length, and a linear relationship between the demand and return period was established. This relationship was extrapolated to estimate a deployable output (DO) for a 1 in 200 year return period event.	C

The next step is to determine how close a company would come to implementing Level 4 restrictions during a 1 in 200 year drought event. For a WRZ with a surplus supply-demand balance for a 1 in 200 year drought event, which Kielder WRZ has, the risk score represents the amount and reliability of this surplus water. Table 2.4 outlines the proposed calculation steps, and Table 2.5 shows the criteria for each Risk Score.

Table 2.4: Calculating the surplus for the 1:200 drought event

Step	Detail	Output
Step 1A	For each WRZ, calculate the volume available for the 1:200 drought event: *WAFU minus outage minus demand plus Table 10 (Drought Interventions) benefits*	The surplus or deficit volume at 1:200 year drought
Step 1B	Express the output from Step 1A as a percentage of the Target Headroom volume, from WRMP Table 10	An '*Optimistic'* percentage of the surplus or deficit relative to the WRZ Target Headroom
Step 2A	Taking the outputs from Step 1A, determine how much of the surplus or deficit depends on supplies and operational interventions which are outside of the company's direct control, such as bulk supplies (where there is uncertainty over the volume that might be delivered during a severe regional event); Drought Permits and Drought Orders.	The surplus or deficit volume at 1:200 year drought within the company's direct control
Step	Express the output from Step 2A as a percentage of the	A '*Pessimistic'* percentage of

2B	Target Headroom volume, from WRMP Table 10	the surplus or deficit relative to the WRZ Target Headroom

Table 2.5: Risk Score Definitions

Risk Label	Resilient WRZs, i.e. have a surplus
1	'Pessimistic' surplus % is > 125% of Target Headroom
2	'Pessimistic' surplus % <125% but still > 100% of Target Headroom
3	'Optimistic' surplus % >= 100% of Target Headroom, but 'Pessimistic' surplus only 50% to 100% of Target Headroom
4	'Optimistic' surplus % >= 100% of Target Headroom, but 'Pessimistic' surplus only 0% to 50% of Target Headroom
5	'Optimistic' surplus % >= 100% of Target Headroom, but the 'Pessimistic surplus' shows an SDB deficit
6	'Optimistic' surplus % >= 100% of Target Headroom, but the 'Pessimistic surplus' shows an SDB deficit AND there is a significant reliance on higher risk interventions to generate the initial surplus

For Kielder WRZ, the Pessimistic surplus for a 1 in 200 year drought event, relative to Target Headroom, is represented in Table 2.6. As specified in guidance provided by Ofwat (Ofwat (2017) Drought Resilience Metric), this figure is calculated as an average over the 25-year planning horizon. Only a Pessimistic surplus is presented as there are no drought permits/orders for the WRZ.

Table 2.6: Risk scoring result

WRZ	Target Headroom (Ml/d)	Pessimistic Surplus (Ml/d)	Pessimistic Surplus relative to Target Headroom	Risk score
Kielder	46.02	88.03	191%	1

The final element is to select the acceptability of the Certainty Grade (the Methodology Grade combined with the Risk Score) by determining whether the methodology used is appropriate to the risk for the Company. This is done by assigning a colour band that suitably defines the Certainty Grade, as shown in Tables 2.7 and 2.8.

Table 2.7: Acceptability colour band definition

Colour	Acceptability definition
Blue	Very certain, no need to review unless there is a large change to the SDB
Green	Certain; approach and margin are acceptable, but there may be some benefit in reviewing either the method or the role of transfers, Orders and Permits on the SDB.
Amber	Some uncertainty; the classification of the WRZ is relatively uncertain and the method and/or the assessment of transfers, Orders and Permits should be reviewed at the next WRMP.
Red	Significant uncertainty; the adopted method is not appropriate and further work on the method and assessment of transfers, Orders and Permits is required.

Table 2.8: Compatibility of the Acceptability colour band and the Certainty Grade

Risk Score	Methodology Grade			
	A	B	C	D
1	A1	B1	C1	D1
2	A2	B2	C2	D2
3	A3	B3	C3	D3
4	A4	B4	C4	D4
5	A5	B5	C5	D5
6	A6	B6	C6	D6

The resulting Certainty Grade and colour band for Kielder WRZ is presented in Table 2.9.

Table 2.9: Certainty grading results

WRZ	Certainty Grade
Kielder	C1

2.11 Resilience to Non-drought Hazards

2.11.1 Overview

We have extensive experience in supplying high levels of demand not associated with drought conditions. Typically high demands occur either due to customers using more water during hot weather, for watering the garden or filling paddling pools etc, or in the winter when freeze-thaw events lead to an increase in burst water mains.

Our network is sufficiently resilient to such increases in demand, potable storage in the network allows any sudden increase in demand to be met whilst the headroom in our treatment capacity allows the DI of the treatment works to be increased to recover this lost network storage whilst supplying the higher level of demand.

Our production planning and short interval control processes ensure that WTWs are able to increase production if high demand does occur.

Recent examples of high summer demand include the summer of 2006 and the recent heat wave in 2018 where demand increased by 20%. We have been able to maintain supplies without issue during these events.

2.11.2 Freeze / Thaw Resilience

Severe winter weather conditions can result in short-term increases in leakage when frozen pipes burst and then thaw. Such increases in leakage and distribution input can be sudden if there is a rapid thaw.

It is not possible to prevent bursts caused by severe weather conditions, such as the 'Beast from the East' in early 2018. However, network monitoring and ensuring we are adequately resourced to promptly respond is paramount. The interrogation of our DMA monitors quickly showed the areas of greatest increase in leakage and also pinpointed that it was predominantly on the customer side. In Northumbrian Water, the demand immediately before the rapid increase was about 685Ml/d. At its peak on the Sunday it reached 754Ml/d and by the end of the week the flows had reduced back to about 700Ml/d. We are well placed to deal with such events with dedicated leakage crews (direct labour and contactors) and other distribution network crews who can be diverted to leakage find and fix. Additionally, extra monitoring, analysis, response and recovery mitigation were also used to minimise the impact of the bursts. We are continually improving and developing our business resilience policy, our adverse weather response plan, and our business continuity arrangements for adverse weather. We have a complete 24 hour standby up to Senior Manager level with the Executive Leadership Team being contacted if Incidents are escalating. This means that all resources and permissions are immediately available to mitigate the effects of events such as "Beast from the East" to the best of our ability.

The "Beast from the East" presented very challenging conditions to the water industry. However we had pre-empted the thaw by maximising our output from the water treatment works and increasing storage of potable water in our distribution system. We were proud that we did not have any more interruptions to supply during that period than we have in a "normal week". This demonstrates the resilience of our network and incident management processes to freeze / thaw events. However, we will review the impact of the "Beast from the East" on the water industry by working with the other companies via WaterUK and apply learning where relevant to do so.

We conclude that we are resilient to freeze / thaw events and so have not undertaken any further sensitivity testing in Section 11 of this WRMP.

2.11.3 Flood Risk Management

Following flooding in the Tyne Valley as a result of Storm Desmond (early December 2015), we were asked by a Tyne flood risk management stakeholder group to look at the potential for providing additional flood storage capacity at Kielder Reservoir. Kielder Reservoir, like all our impounding reservoirs, has many important roles including river regulation to enable strategic support for water abstractions to ensure a secure supply of treated water to meet the demands throughout the North east.

In consultation with the stakeholders new control curves, which determine when releases are made have been developed.

In terms of flood alleviation it should be noted that the impounding reservoirs typically only collect a small percentage of water from the overall River catchment so providing flood storage at the reservoirs does not provide a great level of protection for the major conurbations on the eastern side of the WRZ.

All of our water supply assets were assessed to be resilient to pluvial, fluvial and coastal flood risk in our PR14 flood risk assessments. Consequently, we have not undertaken any further sensitivity testing in Section 11 of this WRMP. We will review and update our flood risk assessment when the CP18 climate projections are issued.

2.12 Company Policies including Level of Service

2.12.1 PR19 WRMP Levels of Service (LoS)

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

LoS 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 we ask our 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) 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 would 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.

Our PR19 'planned' levels of service for our customers (both Kielder and Berwick and Fowberry WRZs) are as follows:

Level 1: Appeal for restraint	1 in 20 years (5% probability in any one year)

Level 2: Temporary Use Ban	1 in 150 years (0.66% probability in any one year)
Level 3: Restriction on non-essential use	1 in 200 years (0.5% probability in any one year)
Level 4: Rota cuts	1 in 250 years (0.4% probability in any one year)

Given the level of Kielder remains above 78% during the design drought year with a demand in the model of 836Ml/d (17% above any dry year forecast demand plus target headroom in the planning period) we feel that the likelihood of imposing any level 2, 3 or 4 restriction on our customers is negligible unless an extreme drought coincides with a prolonged period of extraordinarily high demand. Therefore low return periods for levels 2, 3 and 4 restrictions are appropriate.

Sensitivity testing of the Kielder WRZ DO, as detailed in Section 3.1.2, shows that a DO of 837Ml/d has a return period of 1 in 154 years. It is therefore reasonable to set our level 2 restriction at 1 in 150 years (0.66% probability in any one year), as should we ever experience an annual average demand of 837Ml/d during a dry year it is feasible that level 2 restriction would need to come into force to reduce demand below the 836Ml/d DO of the Kielder WRZ.

Similarly the sensitivity testing shows that the DO of 835Ml/d has a return period of 1 in 200, therefore it is rational to need restrictions beyond level 2, i.e. level 3 restrictions, once every 1 in 200 years (0.5% probability in any one year).

We do not consider the use of standpipes or rota cuts to be viable options as they are not technically possible and because they are unacceptable in modern society. Our customers in the North East are justifiably proud of Kielder reservoir and are fully aware of its importance to their water supplies. Neither they, nor many other important stakeholders in the region, would accept any form of temporary reduction to supply without very good reason.

However, reducing pressure at the customer tap is a viable option in extreme drought conditions and therefore the level 4 restriction has been set at 1 in 250 years (0.4% probability in any one year).

To demonstrate these levels of service are appropriate the Kielder WRZ Aquator model was run in full with the peak annual demand in the planning horizon and the resulting storage for Burnhope, Waskerley, Smiddy Shaw and Hisehope reservoirs combined. This group of reservoirs was chosen as a suitable representation of when the WRZ would be stressed as these reservoirs are in the area that is least capable of being supported by Kielder. The minimum combined stock for each month was then extracted and ranked from low to high. This enabled a distribution to be fitted to the data and the 1 in 20 year (5%) return period to be calculated. This gives a curve for when level 1 restrictions would be enabled.

The level 1 curve was then incorporated into the model and assigned a demand reduction of 7% based on previous experience.

The Kielder WZR Aquator model was then run again with peak annual demand in the planning horizon and the level 1 restriction curve in place. The resulting minimum monthly group storage for Burnhope, Waskerley, Smiddy Shaw and Hisehope reservoirs was again ranked. Extreme Value Analysis of the monthly ranked annual minimum storage levels was then carried out to obtain a fitted distribution that could be extrapolated to estimate storage levels for a range of return periods. This allowed the curves for 1:150, 1:200 and 1:250 return periods to be developed.

We have undertaken an Aquator modelling assessment to determine the frequency of temporary use bans in the Kielder WRZ. Reservoir storage volumes for the Burnhope, Waskerley, Smiddy Shaw and Hisehope group were modelled using the maximum dry year demand forecast for the planning period, 665Ml/d. The number of occasions that reservoir storage was below the reservoir curves was calculated and used to determine the actual level of service customers could expect. The Level 1 curve is crossed 7 times during the 86-year period of analysis giving a return period of 8%. The Level 2, 3 and 4 curves are never crossed.

Our latest supply and demand forecasts confirm that both WRZs have a supply surplus for the duration of the planning period under both our dry year (worst historical drought on record) and 1 in 200 year drought scenarios. Consequently, no new water resource schemes are needed, or planned, for at least 40 years. Therefore lowering the current LoS (i.e. introducing some form of restriction on use), does not result in the deferment of any costs.

2.13 Reconciliation of Data

We have 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).

2.14 Sensitivity Testing

In developing this WRMP, we have 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 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 7.5 within the chapter on Target Headroom.

2.15 Details of Competitors in Each Resource Zone

Since publication of our 2014 WRMP, there have been three new inset appointments.

The three insets are all to Wynyard Park a mixed residential and commercial development in Wolviston in the Kielder WRZ. The inset supplier is Hartlepool Water (Anglian Water) and the water is supplied by Hartlepool Water's own resources.

2.16 Third Party Provision of Supply and Demand Options

We have produced a Bid Assessment Framework which is designed to set out the principles, policies and procedures that we will adopt to ensure a level playing field is created when assessing a bid from a third party for the provision of water resources and/or leakage demand management services against our own provision.

It aims to provide clarity and confidence to third party bidders about the process and that all bids will be assessed in a fair and transparent way against any in house solutions.

We are willing to accept bids from any party that would bring innovation and allow us to identify more efficient ways of delivering water resources, demand management and leakage services without adding additional costs. We have published the water resources market information on our website.

Through this bid assessment framework we are looking to promote innovation which will allow us to deliver water resources, demand management and leakage services more efficiently for the benefit of customers. This will ultimately mean a reduced cost for our customers.

2.17 Links to other Plans

2.17.1 Links to Northumbrian Water Limited Business Plan

We are part of Northumbrian Water Limited. This WRMP also informs our 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:

- Our metering, leakage and water efficiency strategies that have been built into our baseline distribution input calculations; and
- All schemes in our Water Industry National Environment Programme (WINEP) – currently WINEP2.

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

2.17.2 Links with Northumbrian Water Limited Drought Plan

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.

As described in Section 2.10 above, we have completed deployable output assessments for each of our water resource zones against our worst drought on record and for Kielder WRZ for a drought with a return period of 1 in 200 years on average. The resulting deployable outputs ensure that there is a supply surplus across the 40 year planning period without the need for Level 2 customer restrictions (i.e. we only need to make appeals for restraint once in every 20 years on average.

If a more severe drought than those we have tested our plan against were to occur, the actions we would take are outlined in our Drought Plan (www.nwl.co.uk/droughtplan).

Our Drought plan enables us to respond 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).

Our Drought Plan identifies how we intend 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 reduce demand. The benefit of demand side drought actions have been taken account of in our final plan supply demand balance calculations.

2.17.3 Links with the Agency Drought Plan

An Agency document called “Drought response: EA’s framework for England” 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 our own Drought Plan and therefore in this draft WRMP.

2.17.4 Links to Defra's 25 Year Plan

In January 2018, Defra published its much-anticipated environment strategy 'A green future: Our 25-year plan to improve the environment'. We have a responsibility to play our part in this, and are keen to support all of the ten goals in the plan to protect and enhance the environment for future generations. Our business plan sets out how our ambitions for 2020-25 will contribute to meeting these goals, including achieving clean air, clean and plentiful water, thriving plants and wildlife, reducing risk of harm from environmental hazards, using resources from nature more sustainably and efficiently, enhancing beauty, heritage and engagement with the natural environment, minimising waste, and enhancing biosecurity.

Our WRMP and the WINEP detailed in it (see Section 3.4), specifically supports the goals in Defra's 25 Year Plan in terms of:

- Drinking water catchment management under the Drinking Water Protected Area (DWPA) driver;
- South Tyne holistic water management project under the Natural Environment & Rural Communities (NERC) Act driver;
- Further improvements under the Eel Regulations driver;
- Areas of new or improved priority;
- Measures to reduce the risk of transferring Invasive Non-Native Species (INNS); and
- Abstraction sustainability investigations under the Water Framework Directive (WFD) driver.

Outside of the WINEP, our demand management strategy will also reduce customer water use and reduce leakage from our own distribution network (see Section 5).

2.17.5 Links with River Basin Management Plans

The Agency has published a Northumbria river basin district River Basin Management Plan (RBMP) called "Water for life and livelihoods" (December 2015). 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 WRMP, most notably in the development of our PR19 (WINEP) and in considering whether this WRMP increases the risk of deterioration in the status of the surface and groundwaters on which our abstractions could impact.

2.17.6 Links with Flood Risk Management Plans

We have 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 WRMP are not compromised because of any current or future flood risk.

2.17.7 Links with Plans Produced by Local Authorities

Information from Local plans has been used to develop property and population forecasts which in turn have been used to develop our demand forecast (see Section 4).

2.18 Water Industry Strategic Environmental Requirements (WISER)

WISER describes the environmental, resilience and flood risk obligations that water companies must take into account when developing their PR19 business plans.

We are confident that our ambitious plans for 2020-25 and the step change this represents in our relationship with the environment more than meets the EA and NE’s expectations.

The figure below shows how our PR19 business plan addresses the objectives set out in WISER, and how we are demonstrating leadership through the three good practice approaches identified.

We have embedded the statutory obligations and regulatory expectations set out in WISER into our plan, through the resilience and environment themes and the performance commitments and investment plans set out within the business plan.

The EA also requested in WISER that we ‘consider enhancements which go beyond the statutory minimum where there is customer support, and wherever possible identify opportunities for working in partnership to achieve wider environmental benefits’. Our partners are key to delivering our plan, and our aspirations for the ‘wider environment’ illustrate our commitment to go ‘above and beyond’.

In developing our plan, we worked with the EA and NE to develop and agree the content of our portion of the Water Industry National Environment Plan (WINEP), a key part of our business plan for 2020-25. The WINEP identifies environmental transformation activities, setting out the schemes to be delivered, level of investment required, and targets to be achieved in order to make environmental improvements that will allow us to meet our regulatory obligations.

Representatives of the EA and NE also play an important role on our Water Forums. Their challenge through Water Forum discussions shaped our ambitious goals for the environment, our development of demand-side options for water resource management planning, and our commitment to take a catchment based integrated approach to delivering water and wastewater services, joining up planning and agreeing shared objectives with partners for better management of all our catchments.

Our business plan is based on the full delivery of our WINEP3 by 2025 as originally planned and as indicated in our response to the Defra/EA/Ofwat letter of 23rd May 2018. We have benefitted from very good relations with our local and national EA contacts which means that requirements for the Company were well flagged with no surprises in the final WINEP. The scale of the plan is deliverable taking into account our other planned capital investments and we have already started to engage with our supply chain as part of our preparations for delivery. We have already worked closely with our local EA to ensure that we have a robust WINEP3 and that uncertainty has been managed where possible through the adopted traffic light system and has been kept to a minimum through this process.

We are very keen to continue to look for opportunities for innovative approaches to delivering better outcomes and working in partnership to identify catchment measures where possible. We see this very much as an ongoing activity and do not propose that a longer timeframe would be beneficial to this process.

2.19 Biodiversity 2020

Biodiversity 2020 was published in 2011 and is a biodiversity strategy for England which builds on the Natural Environment White Paper and provides a comprehensive picture of how we are implementing our international and EU commitments. It sets out the strategic direction for biodiversity policy for the next decade on land (including rivers and lakes) and at sea.

The mission of the strategy is *to halt overall biodiversity loss, support healthy well-functioning ecosystems and establish coherent ecological networks, with more and better places for nature for the benefit of wildlife and people.*

The strategy sets four high-level outcomes to show what achieving this overarching objective by 2020 will mean in practice. The outcomes are reproduced in the table below.

Outcome	Outcome Description
Outcome 1 – Habitats and ecosystems on land (including freshwater environments)	By 2020 we will have put in place measures so that biodiversity is maintained and enhanced, further degradation has been halted and where possible, restoration is underway, helping deliver more resilient and coherent ecological networks, healthy and well-functioning ecosystems, which deliver multiple benefits for wildlife and people
Outcome 2 – Marine habitats, ecosystems and fisheries	By 2020 we will have put in place measures so that biodiversity is maintained, further degradation has been halted and where possible, restoration is underway, helping deliver good environmental status and our vision of clean, healthy, safe productive and biologically diverse oceans and seas.
Outcome 3 – Species	By 2020, we will see an overall improvement in the status of our wildlife and will have prevented further human-induced extinctions of known threatened species.
Outcome 4 – People	By 2020, significantly more people will be engaged in biodiversity issues, aware of its value and taking positive action.

We believe that delivery of our part of the WINEP (see Section 3.8.3) will help support all four of the outcomes. Our WINEP will ensure all of our surface water and groundwater abstraction are sustainable, that all of our abstraction intakes and river structures are Eel Regulations compliant, and that we will be enhancing the biodiversity of our own land holdings.

2.20 Natural Capitals

We are seeking to understand and monitor the impact we have on our five identified capitals (financial, manufactured, natural, human & intellectual, social). Our essential core function is not the limit of our role or ambition, and the contribution we make is much wider than this. Better understanding of how we depend on and interact with the capitals will enable us to reap the benefits of successfully managing those interactions with potential benefits for the business, society and the natural world.

Engagement with staff and stakeholders has identified seven key areas of natural capital that are of specific importance to us:

- Greenhouse gases
- Air pollution
- Ecosystem services & land use
- Flood attenuation
- Water and sewage pollution
- Water resource management and use
- Waste disposal (including sludge)

We are making good progress on this journey and have identified three opportunities that we are currently pursuing:

- Adapting the investment process to include impact on the five capitals in the decision making to ensure well-rounded decisions are made.
- Including capitals-related data in Management Information and Business Intelligence systems, to be able to understand and monitor progress.
- External reporting of progress via ‘our contribution’ reports.

Looking at our own landholding, we have produced a number of ecosystem service assessments; displaying them as interactive pdfs to enable engagement with a wide audience. These include a mixture of qualitative and quantitative measures.

We have also embarked on a biodiversity site ranking exercise. It aims to rank all 2,000 sites in terms of biodiversity value – using the Defra metric as the starting point, but building on that to include measures such as the presence of priority habitats or species, site connectivity and the presence of invasive species. This will provide a superb baseline of information to enable us to measure the impact of our activities on the biodiversity of our landholding and hopefully, as Natural England’s eco-metric develops, that can then be used to show the benefit or harm that could come from the development of other eco-system services on the land.

2.21 Habitats Regulation Assessment

Both 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.

2.22 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.

We have 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.

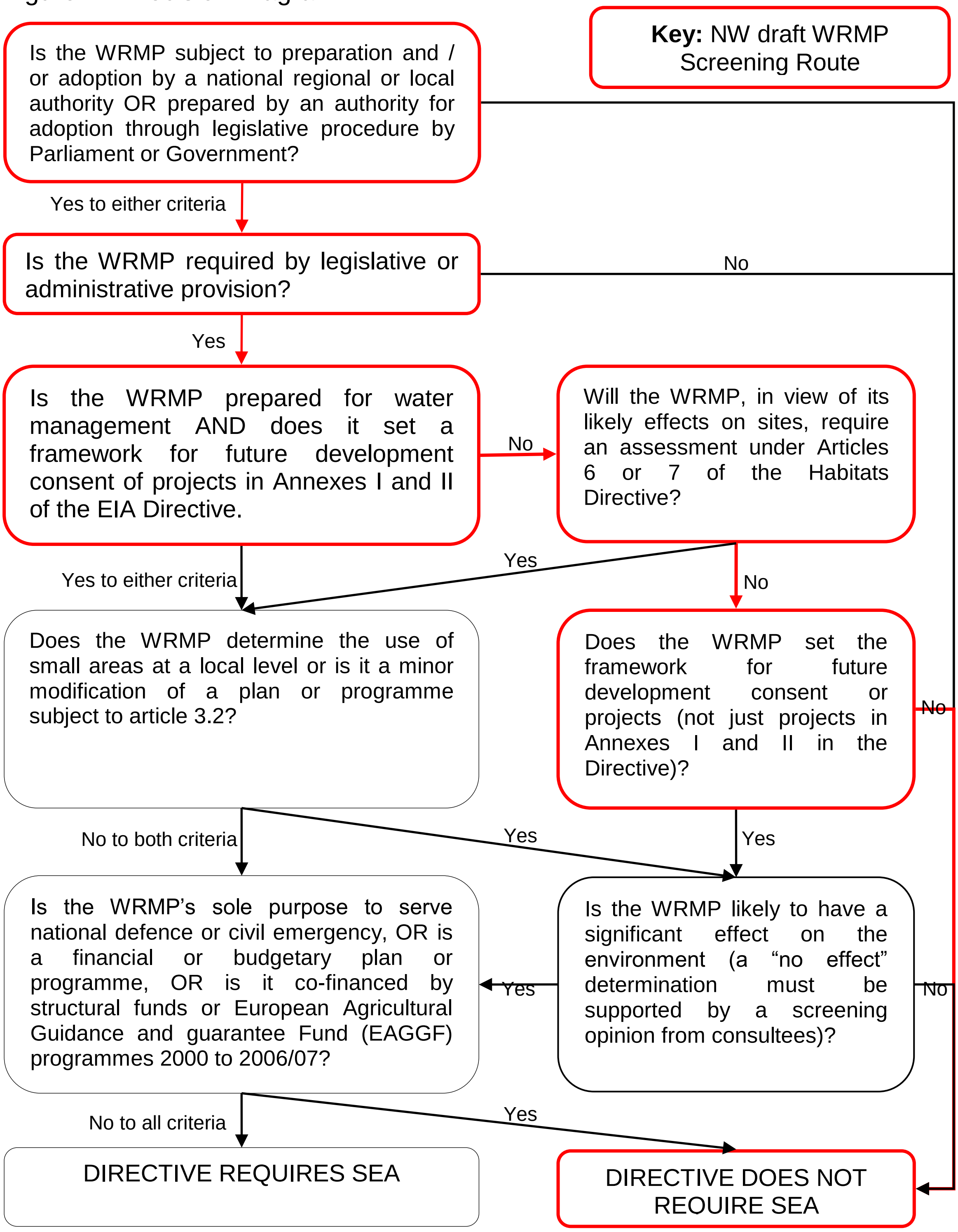
The decision diagram below illustrates the key stages and the results of our SEA screening exercise using the 2007 UKWIR methodology.

The results of the screening exercise are as follows:

i. The WRMP will be prepared and adopted by us who, under the EIA Directive, are 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 (i.e. schemes that create new deployable output);
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, we conclude that our 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.

Figure 2.2 Decision Diagram



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

2.23 Optimisation of Existing Operations

2.23.1 Business as Usual Optimisation

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

Optimising existing operations is considered by us 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.

2.23.2 Abstraction Incentive Mechanism (AIM)

The Abstraction Incentive Mechanism (AIM) is an Ofwat scheme. 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. A screening exercise has been undertaken to establish whether AIM schemes should be implemented to cover any of our abstractions. However, all abstractions have been screened out and so we are not proposing any PR19 AIM schemes in either WRZ.

3.0 WATER SUPPLY

3.1 Deployable Output

In developing Water Resource Zone (WRZ) Supply Demand Balance, water companies are required to estimate the yield of their resource zones in terms of Deployable Output (DO), a building block in determining Water Available for Use (WAFU). DO is defined in the 'Handbook of Source Yield Methodologies' as:

"The output for specified conditions and demands of a commissioned source, group of sources or water resource systems 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;*
- *levels of service."*

3.1.1 Kielder Water Resource Zone Deployable Output

Change from i-think Model to Aquator Model

For the PR14 WRMP we used a software package called iThink to undertake water resource modelling. In the mid-1990s, in conjunction with the Agency, three iThink models were built to represent the three main areas of the Kielder Water Resource Zone (WRZ).

The main disadvantage with the iThink software for water resource modelling was that due to data limitations the Kielder WRZ zone could not be represented in a single model. This meant that DO analysis of the system as a whole could not be carried out, instead each Water Treatment Works (WTW) DO was tested against its yield independently of each other.

In 2014 working in partnership with the Agency, we began the process of moving over to Aquator to carry out our water resource modelling and DO analysis for the Kielder WRZ.

For this draft WRMP, the DO of the Kielder WRZ is calculated using Aquator. Aquator is 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 included within the Aquator model are catchment time series flows, minimum maintained flow conditions for the rivers, daily and annual licence conditions, treatment works minimum and maximum capacities, transfer main capacities, raw water pumping capacities, reservoir control curves, compensation flows and VBA coding to define the behaviour of components under certain circumstances, such as a control curve being crossed.

All updates to the Aquator model, including any assumptions, were done in partnership with the Agency along with a copy of the Aquator model being provided to the Agency.

Model updates since PR14

In addition to moving from iThink to Aquator to carry out all water resource modelling, the following updates have also been made since publishing the PR14 WRMP:

- In partnership with the Agency, reservoir inflows have been remodelled using Catchmod, to derive inflows for the majority of the reservoirs from 1926 to 2014;
- River flow naturalisation was carried out using gauged river data and abstraction data where available. Where gauged data was not available the previously modelled river flow data (done by JBA is 1998) was adjusted to fit the parameters of the naturalised data.; and

- Given an integrated model for the Kielder WRZ is now available and updated flow data has been generated, a review and update of the current control curves has been carried out.
- All the rules in the model that manage which sources are used to meet demand are taken from the Kielder Operating Agreement or the relevant abstraction licence.

The English & Welsh Method DO module in Aquator has been used to determine the systems' DO. This module runs the model over the critical drought period, under a range of demands, to identify the maximum yield of the system, i.e. the maximum demand that can be continually met throughout the critical drought period.

The full details of the Kielder WRZ DO assessment are contained in a separate supporting report, *PR19 Kielder WRZ Deployable Output Report*.

Further planned updates

We are planning to increase the number of rainfall runoff models to cover all the catchment flow time series included within the Aquator model. The catchment flows will also be brought up to date and extended back to 1920.

Deployable Output modelling assumptions

A review of all of the treatment works in the Kielder WRZ, took place to establish their minimum treatment capacities and their maximum DO capacities in 2020 and 2025 taking into account any AMP6 and AMP7 schemes that would alter the treatment works DO.

The DO values for 2020 (as seen in the table 3.1 below) were entered into Aquator as the maximum capacities of the treatment works.

Table 3.1 DO values

	Minimum TWs Output	Deployable Output on 1 April 2020 (Ml/d)
Whittle Dene	80	118
Gunnerton	6	11
Byrness/Rochester/Otterburn	0	0.45
Horsley	82	150
Fontburn	14	19
Warkworth	0	42.5
Tosson	2.04	4.56
Mosswood	90	152
Wear Valley	16	34
Honey Hill	18	45

	Minimum TWs Output	Deployable Output on 1 April 2020 (Ml/d)
Sunderland GWS	0	44
Lumley	10	42
Lartington	65	132
Broken Scar	60	180

Horsley WTW has a DO of 150 Ml/d, the abstraction licence for Ovingham RWPS is 136 Ml/d, and therefore for Horsley to reach its full DO water from the Great Southern reservoir is blended with River Tyne water. There is currently an ongoing AMP5 project to upgrade Horsley WTW and allow the site to treat 100% of River Tyne water regardless of the raw water quality. To allow Horsley to run at 150 Ml/d on 100% river water the abstraction licence for Ovingham was increased (in the model) to 150 Ml/d and the annual abstraction total increased to 54,900 Ml. The application for the increase in licensed abstraction from Ovingham has been submitted and given it is taken from the Tyne, a Minimum Maintained Flow river supported by Kielder, this increase will have no environmental consequences.

The River Tyne is a regulated river, the Ovingham abstraction licence specifies a minimum maintained flow (MMF) of 227 Ml/d downstream of the abstraction point. This condition is monitored at the Bywell gauging station situated upstream of Ovingham on the River Tyne, and a surrogate MMF of 364 Ml/d (227 [Ovingham MMF] + 136 [Ovingham Abstraction licence]) is applied to Bywell. To allow Horsley to run at 150 Ml/d on 100% River Tyne water the MMF at Bywell was increased to 378 Ml/d (227 [Ovingham MMF] + 150 [increased Ovingham Abstraction licence]) in the Aquator model to ensure the MMF downstream of Ovingham is adhered to.

Alterations to the way that the River Pont and Waskerley Reservoir are operated were also included in the Aquator model to reflect the variations in flows proposed under the NEP programme, these amendments are detailed below.

River Pont: A time series flow for the Pont catchment has been derived using Catchmod and inputted in to the model. The compensation flow for the Pont is either the natural catchment flow or the agreed seasonal maximums as detailed in table 3.2 below.

Table 3.2 Pont Compensation Flow

	Ml/d
Spring	19.84
Summer	9.3
Autumn	17.48
Winter	28.31

Waskerley Reservoir: In line with the NEP proposal a compensation flow of 2 Ml/d was added to the reservoir. In the original Aquator model in the design drought year the annual licensed volume of water from Waskerley Airshaft pumps is fully utilised, hence the addition of the compensation flow significantly reduces the DO of the system. To maintain the DO at the level it was prior to the addition of the compensation flow the annual abstraction licensed volume of Waskerley Airshaft pumps was increased from 3,200 Ml to 4,000 Ml in the model.

Honey Hill: At times when the Honey Hill group of reservoirs are in the drought zone the maximum demand that could be met in the area is 48 Ml/d (30 Ml/d from Honey Hill and 18 Ml/d transfer from Mosswood), to maximise the use of the available resource in the area, the restrictions on the maximum permitted flow from Honey Hill WTW was increased to 37 Ml/d and Aquator was allowed to use the water from either the Honey Hill Reservoirs or Derwent Reservoir depending which one is in the better resource state.

We have submitted applications to increase the abstraction volumes at Ovingham and Waskerley Airshaft.

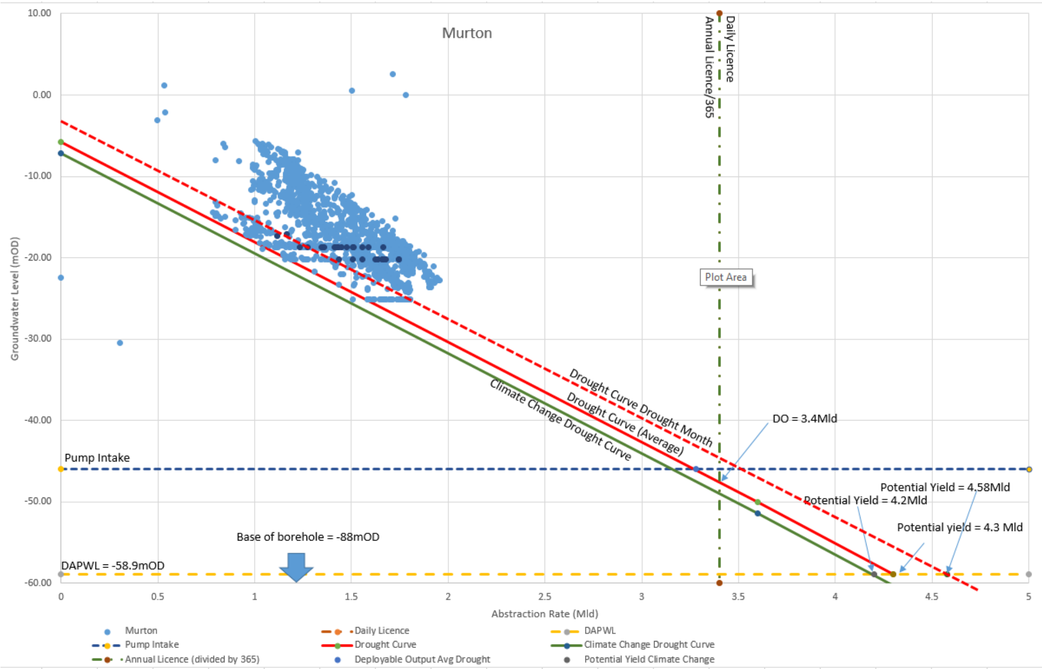
3.1.2 Groundwater Deployable Output (DO) Assessment

We calculated the DO for the Berwick and Fowberry WRZ and Sunderland boreholes by compiling a graph of groundwater level (mAOD) against abstraction rate (m^3/hour). This produces a yield depression curve for the individual borehole which is normally either a straight or curved line plot. However, occasionally this produces a scatter plot due to poor quality data. In these cases, the time period for the data was restricted to the last 3 years as we have independent, quality checked groundwater level monitoring data which produces meaningful yield depression curves.

A drought "curve" was plotted by drawing a line using the lowest data in the cloud of data from plotting groundwater level against abstraction rate. In effect, whilst been given the name "drought curve", this is commonly a straight line that represents the worst-case for a calculated deployable output, usually, but not always, during a drought month. Where suitable data exist, a drought "curve" was plotted using only data for the drought month. This is the month considered to be representative of drought conditions. Either April 2017 or April 2016 was chosen as this coincides with the period of lowest recharge to the aquifer for which quality checked data exist. Normally, this would be expected to occur at the base of the data cloud created by plotting groundwater level against abstraction rate. However, frequently the lowest data lie below the drought month data. As a precautionary measure to take worst-case conditions into account, the line created using the lowest data was used.

Superimposed on these yield depression plots, annual average and daily abstraction licence levels (as m^3/hour) were plotted. Where the daily/annual licence crosses the yield depression plot produces the DO value for the borehole. In the majority of cases, the calculated DO are constrained by their daily/annual licence. Thus the average drought curve and the drought month drought curve DOs are the same. In the case of borehole sites 16 and 17, the DOs are constrained by the Deepest Advisable Pumping Water Level (DAPWL) or by the depth of the pump intake. The DAPWL is based on identifying the key depth constraint for the pumped borehole, for example the presence of adits, the depth at which water quality becomes unacceptable, or a percentage of the saturated thickness of the aquifer. If the borehole is deep enough and the pump intake could be lowered deeper into the borehole, the pump depth is not used to constrain the DO (See Fig 3.2 for Borehole 1 in the Berwick and Fowberry WRZ).

Figure 3.2 Example of yield depression plot for Borehole 1, Berwick and Fowberry WRZ



Where the DAPWL constrains the DO, it is possible that two DOs may be calculated, one for the average drought curve and one for the climate change drought curve. However, in the case of borehole sites 16 (see Figure 3.3 below) and 17 only one value is given in the table below as the Average and Climate Change drought curves produce the same DO value to within 1 decimal place.

Figure 3.3 Example of yield depression plot for Borehole 16, Sunderland

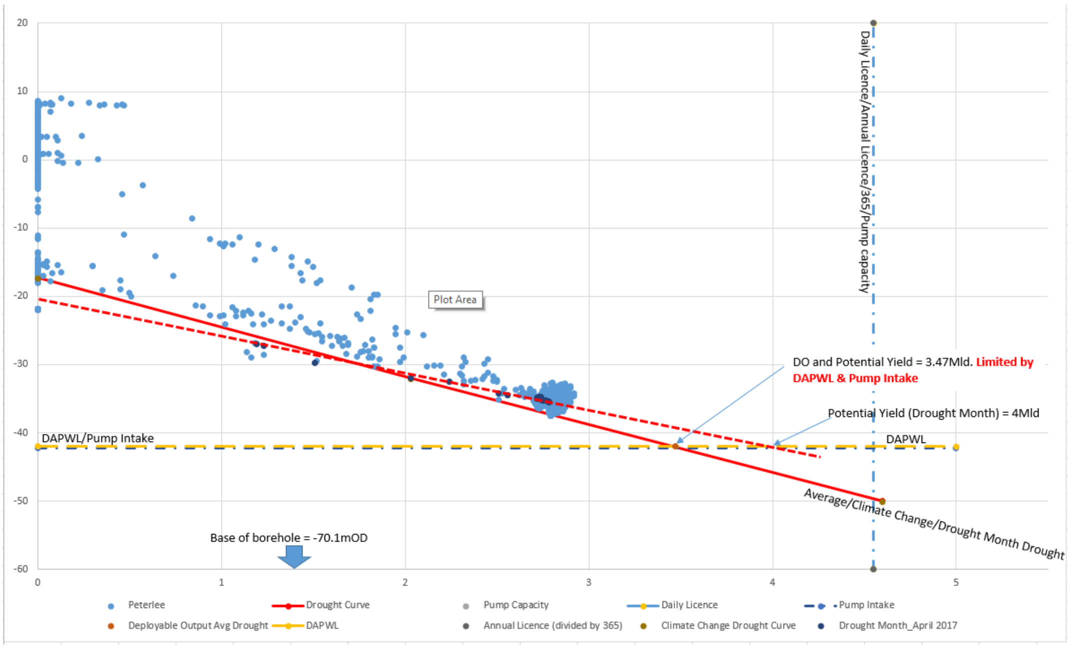


Table 3.4 below shows the calculated DO's for the Sunderland GWS using the method described above.

Table 3.4 Sunderland GWS DO

Borehole Sites	DO_2017 (Ml/d) Drought	DO_2017 (Ml/d) Climate Change	2017 Potential Yield (Ml/d) based on intersection or average drought curve with DAPWL
Borehole 10	5.13	5.13	6.55
Borehole 11	4.01	4.01	11.3
Borehole 12	4.04	4.04	7.6
Borehole 13	4.58	4.58	14.0
Borehole 14	8.31	8.31	15.7
Borehole 15	10.24	10.24	22
Borehole 16	3.47	3.47	3.47
Borehole 17	3.8	3.8	3.8
Borehole 18	9.1	9.1	9.1

Due to network restrictions downstream of the boreholes identified in the table above the maximum combined DO of the Sunderland GWS is 44 Ml/d. This DO is included in the 836 Ml/d DO calculated for the Kielder WRZ.

Results

The English & Welsh Method DO module was ran on the Kielder WRZ Aquator model set up as detailed above to determine the systems DO, with no customer

restrictions applied along with 130 Ml/d of raw water demand for the Industrial water system.
The DO of the Kielder WRZ was calculated to be 836 Ml/d, with the additional 130Ml/d of raw water demand in the Industrial WRZ, the failure point under the DO model run is Derwent annual licence running out in 1953. This is not the design drought year and even though Derwent is in a healthy position as the demand is so high the licensed volume of water available from Derwent is used up before the end of the year.

3.1.3 Kielder Resource Zone Sensitivity Testing

To test the resilience of the Kielder WRZ against droughts not represented within the Aquator model, the Scottish Method DO module in Aquator was utilised. This module, unlike the English and Welsh Method, permits multiple failures to occur during the analysis period. This allows a return period to be calculated based on the number of failures and total length of the inflow data used in the model.
Once the model has been ran multiple times, each time with an incrementally increased demand, two column series are produced comprising of an increasing number of failure years paired with increasing overall demand. The return period of each of the demands can then be calculated assuming a General Extreme Value (GEV) distribution as set out in *Low Flow Studies Report, Institute of Hydrology, January 1980, Report Number 1.*

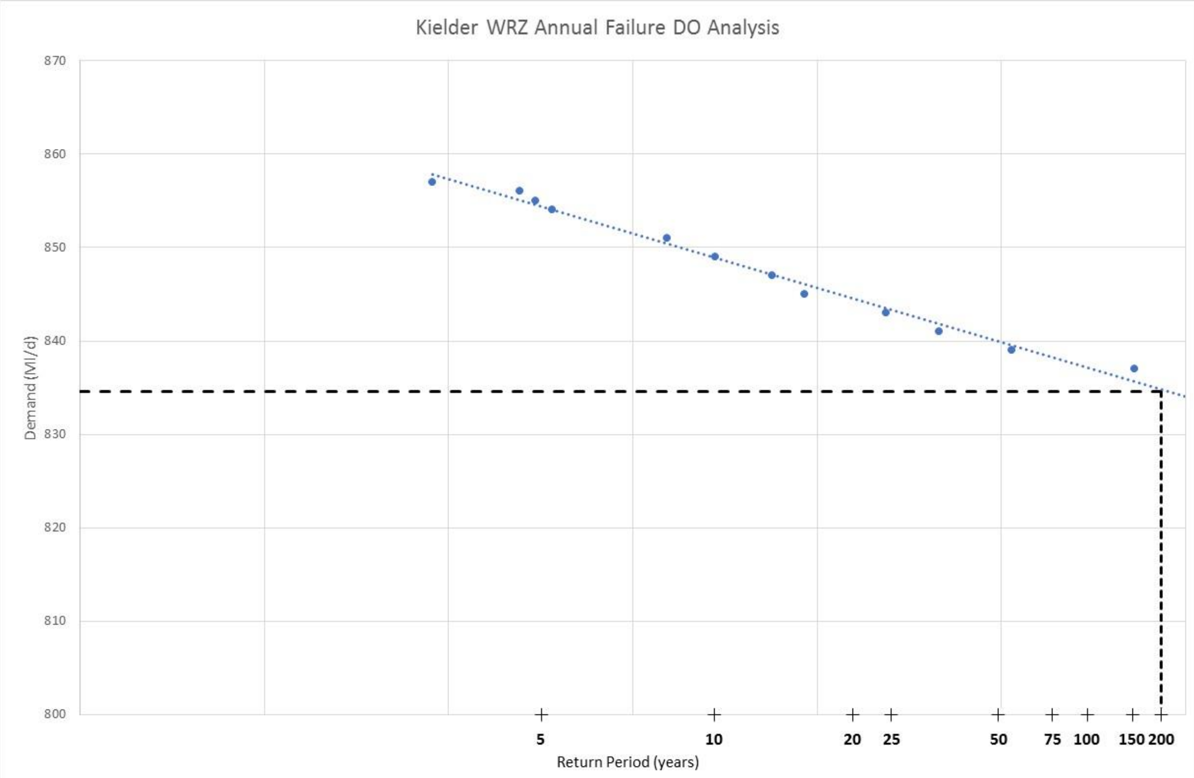
The results of this analysis for the Kielder WRZ are shown in the table 3.3 below.

Table 3.3 Kielder WRZ Return Period

Demand, Ml/d	Number of Failure Years	Return Period, Years
837	1	154
839	2	55
841	3	34
843	4	24
845	6	15
847	7	13
849	9	10
851	11	8
854	17	5
855	18	5
856	19	5
857	25	4

Interpolation of the GEV plot, figure 3.1, shown below, enables the failure demand at any intermediate return period to be estimated. Specifically the DO that could be achieved during a drought with at least an approximate 0.5% chance of annual occurrence (i.e. approximately a 1 in 200 year drought event) is 835Ml/d with no restriction on customer use. Therefore the Kielder WRZ is sufficiently resilient to withstand a 1:200 year drought event without any changes to our stated levels of service.

Figure 3.1 GEV Plot



3.1.4 Drought testing

We are required to test the plan against different types of droughts (in terms of magnitude and duration as outlined in the drought plan representation) and identify when our supply is likely to be vulnerable.

To do this, we have reviewed rainfall data for several sites across the region which starts in 1926. We have then calculated monthly rainfall deficits for rolling 6, 12, 18, 24 and 36 month periods. For each of these drought duration periods, we have then identified the highest rainfall deficit and confirmed the year in which it occurred.

Several historic droughts are contained within the model as detailed below. Several historic droughts are contained within the model as detailed below, the return period calculations are based upon papers published by the National Climate Information Centre (Allen, 2012) and in the Meteorological Office Scientific Paper No. 37 (Tabony, 1977).

Drought Duration	Percentage of LTA	Return Period	Date of drought end
6 month	44%	> 1 in 200	16th Oct 1959
12 month	56%	> 1 in 200	16th Oct 1959
18 month	68%	> 1 in 200	27th Sept 1996
24 month	76%	1 in 85	29th June 1974
36 month	79%	1 in 100	6th Dec 1973

For dry periods lasting one month or more, it is suggested to use Tabony tables for extreme value analysis of return period. The cumulative rainfall and cumulative long-term average rainfall is calculated throughout the analysis period, and the percentage of the cumulative rainfall in relation to the cumulative long-term average rainfall is calculated. The Tabony table for the North East region, which identifies the percentage of long-term average rainfall corresponding to a given return period, was used to estimate a return period for a range of drought durations.

Our Kielder WRZ Aquator modelling shows that the final plan DO of 836Ml/d is achievable through all of these droughts without the need for any demand reduction measures.

Further work will be undertaken to test against droughts of greater magnitude than those currently in the model using the Agency's Drought Vulnerability Framework. This will be reported in our first Annual Update of the published WRMP19.

3.1.5 Berwick and Fowberry Water Resource Zone DO Assessment

Based on the method described above table 3.5 below shows the calculated DOs for the Berwick and Fowberry groundwater sources.

Table 3.5 Berwick and Fowberry DO

Borehole Sites	DO_2017 (Ml/d) Drought	DO_2017 (Ml/d) Climate Change	2017 Potential Yield (Ml/d) based on intersection or average drought curve with DAPWL
Borehole 7	3.4	3.4	4.6
Borehole 6	6.8	6.8	8.82
Borehole 5(2)	2.3	2.3	3.1
Borehole 5(1)	1.54	1.54	1.5
Borehole 4	2.77	2.77	5.4
Borehole 3	2.9	2.9	4.6
Borehole 2	3.18	3.18	6.4
Borehole 1	3.18	3.18	5.1

The maximum treatment capacity of Murton WTW is 8.4 Ml/d, this along with the revised dry year yield availability of Fowberry boreholes of 3.2 Ml/d gives a total DO for the Berwick and Fowberry WRZ of 11.6 Ml/d.

The Deployable Output of each borehole may be increased, as may the potential yield, by lowering the borehole pump since the borehole pump intake can form the major constraint on a borehole DO. Lowering a groundwater pump is, in itself, a relatively simple operation by extending the length of the rising main, provided the pump is suitably rated for the new depth. However, this may place the pump intake at the non-optimal depth for the borehole with respect to the solid and slotted screens. Lowering the pump, and increasing the DO, is likely to further depress the groundwater table. In the Berwick Fell Sandstone aquifer, which is made up of a series of thick Sandstone aquifers with intervening mudstone layers, this can lead to a confined aquifer unit becoming unconfined. This in turn changes the storage co-efficient (which in turn changes the time/drawdown behaviour of the borehole and thus affect the DO) as this can be orders of magnitude higher under unconfined conditions than under unconfined conditions (Younger, 2012: Fell Sandstone aquifer of north Northumberland; Recommendations to Northumbrian Water Ltd. Internal Report). Thus overall, lowering the groundwater pump is not a practical option in some boreholes (for example, Fowberry Mains, Fowberry Treatment and Bleak Ridge) due to operational/practical issues and needs to be assessed on a borehole by borehole basis for Murton, Felkington Thornton Bog 1 and 2 and Thornton Mains. It may be a suitable method, in the relatively short term, for drought actions but may not be suitable for longer-term issues such as deployable output and outage.

3.1.6 Industrial Water Resource Zone Deployable Output

Based on licensed quantities from the River Tees there is 170Ml/d of water available for the Industrial WRZ under normal operation, this is based on the following reasoning.

- Dry year DO of Broken Scar WTW (just for potable water in the Kielder WRZ) is 150Ml/d.
- Combined licence condition of Broken Scar and Blackwell is 320Ml/d
- This leaves 170Ml/d of water available for abstraction to support the Industrial WRZ.

However in the design drought year there is only 130Ml/d of water available for the Industrial WRZ.

This means that based on the current demand of 82Ml/d the WRZ has a headroom value of 48Ml/d, in the design drought year.

3.2 Reductions in Deployable Output

In the Kielder WRZ, the DO has reduced from 969.38 Ml/d to 836 Ml/d. This reduction is purely due to the improved methodology ensuring our analysis uses the dry year yield assessments rather than the maximum treatment works capacities used in the PR14 plan. The change in resource modelling software has also allowed the impact of a dry year on the entire Kielder WRZ to be evaluated.

All treatment works are still capable of the individual DOs stated in the PR14 WRMP, and are able to meet a peak in demand greater than the 836Ml/d dry year average. A DO run of the Aquator model between the years 1930 and 1935 suggests a DO of 895Ml/d for the Kielder WRZ under average conditions.

The period 1930-1935 was chosen as the 12 month average rainfall for the NW region was 1,287.2mm.

The reductions in DO for the Berwick and Fowberry WRZ is due to using the dry year yield assessments, as opposed to the peak daily figure used in the PR14 plan.

The reduction in DO for the Industrial WRZ is due to the operational decision to reduce the licensed abstraction quantities for Blackwell RWPS and Low Worsall RWPS due to the low demand experienced in the WRZ in recent years.
See section 4.7 below which covers assumptions regarding sustainability reductions.

3.3 Abstraction Reform

3.3.1 Allowances for Abstraction Form

We have 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.

3.3.2 Emergency Abstraction Licenses

The WRPG 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 purpose are. Table 3.6 below shows the emergency use abstraction licences.

Table 3.6 Emergency Abstraction Licences

Abstraction Licence Number	Emergency Use Conditions
1/23/01/002	To be used when due to failure of plant or equipment or pollution water cannot be supplied to or treated at Whittle Dene or Horsley Treatment Works.
1/25/02/103 & 1/25/02/109	To be used when due to plant or equipment failure, adverse river conditions or other circumstances it is not possible to abstract from our licensed sources the quantities required for supply.

3.4 Water Industry National Environment Programme

3.4.1 Background

The Water Industry National Environment Programme (WINEP) is a list of environmental requirements produced by the 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 (INNS) risk, fish passage and discharges to the environment.

The sections below describe:

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

3.4.2 PR14 AMP 6 NEP

Investigations

We abstract groundwater from the Fell Sandstone aquifer in order to provide drinking water to Berwick Upon Tweed, and the surrounding area. The Agency believe our licensed abstractions from the Fell Sandstone may not be sustainable, when assessed against Water Framework Directive (WFD) targets for the Fell Sandstone water body. Consequently, our Fell Sandstone abstraction licences were included in our AMP6 National Environment Programme (NEP) for investigation. In addition, the Agency and Natural England (NE) have expressed concern that our abstractions from its two groundwater stations near Wooler may be reducing base flow to the River Till.

The purpose of the investigation was to evaluate the sustainability of the licensed abstraction volume from each individual abstraction, and collectively (the in-combination effect) from all of our abstractions from the Fell Sandstone aquifer, and to evaluate any impact from the Fowberry groundwater abstractions on the River Till. This will be achieved using the following methods:

- Identify, where possible, the size and shape of the cone of depression for each abstraction (the catchment area for each individual borehole);
- Identify, where possible, the aquifer unit(s) from which groundwater is abstracted by us for each individual borehole;
- Drill new observation boreholes within the Fell Sandstone aquifer to
- Compile yield-depression curves and compare deployable output (DO) to potential yield (PY) for each abstraction borehole;
- Collate and review data on the groundwater level in each abstraction borehole and produce a hydrograph of groundwater level against time. If the groundwater level shows an overall year-on-year decrease in groundwater level it may be considered to be unsustainable;
- In addition, an independent MSc study has been undertaken to determine if our abstractions are sustainable by comparing recharge to individual aquifer units with abstractions. Where abstraction volumes exceed recharge, the groundwater abstractions may be considered to be unsustainable.

Our groundwater level data has been extensively reviewed and revised groundwater level hydrographs have been produced for these revised data. Hydrographs have also been produced for ten new observation boreholes we drilled in the Berwick and Fowberry areas where significant gaps in data existed and for the available Agency data for its observation boreholes. Spring discharges, principally in the Fowberry area, and surface water levels and flows principally in the Berwick area, have been monitored. Groundwater level trends have been produced for all available boreholes so that boreholes showing similar physical trends may be grouped together showing potential hydraulic connectivity to specific aquifer units by individual boreholes. Geological maps and cross-sections have been modified or produced for the Berwick and Fowberry areas which provide a different interpretation of the geological sequence from earlier studies, and support the determination of potential hydraulic connectivity to specific aquifer units from individual NW and Agency boreholes. Geochemical data indicate that relatively young/immature groundwater is Na/K-Chloride dominated. Relatively mature groundwater shows a trend from Ca- to Ca/Na/K- to Na/K-carbonate dominated groundwater.

Observations on groundwater levels in the Fowberry area adjacent to the River Till indicate there is no impact on base flow of groundwater into the River Till associated with our groundwater abstractions in the area.

An MSc undertaken at Imperial College London performed hydrological modelling in order to calculate the recharge required to support our current abstractions in the Berwick area. This concluded that the recharge is sufficient to meet our current abstractions for all but the Peel Knowe aquifer.

The yield-depression curves for all the Berwick and Fowberry boreholes, with the exception of Berwick5, have a Deployable Output (DO) level that is less than the Potential Yield (PY). Based on Younger (2012) this is indicative of sustainable abstraction. Berwick5 has a DO that is equal to or < PY, and is thus considered to be borderline non-sustainable. In an earlier DO assessment by ENTEC (1997), Berwick5 had a DO < PY.

In terms of sustainability of groundwater abstractions in the Berwick and Fowberry area, taking all the current interpretations of “sustainable groundwater management” and the various methodologies used in the NEP study to evaluate the sustainability of an abstraction, the groundwater abstractions in the Berwick and Fowberry areas, with the exception of the Berwick5 abstraction, are sustainable.

Due to existing operational constraints, all the recent work on sustainability has been undertaken at current operational (recent actual) abstraction rates, and not fully licensed abstraction rates. Further work will be needed to determine if abstractions at fully licensed rates are sustainable following completion of the planned groundwater treatment works at Berwick7 and Wooler in autumn 2019. This further work will entail undertaking pumping tests on all boreholes at fully licensed abstraction rates, and an evaluation of the effect of these pumping tests on the conclusions of the sustainability report.

An Options Appraisal Report has been produced that evaluates all the possible options available to us to make our Berwick Groundwater Abstractions sustainable. These options include: Do Nothing; Demand side measures; Changes to the existing borehole infrastructure; Warkworth Pipeline; Reallocation of Abstraction; Groundwater Augmentation scheme; Utilise groundwater abstractions by Coal Authority; Abstraction from the River Tweed; and, Felkington/Fowberry Pipeline . These options will be appraised as follows;

- Demand side management options; Increased level of metering or improvements in leakage controls
- Supply options; Identifying and developing new groundwater abstraction sources outside the Berwick5 area
- Mitigation options;
  - Identify alternative sources of drinking water including;
    - the abstraction of groundwater from the Coal Measures in the Berwick area
    - build a mains water pipeline from the Warkworth Water Treatment Works to Berwick
    - abstract surface water from the River Tweed
    - Link the Berwick and Fowberry areas with a new pipeline.
  - Mitigate the effects of groundwater abstraction on the Fell Sandstone
    - develop a Groundwater Augmentation Scheme whereby surface water is used to artificially recharge the Fell Sandstone aquifer to compensate for the groundwater abstracted in the Berwick5 area.

Each of these options has been subject to a high level, qualitative Stage 1 appraisal covering technical and financial feasibility issues. This removed the Do Nothing, Warkworth Pipeline, Groundwater Augmentation Scheme, the Felkington/Fowberry Pipeline and Abstraction from the River Tweed options. In terms of demand side measures, only leakage reduction from the groundwater distribution network was considered to be feasible. In terms of the reallocation of groundwater abstractions, only increasing abstraction from the Berwick3 and Berwick4 boreholes was considered feasible.

Those considered feasible are appraised further in a Stage 2 appraisal, which involves an environmental appraisal based on available internal and consultants reports using expert judgement, realisation of predicted benefits, issues concerning landowner agreements, scheme operational failures, robustness of costs and/or benefits and the nature and possible outcome of legal challenges to the scheme. The Stage 2 options appraisal is currently being completed. These results of the Options Appraisal will be implemented in AMP7.

Since submitting the draft WRMP in November 2017, further work has been completed including an updated NEP investigation report and an NEP options appraisal report. Key results include:

1. Recharge calculations: Revised recharge calculation provide very similar results to previous assessments and thus provides more confidence in results. Comparison between abstraction and recharge rates indicates groundwater abstractions are sustainable.
2. NW will have to introduce some compensation flow into Newbiggen Dean and Horncliffemill Burn (around 0.6Ml/day to each) in order to mitigate current impacts of groundwater abstractions on surface water EFI's.
3. NW have completed an Options Appraisal Report. In order to meet the WRMP supply surplus NW's current preferred option is to drill a new abstraction BH at Felkington.

Compensation Releases

In the Kielder WRZ work for Phase 2 of the National Environment Programme has concentrated on Heavily Modified Water Bodies (HMWB) issues. At many of our impounding reservoirs we undertake compensation flows which are made to ensure water enters the river course below where it has been impounded.

Generally these flows have been at a constant rate and studies have suggested that this is not the best practice as naturally there should be a seasonal variation in the volumes released. The reservoirs investigated in the Kielder Zone were Burnhope, Grassholme, Hury, Derwent and Waskerley.

In order to achieve the proposed compensation release from Waskerley and still maintain the DO from Honeyhill WTW we have applied for an increase in the abstraction licence at Waskerley Airshaft. This increase has no environmental consequences as the water is taken directly from the Tyne-Tees Transfer.

Fish Passage

Two fish passes are required for completion in AMP6. Design has been agreed with the Agency with one programmed for installation in 2018 and the other in 2019.

Eel Regulations

Eel screens are required to be in place before the end of AMP6 at six river abstraction points. At the time of writing one has been installed and design has been agreed at three more. All are scheduled to be completed by the due date. The design of the screens does not affect our ability to abstract water and has no impact on the Deployable Output at any of the works where they are installed.

Eel passage is required on two weirs, again the work has been planned for completion in AMP6.

3.4.3 WINEP AMP7

The Environment Agency's guidance entitled "Sustainable Abstraction" (June 2017), 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 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 is not possible to allow for new WINEP2 green and amber schemes to be included in the draft WRMP, the 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 Agency in September 2017, contains the following schemes:

- Seven Sustainable Change Investigations.
- One Eel Screen installation – the design of the screen will ensure DO is not effected.
- Eight Investigations and Options Appraisals.
- Four Fish Passage Investigations.
- Five No deterioration schemes for catchment management work to protect water quality in some of our surface water catchments

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Sustainability Reductions

Kielder WRZ – six of the seven Sustainability Change investigations involve alterations to compensation flows building on the work completed in the AMP6 NEP. It is not yet clear what values will be given to these changes and therefore they have not been included in our supply demand balance calculations. Once confirmed, we will incorporate them into the baseline DO assessments.

Berwick and Fowberry WRZ – the other Sustainability Investigation involves groundwater abstractions in Berwick (see AMP6 Investigations above). In previous discussions with the Agency a value of 9.5 Ml/d has been seen as the likely abstraction limit from the Berwick area boreholes and this figure has been used in our supply/demand calculations.

Invasive Non-Native Species

In addition to the above, we will undertake investigations and options appraisals, covering all of our raw water transfer systems, and other pathways of potential INNS transfer are required which 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.

Protection of Drinking Water Protected Areas

<u>Drinking water Catchment management</u>

To ensure our catchment management approach is consistent across all of our Water Resource Zones, for AMP7, we intend to recruit additional catchment advisors so that we have a dedicated catchment advisor for each of the main river and groundwater catchments that we abstract from. We will continue to work with the catchment partnerships to address wider water quality issues through delivery of agri-advice, and deliver multiple benefits to the environment through catchment management, linked to our environment ambitions.

Our PR19 commitment is to ensure all abstraction safeguard zones within our operating areas are supported by agri-advice or local delivery partnerships under the Catchment Based Approach (CaBA). This will help us take a catchment-based integrated approach to delivering water and wastewater services, joining up plans and agreeing shared objectives with partners for better management of all our catchments.

In June 2018, we were delighted to be able to sign the Catchment Management Declaration drawn up by the Cambridge Institute of Sustainability Leadership, which aims to bring sectors and organisations together to enable effective catchment management. The declaration will address six key principles in order to create a step change in catchment management activity to support the ambitions of the Government’s 25 year plan by supporting water catchment-related activities that will facilitate a greater level of delivery. This aligns with our own ambitions for catchment working and we welcome the support from stakeholders that this declaration and its related activities will bring.

In our NW operating area, our approach to catchment management includes working with the Peatland Partnership. Restoration of peatland habitats through raising water levels and preventing erosion supports natural flood management, increases carbon storage, and prevents dissolved organic carbon from running into rivers and reservoirs and causing the water to become discoloured. In 2015-20 our contribution, together with that of other partner organisations, helped secure £10m of funding from Defra and EU Life for this work in the north of England which will continue into the 2020-25 period.

The benefits for water treatment are not yet measurable, but the number of multiple benefits delivered and the results of catchment research give us confidence that it is right to maintain our support in this area. We will continue to invest in supporting the work of the Peatland Partnership through our investment in the WINEP.

In some cases where raw water quality is poor, we also have the option to undertake abstraction management. River water quality in particular can often change, reflecting for example recent weather and upstream land management practices. During risk periods, samples are taken frequently, so we can assess the quality of our raw water. This information allows us to choose not to abstract poor quality water, if we can source supplies from less-affected locations elsewhere. Abstraction management is not always possible when water resources are constrained, however, and we remain vigilant, ready to install additional treatment options if required.

In 2020-25 we will continue to improve our abstraction management by working towards full automation of the process. This will begin with developing a wider range of real time water quality monitoring at our abstraction sites. We are already monitoring some aspects of raw water quality, such as turbidity and colour.

For other aspects like pesticide levels we are doing manual sampling which then has to be processed in a lab. If we do identify a change in water quality we then have to respond manually. We plan to link up a full range of real time water quality monitoring to our industry leading Aquadapt (now Aquadvanced Energy) water network management system, which we already use to manage and distribute treated water in the network. This software can automatically control and adjust where we take water from; this means that we can respond to changes in raw water quality more quickly to prevent this impacting on our treatment processes and ultimately on the quality of customers' water supplies.

Protection of Drinking water Protected Areas

Two surface Drinking Water Protected Areas (DrWPA), the Warkworth and Whittle Dene abstractions, are deemed to be 'at risk' for metaldehyde, a widely used molluscicide for the control of slugs. This is as a result of agricultural activities in the catchments and in order to protect the DrWPA from further deterioration the areas of land where management practices and other activities may impact on the abstraction have been designated as Safeguard Zones (SGZ). SGZ action plans detail measures designed to protect the water quality in the DrWPAs and 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, others are more generic and aim to encourage good agricultural practise. Details of all actions are shown in the action plans.

Links to SGZ action plans:

- Whittle Dene SGZ - https://Agency.sharefile.com/app/#/share/view/s0c1e95c74cd4131a
- Warkworth SGZ - https://Agency.sharefile.com/d-s8b5008dd8ea4e188

The Berwick Fell Sandstone Aquifer has recently been designated as a groundwater SGZ, as the aquifer is deemed to be 'at risk' for nitrates. We are undertaking research, in collaboration with the Agency and Newcastle University, to understand the impact of the application of nitrate fertiliser on groundwater quality in the Berwick area. Current nitrate levels are well below the drinking water standard, but timely action through engagement with local farmers is aimed at preventing, or even reversing, any derogation of water quality in the area due to the application of nitrate fertiliser. A formal action plan is currently being drawn up.

In order to help protect our raw water sources across all Water Resource Zones, we have employed two catchment advisors to work across our operating area in the catchments from which we abstract water, with particular focus on the SGZs. 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 the risk of outage due to pollution from land practices and help protect supplies against long-term pollution risks e.g. rising nitrate in groundwater.

In AMP6 much of our catchment work has been focussed through the 'Pesti-wise' programme. Pesti-wise is the name of NWG's catchment investment programme for 2015-2020 which launched in April 2015 in five small catchments, two in our northern customer supply area - Tyelaw Burn on the River Coquet and the Whittle Dene Reservoir complex. 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, conversation at a meeting or a telephone call has been delivered to farmers covering 77% of the land area in the Pesti-wise catchments. Around 13% of the land holding that has not been engaged is not arable land or not even farmland leaving only 10% of potentially relevant land that has had zero engagement. Three grants have been given to farmers in the catchments to improve their slug pellet applicators. Attempts to engage will continue over the remainder of the AMP.

In addition to Pestiwise, we also committed to invest in peat land restoration in partnership with the North Pennines Area of Outstanding Natural Beauty (AONB). The money was to provide match funding for a wider EU Life Bid, 'Pennine PeatLIFE, a £6 million peatland restoration project led by the North Pennines AONB Partnership in collaboration with Yorkshire Wildlife Trust and Forest of Bowland AONB. The project aims to restore 1,300 hectares of internationally important blanket bog habitat in northern England. Eroding peat bodies are massive sources of sediment and carbon and there is a clear link between eroding peatlands and increased sediment loading into rivers either as DOC or POC. Restoring these landscapes should help protect our water resources for the future.

Although a good level of engagement has been achieved in AMP6 through our Pestiwise approach 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 we need to ensure that our approach for AMP7 recognises the differences across the catchments and looks at how we can work better with external partners to help deliver a wider range of benefits. For AMP7 we plan to implement a grant scheme that will replace Pestiwise. The aim is to consider a wider range of diffuse pollutants and measures and to develop a grant delivery system which will allow other stakeholders to bring in money that will fund other ecosystem service improvements.

In addition we plan to undertake work in the new Berwick groundwater SGZ to help address the rising nitrate trend to safeguard this important resource. This will involve working with farmers to help reduce nitrate losses from agriculture. We will also continue with our investment in peatland restoration to protect our upland water resources.

An allowance in our PR19 Business Plan has been made to fund all of the above work in AMP7.

3.5 Raw Water Losses

Similarly to previous WRMPs a default value for trunk main losses of 200l/Km/day/year of age of main, taken from “Managing Leakage”, has been used. Lengths of raw water mains and their average age have been taken from our GIS for the Kielder, Berwick and Fowberry zones and also the Industrial system.

This analysis showed that in Kielder WRZ there are 292 Km of raw water mains with an average age of 73 years at the start of the planning period giving an estimated loss of 4.26 Ml/day in 2020/21 rising to 6.54 Ml/day in 2059/60.

Berwick has 35 Km of raw water mains with an average age of 43 years giving losses of 0.30 Ml/day. As a result of the ongoing upgrade to the treatment works in Wooler along with new boreholes and associated raw water mains it is appropriate for the raw water losses in the Berwick WRZ remain constant over the planning period.

The Industrial system has 192 Km of mains with an average age of 43 years giving losses of 1.65 Ml/day rising to 3.15Ml/day in 2044/45.

There is only limited operational use on the raw water system within the Kielder water resource zone. On an annual basis the pipeline from Catcleugh Reservoir is cleaned and releases are made at Frosterley and Eggleston to maintain water quality in the Tyne-Tees tunnel. These operations were estimated to use the equivalent of 0.56 Ml/day during 2016/17.

An analysis of water onto and out of some treatment works sites has shown that on average the losses across works is around 1.96%. This figure has been applied to the water abstracted value to give overall treatment works losses within the Kielder WRZ.

In the Berwick & Fowberry area the treatment process involves re-circulation of the water and therefore there is perceived to be no losses across the treatment works.

Raw water losses in the form of leakage, operational use and treatment works losses, have been determined to allow the calculation of the amount of raw water abstracted in the planning tables. They have not been included in the DO calculation as the licensed abstraction volumes are in excess of the treatment works capacities and therefore there is an excess of raw water available to support these losses without impacting on the DO calculation.

3.6 Outage

3.6.1 Approach

Since the last Water Resource Management Plan, we have improved our system of recording daily outages at each treatment works. This has allowed the outage to be developed using the principles set out within the 'Outage Allowance for Water Resource Planning (UKWIR 1995)' document using data covering the previous 5 years.

The outage figure would only be varied over the planning horizon if we had some very specific changes that we were highly confident would result in a change to the calculated outage figure. We do not have anything of this nature occurring over the life of the Plan that would cause a varied outage figure to be used.

Outage is defined in the UKWIR report Outage Allowances for Water Resource Planning (1995) 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

Under the assessment carried out for our WRZs both planned and unplanned outage events were considered.

The methodology we used to determine outage allowance comprised of the following:

3.6.2 Data Gathering and Interpretation

Daily Distribution Input (DI) data along with the Production Plan (PP) is used as the basis to calculate outage magnitude and duration.

Planned Outage: the PP is analysed and if a treatment works is not due to be running at its treatment capacity further investigation is undertaken. If the treatment works is running below its treatment capacity for optimisation purposes (for example minimising an expensive treatment works) then it is not a planned outage. If the PP for a treatment works, that would normally be optimised, is below its treatment capacity then this categorised as a planned outage.
Note if the PP for a treatment works, that would normally be optimised, is below its treatment capacity for a forecasted resource restriction or predicted low demand then this is not a planned outage.
Unplanned Outage: daily DI data provided by the Network Performance Team is used to compare the actual daily works output, to the planned PP output for each treatment works. If the DI data is below the PP value for the day then further investigation is carried out.
The daily Water Production reports and the WAFU report are used to determine the reason that a treatment works DI is below the PP value. If the treatment works DI is below PP due to resource restriction, or because another cheaper WTW is out performing its PP flows then this is not classified as an outage. If however the treatment works DI is below its PP flows due to a failure or issue on site then the PP value minus the treatment works DI is recorded as an outage and assigned to a category (either pollution, turbidity, nitrate, algae, power or system failure).

Outage events excluded: There was a planned outage at Warkworth WTW where the site was totally offline for 2 months to allow the strategic mains in the area to be cleaned. This outage event has been removed from the calculation as a mains cleaning programme of this magnitude will not take place again in the planning horizon.

3.6.3 Development of Probability Distributions and Monte Carlo Analysis

For each treatment works, the mean and standard deviation of the outages is calculated. These are then used to derive 5,000 random outages for each site based on a normal distribution. For each iteration the random outages at the treatment works are summed together for each water resource zone. The unplanned outage allowance is then calculated as the 90th percentile of the 5,000 WRZ unplanned outages, and the planned outage allowance is taken to be the 50th percentile of the 5,000 WRZ planned outages.

The tables below summarise the daily averages of the actual planned and unplanned outage events experienced from 2012 to 2016.

Table3.7 Planned Outage

2012 -2016	Planned Outage, Ml/d
BERWICK	0.00
FOWBERRY	0.00042
WHITTLE DENE	1.41
GUNNERTON	0.41
HORSLEY	0.00
FONTBURN	0.41
WARKWORTH	4.51
HONEY HILL	3.20
WEAR VALLEY	0.38
MOSSWOOD	6.7
SUNDERLAND GWS	1.48
LUMLEY	0.0
LARTINGTON	6.3
BROKEN SCAR	0

In the Kielder WRZ, Warkworth and Honey Hill WTW were the main contributors to planned outage due to a yearlong programme of capital maintenance of filters at Warkworth and clarifier repair work at Honey Hill.

Table 3.8 Unplanned Outage

	Pollution	Turbidity	Nitrate	Algae	Power	System Failure	Other	Total, Mld
BERWICK	0.00	0.00	0.00	0.00	0.0032	0.00	0.00	0.0032
FOWBERRY	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.017
Total, Ml/d	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.021
WHITTLE DENE	0.00	0.00	0.00	0.00	0.00	0.04	0.28	0.323
GUNNERTON	0.00	0.01	0.00	0.00	0.00	0.27	0.00	0.284
HORSLEY	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.009
FONTBURN	0.00	0.00	0.00	0.00	0.00	0.10	0.04	0.139
WARKWORTH	0.00	0.00	0.00	0.00	0.00	3.18	0.00	3.177
TOSSON	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
HONEY HILL	0.00	0.00	0.00	0.00	0.00	0.30	0.47	0.767
WEAR VALLEY	0.00	0.01	0.00	0.00	0.02	0.40	0.49	0.916
MOSSWOOD	0.00	0.00	0.00	0.00	0.00	0.54	0.16	0.704
SUNDERLAND GWS	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.370
LUMLEY	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.041
LARTINGTON	0.00	0.00	0.00	0.00	0.00	0.93	2.61	3.542
BROKEN SCAR	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.025
Total, Ml/d	0.00	0.02	0.00	0.00	0.02	6.15	4.11	10.30
Total, Ml/d	0.00	0.02	0.00	0.00	0.03	6.15	4.14	**10.339**

As can be seen the table 3.8 above the majority (99.7%) of the unplanned outages were a result of system failure or 'other' which includes outages due to filters / clarifiers requiring cleaning that wasn't planned in.

The results of the Monte Carlo analysis are presented figure 3.4 and 3.5 below.

For the Kielder WRZ the 50th percentile (the 50th percentile was chosen as due to the fact the outages are planned we did not feel they would alter greatly from the previous 5 year average over the planning horizon) of the planned outages is 31.3Ml/d, and the 90th percentile of the unplanned outages is 26.3Ml/d, giving a total outage for the Kielder WRZ of 57.6Ml/d. An increase on the 2012 WRMP figure (of 38.99Ml/d), this is due to the increased planned outages due to large capital maintenance schemes experienced during the past five years.

Figure 3.4 Monte Carlo Planned Outage

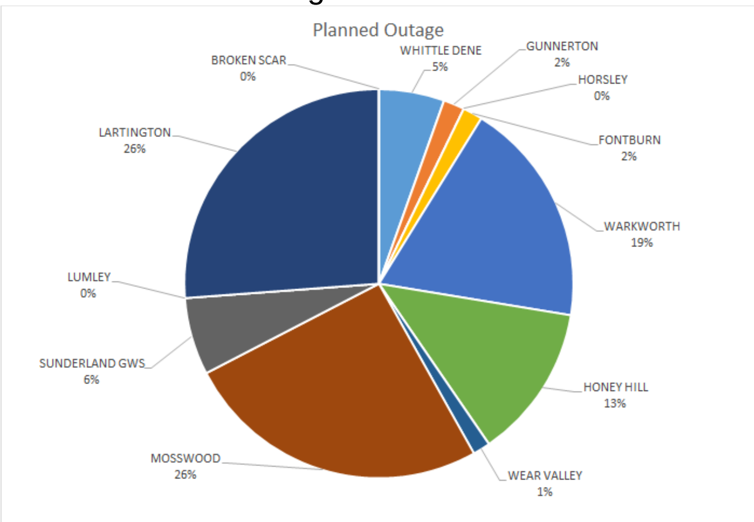
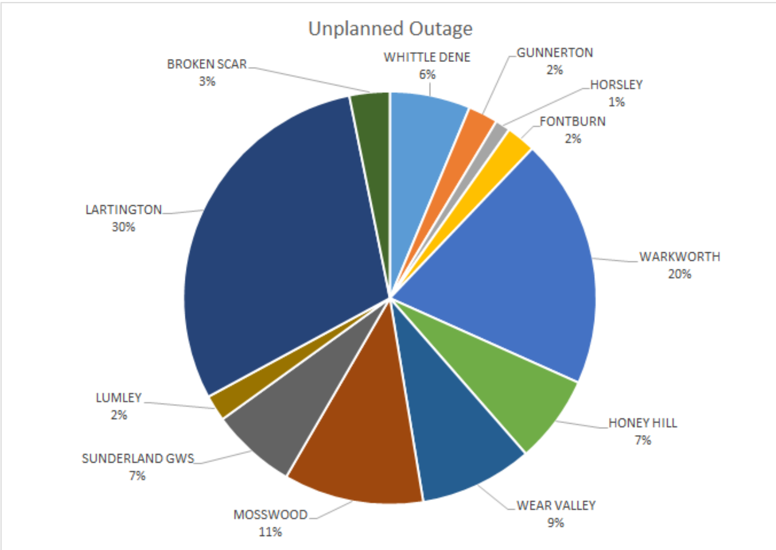


Figure 3.5 Monte Carlo Unplanned Outage



For the Berwick and Fowberry WRZ the results of the Monte Carlo analysis was an outage of 0.28Ml/d.

3.6.4 Opportunities to reduce outage

The WRPG (April 2017) states that, where appropriate, water companies should identify potential options for reducing outage allowance for inclusion in options appraisal to solve a supply demand deficit. Our draft dry year annual average supply demand balance calculations indicate that both 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 us 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, we have 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.

Pollution of our groundwater sources is minimised through both the design of our wells and boreholes and through an ongoing inspection programme. As a minimum, all of our 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 mitigation action is taken either in the form of refurbishment of the existing borehole (e.g. re-lining) or by constructing a replacement borehole.

We employ catchment advisors to work in each of the catchments we abstract 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 pesticides, as agricultural activity intensifies over the planning horizon. Further information on our catchment management work can be found on our website www.nwl.co.uk/catchmentmanagement.

3.7 Raw and Potable Water Transfers and Bulk Supplies

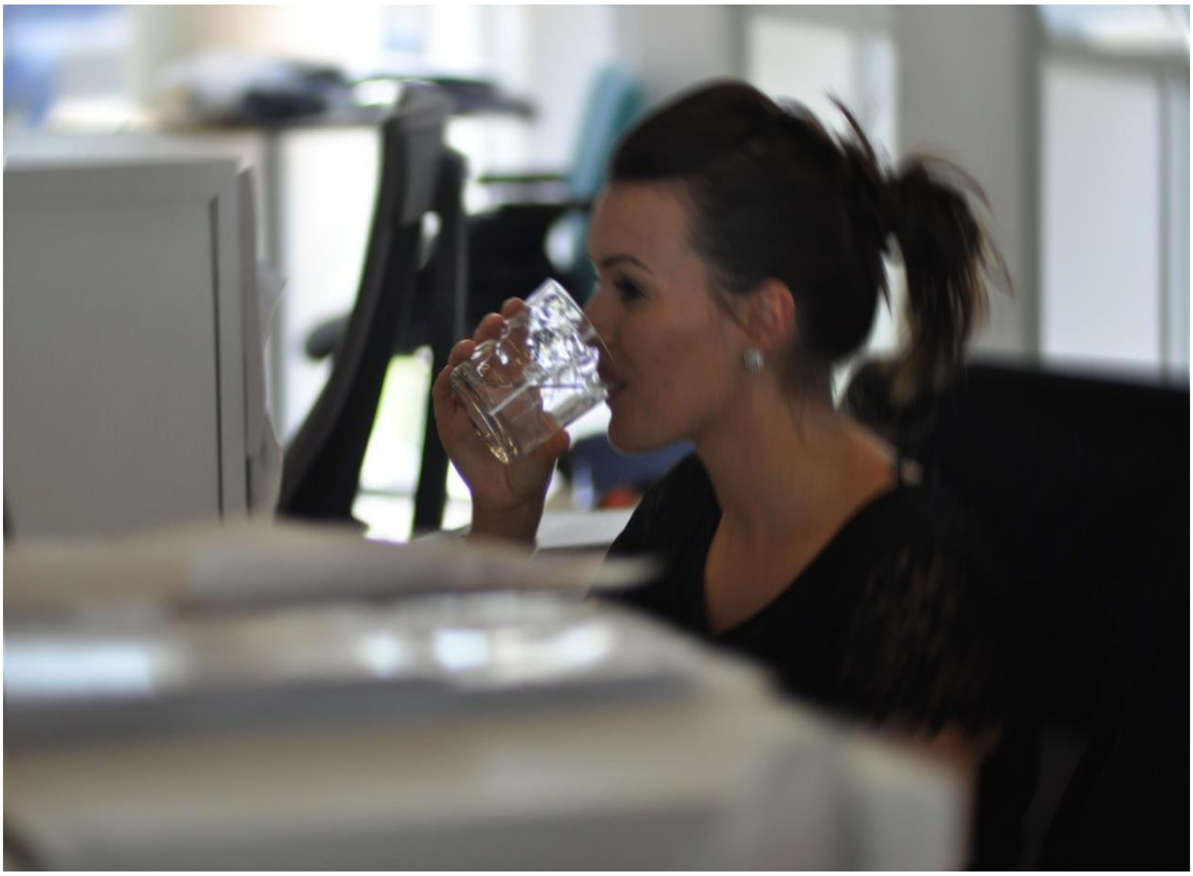
Currently there are only very small transfers of potable water between ourselves and United Utilities.

The transfer agreement to United Utilities from Wear Valley TW is for the export to be a minimum of 0.7 Ml/d and a maximum of 1.3 Ml/d. However, as we are supplying a discrete area, if demand is less than 0.7Ml/d then the export is the lower of the two values. The export has been averaging 0.65Ml/d although for planning purposes we have assumed the export is at a rate of 0.7Ml/d.

The import of potable water from United Utilities at Reaygarth is through a 2.5 inch meter which has a maximum capacity of 1.9Ml/d. Recent average imports have been ~0.01Ml/d - in this instance we are reporting only on the actual daily average.

Both the import and export are seen as secure in all circumstances and so no amendments to them are necessary under drought conditions.

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, 2016), WRMP19 methods – Risk based planning (UKWIR, 2016), Methods of Estimating Population and Household Projections and Customer Behaviour and Water Use 12/CU/02/11 (UKWIR, 1995)(UKWIR/EA, 1997).

Forecasts have been prepared for the Northumbrian supply area. The forecast has then been apportioned into the water resource zones (WRZs), Kielder and Berwick. Normal year forecasts have been made against a 2016/17 normalised base year which has been amended from the published Annual Regulatory report figures. They incorporate the rebasing process for properties as well as normalising the 2016/17 per capita consumptions (PCC). 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 and weighted average year forecasts.

The total baseline demand forecast is comprised of the elements described in the following sections and the demand management described in section five.

4.2 Base Year Demand

As outlined in the introduction, 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.

4.2.1 Normalised PCC

The unmeasured and measured normalised PCC for 2016/17 is calculated from the re-basing of the water balance. Table 4.1 shows result of this adjustment to PCC in WRZ's Berwick and Kielder. To ensure the trend for micro-components is consistent with the WRMP, total PCC has been altered across the forecast by PCC adjustment.

Table 4.1: PCC adjustment to normalise PCC

	Kielder		Berwick	
	Unmeasured PCC (l/h/d)	Measured PCC (l/h/d)	Unmeasured PCC (l/h/d)	Measured PCC (l/h/d)
2016/17	143.45	127.99	143.72	120.87
2016/17 rebased	143.40	130.01	147.24	123.02
PCC adjustment	-0.05	+2.02	+3.53	+2.16

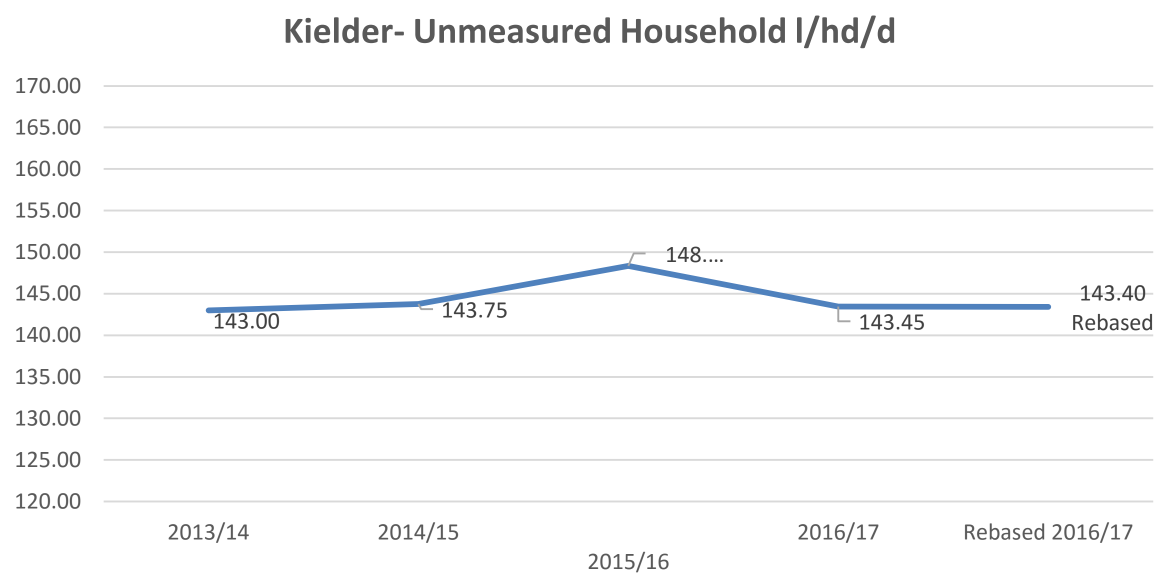


Figure 4.1: Kielder Unmeasured Household l/h/d

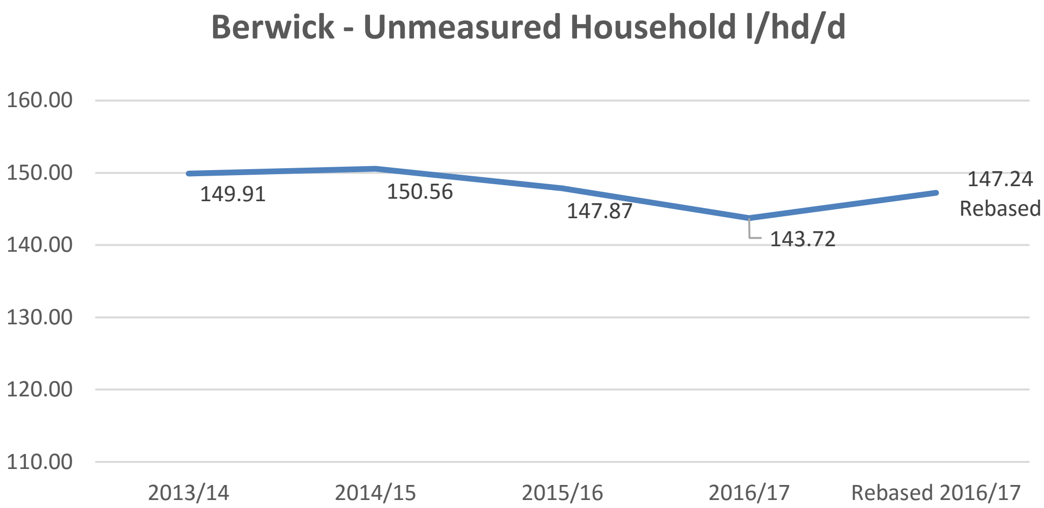


Figure 4.2: Berwick Unmeasured Household l/h/d

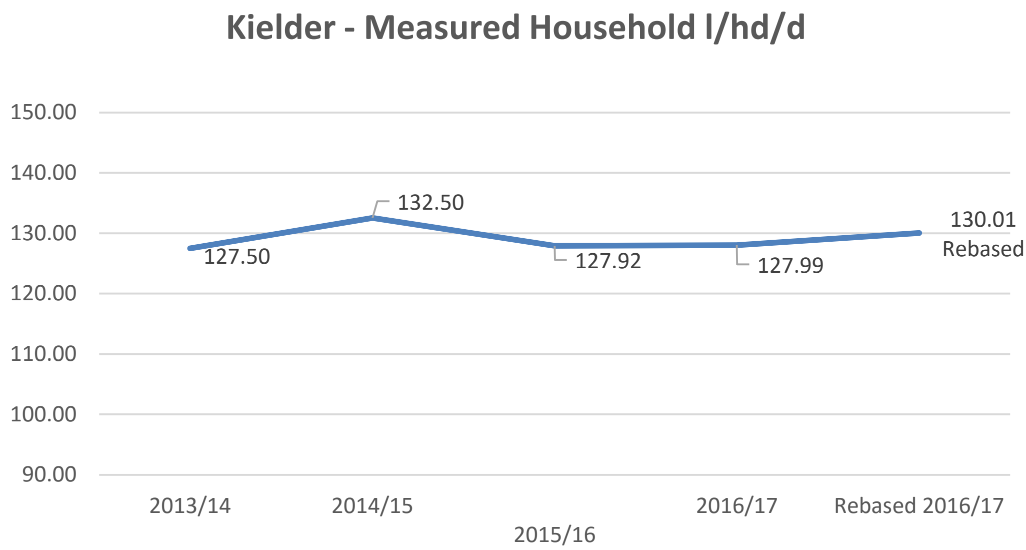


Figure 4.3: Kielder Measured Household l/h/d

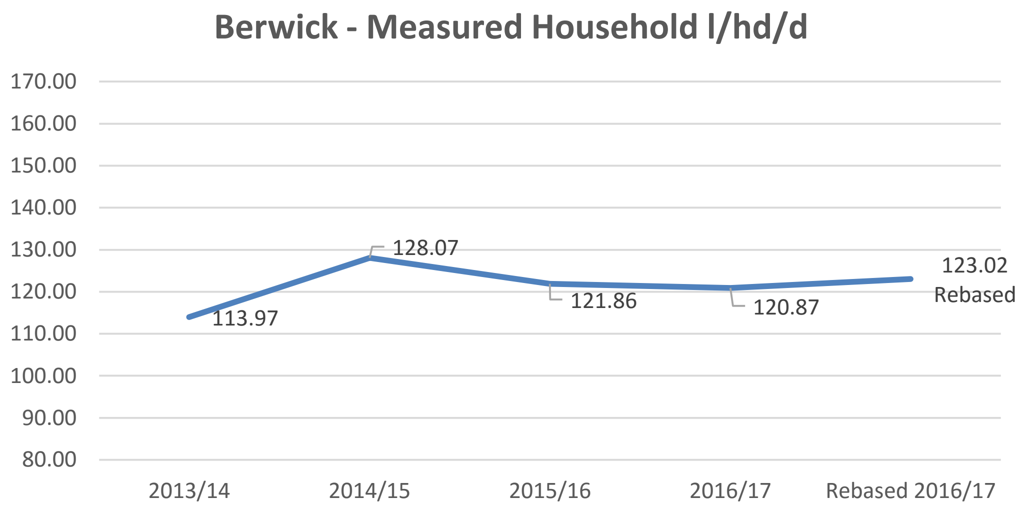


Figure 4.4: Berwick Measured Household l/h/d

In addition, at the end of each Asset Management Plan (AMP) period we believe the best approach is to group all the metered households, metered by the base year, into a single group, which we call "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 our 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.

4.2.2 Unmeasured Household Water Delivered

The PCC is provided by our Cul-de-Sac monitor with 3,135 properties split into three socio-economic groupings based on Rateable Value. This monitor has remained very stable with the same amount of close management that it has received over the last 15 years. We operate the PCC calculation using Netbase and ensure it remains in accordance with the UKWIR best practice for small area monitors.

We are proactive in our Assessed Fixed Charge Scheme (AFCS) which is offered to customers where necessary, in order to ensure less than 10% measured households. Our overall figure for meter penetration is maintained at less than 5%. Most of the measured household consumption within the monitor is calculated by monthly meter reading. However, a small number of internally installed meters have proved difficult to read on a regular basis. Their consumption is estimated throughout the year based on the previous year's meter readings.

The reported PCC figure is not influenced by any form of Meter Under Registration (MUR) as the meters within the PCC area (20 No.) are very high specification Electromagnetic (EM) meters which are verified every 2 years. Our mechanisms for the management of the void properties within the monitored areas are based on regular surveys, the results of which are input to the billing system ICIS.

We continue to check occupancy rates within the monitor in line with UKWIR best practice. A number of quality procedures are regularly completed to ensure accurate robust data is used in the calculation of this figure. These include the programme of "door knock" surveys for area occupancy rates and proactive leakage checks of all areas, based on close monitoring of nightlines and boundary valve operations.

We have clear mechanisms for the management of the void properties within the monitor, based on regular surveys which are input to ICIS and then supplied monthly to an income generation project team that uses the Land Registry website to investigate and validate void properties.

Each PCC monitor area is monitored closely with our own District Meter Area (DMA) operability which maintains an average above 90%. Any areas that are not operable are not used for their period of inoperability.

Total customer night use (CNU), including plumbing losses, continues to be assessed on a monthly basis from area flows using Smart software from WRc. Like Smart, the 15-minute flow data are adjusted by one hour between April and October for the calculation of DI and rolling minimum nightline. This is required due to loggers remaining set at GMT throughout the year.

4.2.3 Measured Household Water Delivered

The average water consumption for measured households for 2016/17 has been rebased by using the normalised measured PCC's. 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.

4.2.4 Non-Household Water Delivered

Our 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 8,266 unmeasured non household properties in our customer supply area. It should be noted that because of the very small number of properties involved, this group only accounts for 3.5% of our non-household demand.

Measured non-household consumption uses the metered consumption from meter reads. This is then increased to allow for meter under-registration and an estimate of supply pipe leakage for internally metered non-households is added to this to provide the water delivered figure.

4.2.5 Supply Pipe Leakage

We previously calculated the supply pipe leakage for the purposes of the overall leakage calculation as 35% of total losses within the distribution system. However the methodology has now been aligned to Essex & Suffolk Water's (ESW) procedure for quantifying supply pipe leakage to improve accuracy. ESW is a trading division of Northumbrian Water Limited.

The same methodology for quantifying supply pipe leakage has been used since 2006 in ESW, when a project was undertaken to improve 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 (Study of Water Use; ESW's unmeasured household monitor) 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 also it is based on southern data rather than local northern area data.

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 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 and 17.37 litres per property per day 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 Leakage (SPL) values as shown in Table 4.2 below.

Table 4.2: Supply pipe leakage values

	NW (l/p/d)
Unmeasured Hsehld SPL	32.00
Measured Hsehld/Measured Non-Hsehld SPL (Ext)	17.00
Measured Hsehld SPL (Int)	32.00
Unmeasured Non-Hsehld SPL	32.00
Empty Property SPL	32.00

4.2.6 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: Northern region: 3.79%
- Under-registration figures for non-household meters have been calculated based on the data supplied to WRc, as: Northern region: 3.83%

4.2.7 Void Properties

Base year property figures are taken from our billing database which includes the total number of void properties each year. Void properties are forecast the decrease over the planning horizon. The forecast number of household voids as a percentage of total household properties is shown in table 4.3.

Table 4.3: Forecast Voids

	2016/17	2059/60
Unmeasured Households	5.02%	4.63%
Measured Households	4.49%	4.35%

4.2.8 Operational Use and Water Taken Unbilled

Operational use continues to be assessed using similar methods in both Northern and Southern Operating Areas. The original methodologies were supported by a consultancy report (Ewan Associates, 2002), these have been used and new data input where it has become available. In addition, individual components have been reviewed and clear methodologies have been developed for determining all aspects of operational use and water taken unbilled and included site measurements for certain parameters. Some improvements have been made generally in data reporting systems and also the standpipes we hire are now metered.

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

Operational use, water taken legally unbilled and water taken illegally unbilled include the following components show in Tables 4.4,4.5 and 4.6 below.

Table 4.4: Distribution System Operational Use

1.1	Sample Taps (Continuous & Non-Continuous)
1.1.1	Continuous
1.1.2	Non-Continuous
1.2	Service Reservoirs & Tower Cleaning
1.3	Tanker Filling/Bowsers
1.4	Bleeds
1.5	Sewer Flushing & Jetting
1.6	Third Party Events
1.6.1	Bursts
1.6.2	*Tyne Only* - STM Charging + GTAS Mains Cleaning + TMC - Contract 4
1.7	Flushing
1.7.1	Routine
1.7.2	Planned / Reactive / Water Quality
1.8	New Mains, Diversions, IM and S19
1.8.1	New Mains
1.8.2	Non-Strategic Mains Diversions
1.8.3	Infrastructure Maintenance

Table 4.5: Water Taken Legally, Unbilled

2.1	Supply Pipe Leakage Voids
2.2	Unbilled Supplies
2.2.1	Treatment Works + Offices
2.3	Standpipes
2.4	Water Donations
2.5	Council Usage
2.6	Metered Allowances
2.6.1	Vulnerable Customers
2.6.2	New Properties
2.7	Waste Water Notices
2.8	Fire Fighting
2.8.1	Fire Brigade
2.8.2	UGSPL On Fire Mains

Table 4.6: Water Taken Illegally, Unbilled

3.1	Occupied Voids
3.1.1	Measured
3.1.2	Unmeasured
3.2	Illegal Connections
3.3	Hydrant Vandalism
3.4	Illegal Hydrant Use
3.5	Transient Population Usage

4.2.9 Bulk Supplies

Our water accounting records make use of MIPS Enterprise, a bespoke internal system, channelling the data with the highest level of accuracy for collation.

We calculate the daily average distribution input, taking account of major service reservoir stock changes and any imports to or exports from the distribution network.

In our Operating Areas Distribution Input meter verifications are no longer carried out. The verification program which previously existed, attempted to prove the accuracy of our meter stock and quantify the level of accuracy of both our permanent meters and the temporary meter at each site. The accuracy of permanent full-bore electromagnetic meters exceeds that of the temporary meters used for verification. 96% of our DI meter stock is full-bore electromagnetic meters and the remaining type are monitored closely.

4.2.10 Distribution Losses, Service Reservoir Losses and Trunk Main Leakage

No change has been made in the methodology used for determining distribution losses. Service Reservoir losses are based on drop test results routinely carried out as part of the reservoir cleaning programme.

The Netbase leakage analysis process provides a calculation of total leakage across the entire mains network for the whole of the Northern Operating Area. In order to achieve this, it must provide calculated values or estimates of leakage for all operable and non-operable DMAs and also for the dummy DMAs. The dummy DMAs are areas which contain mains but which are outside the DMAs. Trunk mains are generally upstream of the district meters and are therefore not included in DMAs. Consequently, most of the trunk mains are in dummy DMAs and, as a result, a significant proportion of the leakage attributed to the dummies is trunk main leakage. For each DMA or dummy DMA which contains trunk mains, an estimate has been made of the leakage that can be attributed to the trunk mains. This indicates a total trunk main leakage in the Northern Operating Area. This leakage is already included in the overall bottom-up leakage analysis in Netbase.

As of April 2020 we will be fully compliant with the leakage consistent reporting methodology as defined by Water UK and Ofwat.

4.2.11 Re-basing the 2016/17 Figures

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.

Our 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 our Business Plan in 2004, it was decided that the best way to forecast metered household consumption, was to create a category of our customers 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 but past metering policy had not been this simplistic.

For this reason, 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.

We believe 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 forecast based on the plan based scenario that we commissioned Edge Analytics to produce. The overall occupancy forecast for 2016/17 onwards is derived from this population forecast and household forecast.
3. 135.38 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.
5. 2017/18 actual property numbers have been used in the forecast.

4.3 Population and Properties

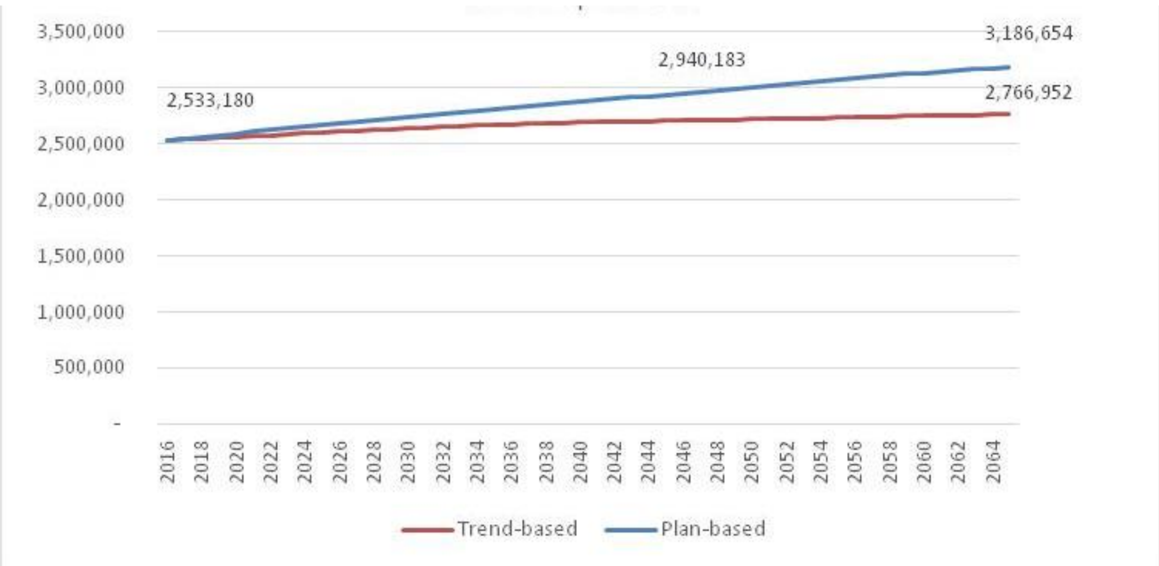
The base building block for demand forecasting is the base year population served and the projected growth in population annually over the WRMP. This is a highly specialised area of the demand forecast, along with property growth numbers, and we employ specialist consultants to prepare the forecasts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

4.3.1 Population

We have commissioned Edge Analytics to prepare the base year and forecasted year populations. NW own the forecasts produced.

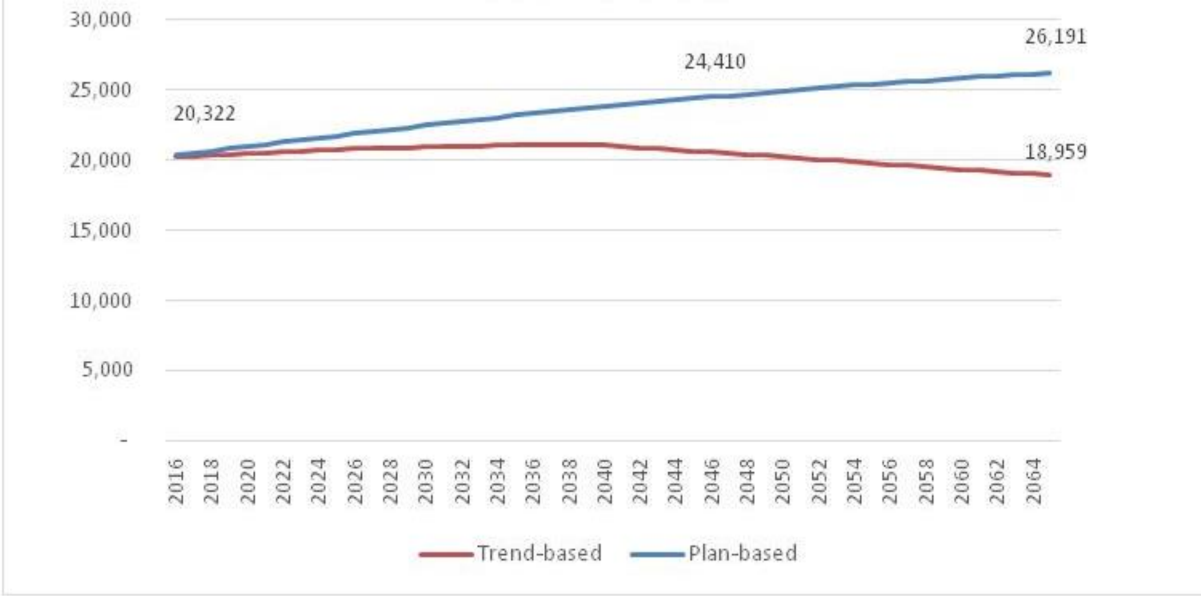
In line with the WRPG requirement, we have used Local Plan housing growth evidence from all local authorities and has selected the Plan-based scenario. The detailed methodology used to determine household growth, including assumptions and limitations, is provided in Population, Household and Property forecast technical report (2017). [3] A comparison between Trend and Plan-based scenario's is shown in the following figures.

Figure 4.5: Kielder WRZ Total Population



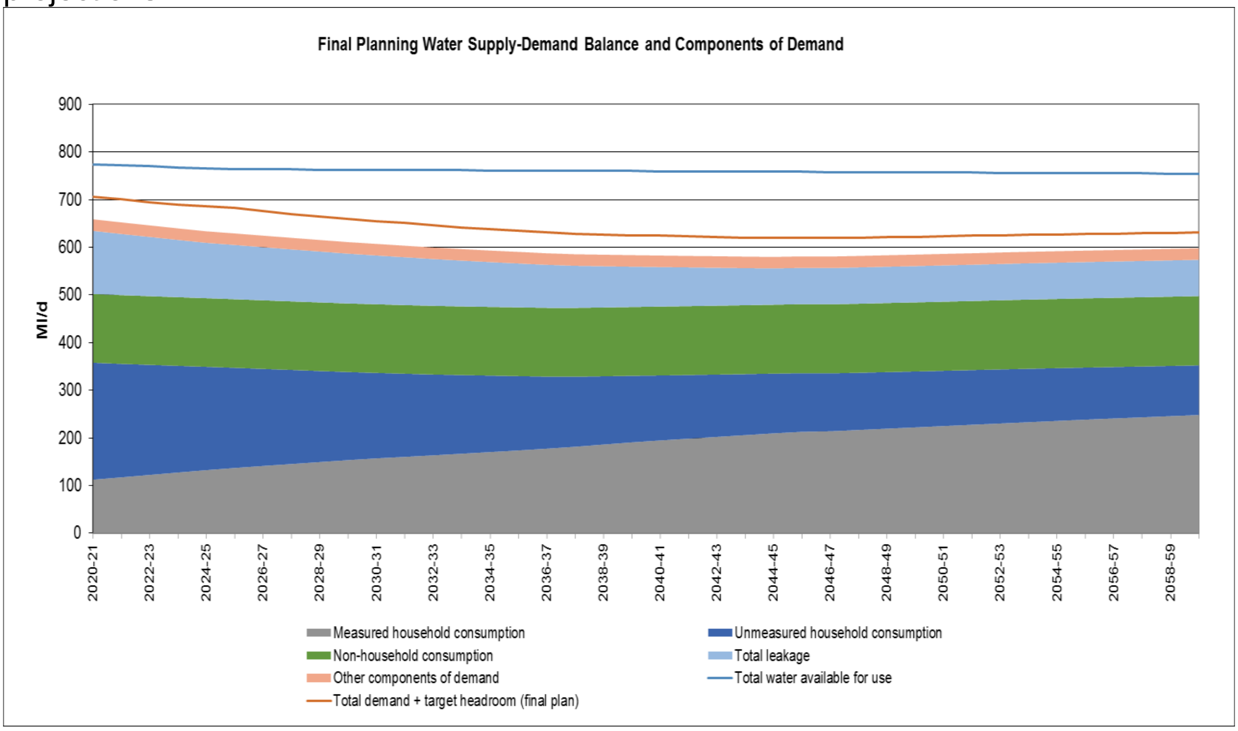
[3] Edge Analytics (2017) Population, Household and Property forecast, Demographic evidence for Water Resource Management Plans, Edge Analytics.

Figure 4.6: Berwick and Fowberry WRZ Total Population



Edge Analytics used best practice methodology which follows the requirements of the WRPG. Below is the Kielder WRZ supply demand balance for the Local Plan growth projections for population and property.

Figure 4.7: Kielder WRZ Supply-demand balance for the Local Authority Plan growth projections



Edge Analytics was contracted to produce an update to the population and household forecasts by DMAs in our customer supply 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 (Northumbrian Water and Essex & Suffolk 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 Table 4.7 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 4.7: Local Plan status, January 2017 NWG area (Source: Local Planning Inspectorate, Local Plans)

Area	Latest Local Plan Status[1]	Local Plan Period	Housing Target
Carlisle	Adopted	2015-2030	9,606
County Durham UA	Consultation	2014-2033	29,127 - 32,623
Darlington UA	Emerging	2016-2036	10,000
Gateshead	Adopted	2010-2030	11,000
Hambleton	Consultation	2014-2035	5,400
Hartlepool UA	Consultation	2016-2031	6,135
Lake District National Park	Adopted	2010-2025	900
Middlesbrough UA	Consultation	-	6,970
Newcastle upon Tyne	Adopted	2010-2030	30,000 (Newcastle upon Tyne & Gateshead)
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
Redcar & Cleveland UA	Draft	2051-2032	3,978
Richmondshire	Adopted	2012-2028	2,880
Scarborough	Examination	2011-2032	9,450
South Tyneside	Consultation	2011-2036	-
Stockton-on-Tees UA	Consultation	2014-2032	11,061
Sunderland	Consultation	Until 2033	-
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 technical report (Population, Household and Property forecast (Edge Analytics, 2017) has detailed the development of two key scenarios: a Trend-based scenario which replicates the 2014-based sub-national projection from Office for National Statistics (ONS); and a Plan-based scenario which is driven by Local Plan housing growth statistics. Our 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 our 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 our 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 our billing database has been used to provide an alternative property forecast that is more closely aligned to the number of our 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 our 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 our supply areas, the population forecasts for PR19 shows a growth in population over the planning horizon. This has resulted in a 15% increase for us over 25 years.

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

In Berwick WRZ unaccounted for population has been included in population growth. This is to account for the movement of people from Scotland into Berwick for work. This amounts to 750 people per year across the planning horizon.

Table 4.8: Population Growth

	2016/17	2044/45	Increase	% Increase
Northumbrian	2554.25	2952.13	384.57	15%

Figure 4.8: Kielder WRZ Total Population

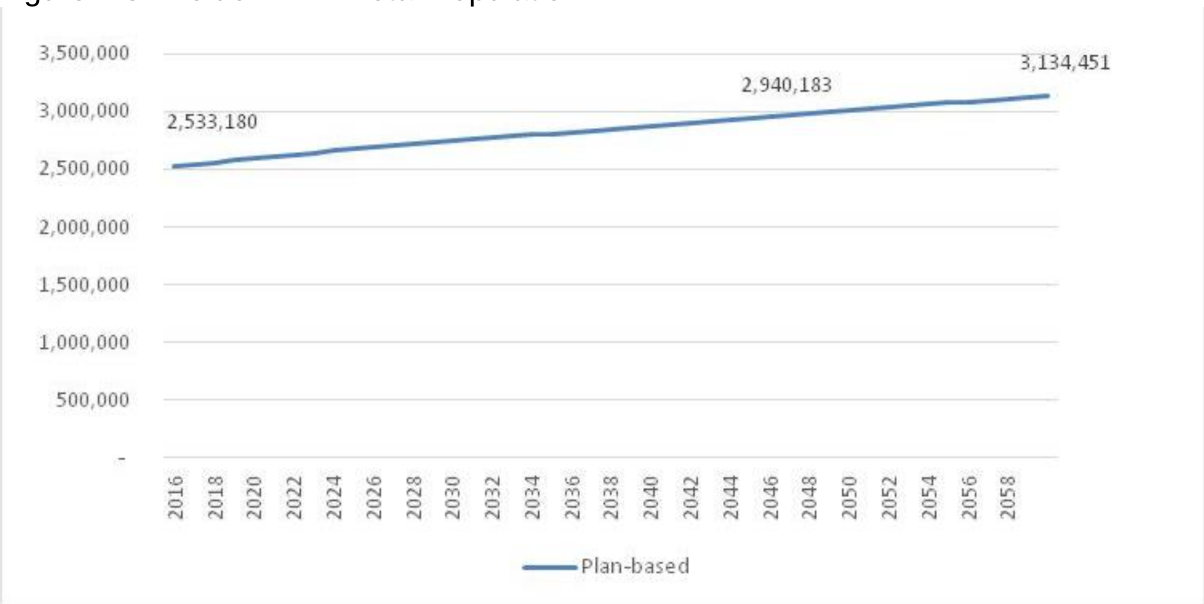
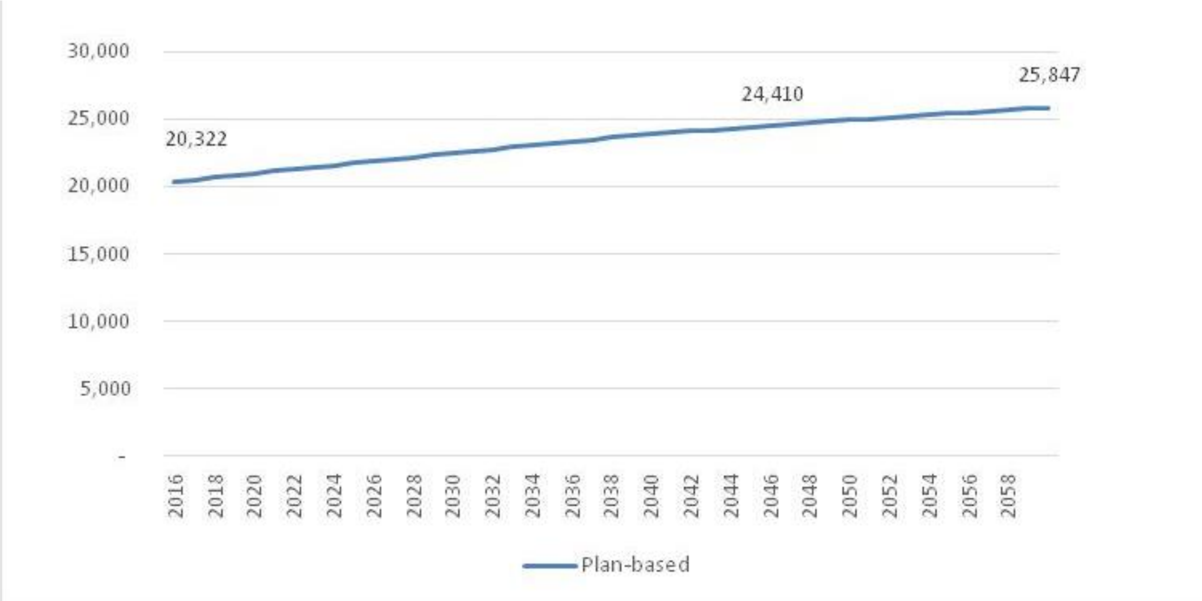


Figure 4.9: Berwick and Fowberry WRZ Total Population



4.3.2 Occupancy

The overall occupancy comes from the Edge Analytics domestic population figure plus the short term migrant / illegal immigrant population from Demographic Decisions. 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 our 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 our 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 us, ranging from specific occupancy surveys sent to a random selection of customers, occupancy taken from meter optant applications, 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. We received a total of 5,028 responses. 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, 2016). More information on these surveys is available in section 4.4.2.

The overall occupancy for all households steadily declines from 2.34 in 2016/17 to 2.28 in 2059/60. The occupancy forecast for different metered properties and unmetered properties are shown in Table 4.9.

Table 4.9: Occupancy Rates

Year	2016/17	2020/21	2030/31	2040/41	2050/51	2059/60
New Homes	2.15	2.20	2.26	2.31	2.36	2.41
New Optants	1.60	1.69	1.79	1.89	1.99	2.08
Existing Measured	1.83	1.87	1.94	2.01	2.11	2.18
Measured	1.84	1.87	1.96	2.05	2.15	2.22
Unmeasured	2.60	2.65	2.77	2.77	2.61	2.45

New Homes:
The occupancy for new homes reflects 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.

New Optants:
The optant occupancy has been slightly lowered. We forecast 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.

Existing Measured:
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. This occupancy is reset every five years when the new WRMP is produced.

Measured:
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 is influenced by the occupancy of the groups that dominate in the future e.g. new homes and optants.

Unmeasured:
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.

4.3.3 Properties

Base year property figures are taken from our billing database. The growth property figures for each of the forecasted years are provided by Edge Analytics, commissioned by us. In line with the WRPG requirement, we are using Local Plan housing growth evidence from all local authorities that are either wholly or partially included within our operational boundary. Please refer to the Population, Household and Property forecast technical report (Edge Analytics, 2017) for detailed information.

4.4 Household Demand Forecast

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 we believe 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 we call "Existing Metered" every five years.

4.4.1 PCC

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

For the meter optant groups we have determined their future PCCs as a percentage reduction relative to the unmeasured PCC, maintaining the previously accepted and agreed assumptions. A further percentage reduction has been included from 2021/22 when smart metering is introduced. For more information please refer to section 5.2.

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, we 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. New homes start with a forecasted PCC of 118 l/h/d which decreases in 2021/22 with the introduction of smart metering.

Savings from the water efficiency target and smart metering have been included in the baseline and final PCC forecasts. Further details of these savings are provided in section 5 of the WRMP.

4.4.2 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 our customers. An overview of the method is given below with detailed information available in the Micro-components Technical Report (2017).[4]

Following the best practise for customer water use surveys in the UKWIR (2016)[5] report, 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 as shown in table 4.13. The measured group was divided by meter status (e.g. optant, selective) and then all these groups were further divided into ACORN[6] categories. (Please refer to the Micro-components Technical Report for more detailed information on the sampling method).

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 follow a 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.

Previous surveys of this nature have generated a 20% response rate for us and so based upon this expectation a total of 23,684 of our customers were mailed in January 2017 with the water use survey. 3,288 of these customers also received an email version as they had already supplied us an email address.

A sum of 4,700 surveys was returned from this initial mailing. Although this is a 20% 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.

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[4] Northumbrian Water (2017) Micro-components Technical Report

5 UKWIR (2016) Integration of behavioural change into demand forecasting and water efficiency practises, Appendix 7.

6 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.

2,315 customers were sent the second mailing in February 2017 with 317 of these also receiving the email version. In total 5,027 surveys were returned. Survey answers were then split into different micro-components for analysis.

4.4.3 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)[7] 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)[8] 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 our 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.

4.4.4 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

[7] UKWIR (2016) Integration of behavioural change into demand forecasting and water efficiency practices.
[8] UKWIR (2014) Understanding customer behaviour for water demand forecasting

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) [9]. 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)[10]. From this report the highest tier for forecasting PCC has been selected for improved accuracy which forecasts trend using micro-components.

The model data sources are customer water-use surveys (please see section 4.4.2) and Defra MTP reports[11].

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 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 NW 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. The model has been split between the two WRZ's, Kielder and Berwick to account for the different occupancy in both zones, however both areas use the same customer survey base data to ensure a large enough sample.

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 values also do not include any water efficiency savings. Metered values refer to metered existing properties only.

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[9] UKWIR (2015) WRMP19 Methods- Household consumption forecasting- Supporting guidance
[10] Paul Herrington, Climate change and the demand for water, HMSO, (1996).
[11] DEFRA (2012) MTP reports

An overview how the micro-components make up PCC is given below but for more detailed information please refer to the Micro-component Technical Report (NW, 2017).

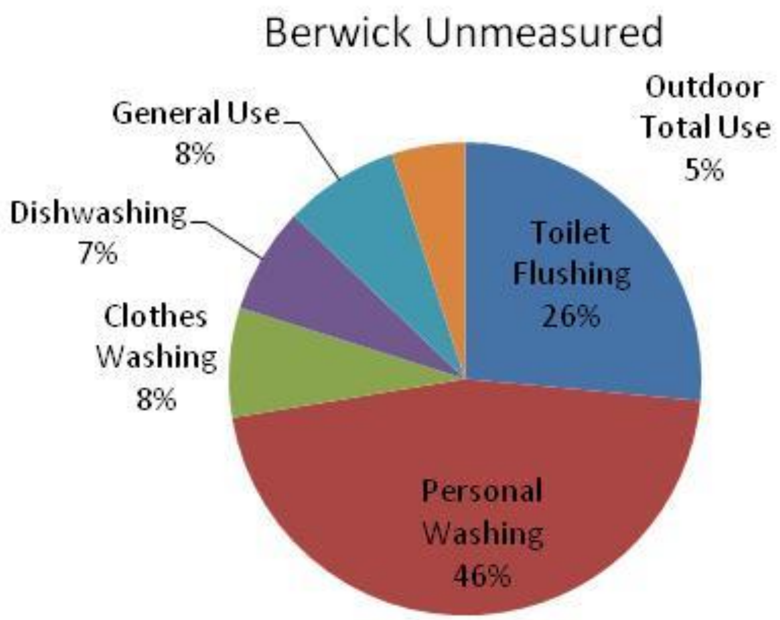
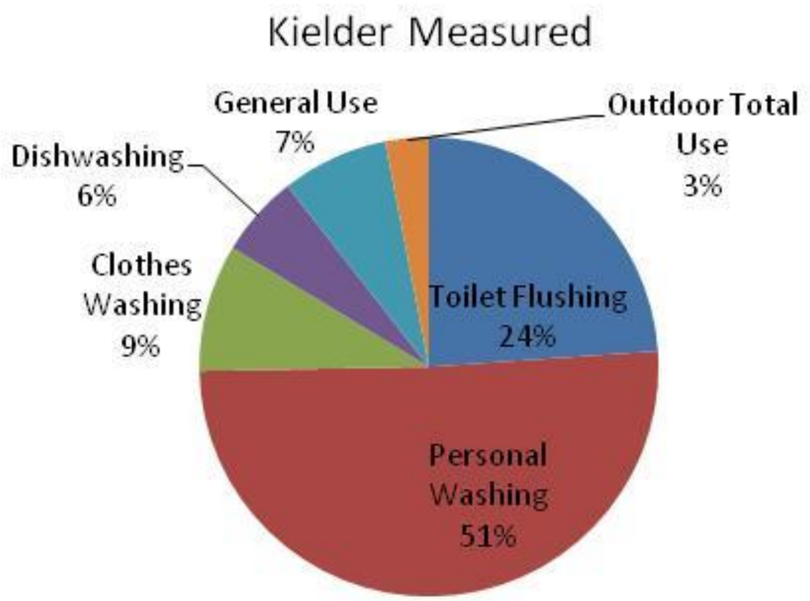


Figure 4.10: Unmeasured micro-components



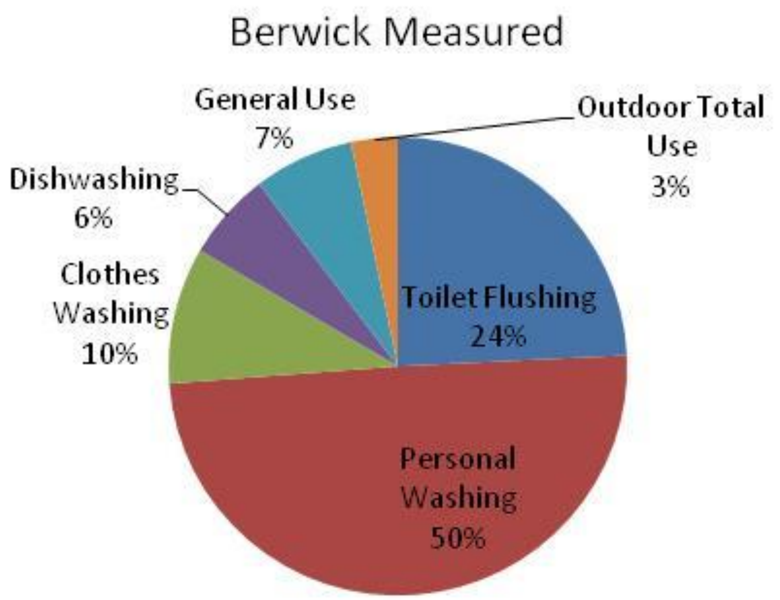


Figure 4.11: Measured micro-components

4.4.5 Overall Household Demand

The resulting PCC forecasts show an overall household PCC, for the normal year, reducing steadily over the planning horizon from 141.12 l/h/d in 2016/17 to 125.35 l/h/d in 2059/60.

4.5 Non-Household Demand Forecasts

This section sets out our non-household demand forecasts for 2017/18 to 2059/60. These forecasts show actual volumes up to 2016/17 and use our non-household demand forecast methodology for 2017/18 and beyond. We set out the methodology we have used for forecasting our non-household demand and then discuss the forecast results.

Non-potable demand is forecast using the same methodology as potable demand, and we also discuss the forecast demand for this type of water use.

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 our primary 'customers' 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, we 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 us about end users will be the data that is available within the Central Market Operating System (CMOS).

4.5.1 Methodology

We have developed its own methodology forecast for non-household demand for the 2020 Water Resource Management Plan 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.

Our demand forecast methodology is based on a number of assumptions and a formula built on three elements. We have split our customer base into two groups by:

- 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; and
- 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 that we have 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 customers site, or if they

fundamentally change how they use water. These events cannot be predicted and so we cannot make assumptions 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 we have used a forecast calculation that trends demand to a flat line over time;
- It is extremely difficult to robustly forecast the economic climate 25 years in advance. Therefore we have not modified our forecast for the behaviour of the economy.

Taking into account these key assumptions we have developed a formula that uses a logarithmic trend 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 average demand.

<u>Trend forecast</u>

The past 10 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.

<u>Step change adjustment</u>

Over the past 10 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 10 years ago. A pure trend analysis will not take full account of this step change, and therefore we have included a calculation 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, which we have called the “step change adjustment”, to bring the forecast into line with actual demand experienced in the recent past.

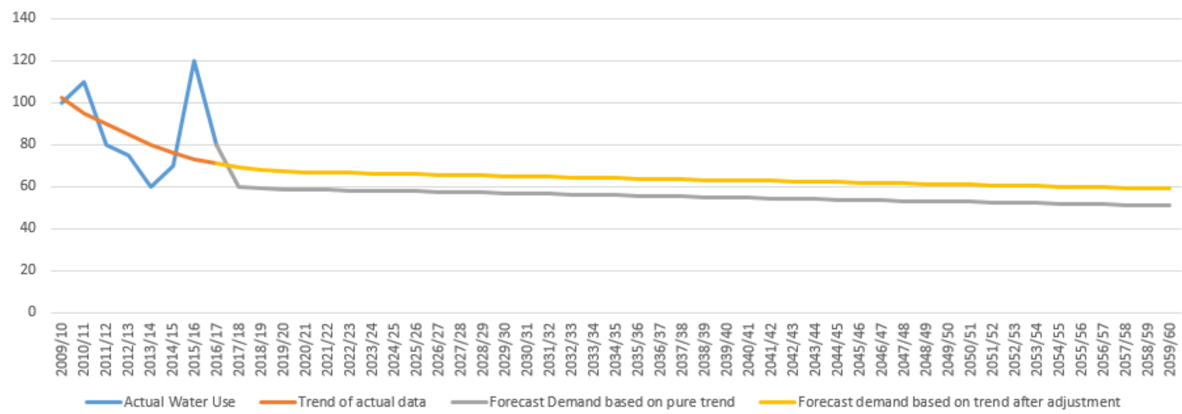
<u>Economic adjustment</u>

This is a percentage multiplier to be factored in to the trend forecast, which is an assumption that allows us to say whether future demand will be more or less positive than experienced in the past.

We have currently not applied an adjustment to this element of the formula because we do 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. We also believe 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 we prefer to make no adjustment on this basis at this time. We may review our position on this adjustment.

The graph below illustrates how this demand methodology would predict demand for a customer.

Figure 4.12: Example of demand forecast (yellow line would be used in our 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.

<u>Application of the methodology</u>

Our demand forecast applied an individual trend line for each of our identified customers. For all of the remaining non-identified customers we have derived an average demand per property and have applied the same trend approach to 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.

4.5.2 Non-Household Forecasting

Uncertainty

We can never predict with certainty what will happen in the future, as has been demonstrated with the change to the economic climate over the past five years. Customers can close at a moment's 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 to us in advance.

The methodology we have chosen to use for our non-household demand forecast uses the real data we have available, and combines this with an overall view to result in a reasonable looking forecast. If we have experienced 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.

Over the years of producing WRMP's various methods have been used to forecast non-household demand. Economic forecasts used to produce non household water forecasts have proved unreliable and given to dramatic change even between the draft plan and draft final plan. Talking with large users has also proved fruitless as even if future closure is planned they do not inform us before their own workforce being informed at the appropriate time. Their forecasts of potential growth, based on future economic forecasts prove equally unreliable, certainly beyond a few years. The retailers are not mature enough for this year to produce reliable forecasts and they would meet with the same degree of uncertainty from their larger customers that we have found. We have used trend analysis for the previous two WRMP's and these have proved sufficiently accurate. The method used is described below.

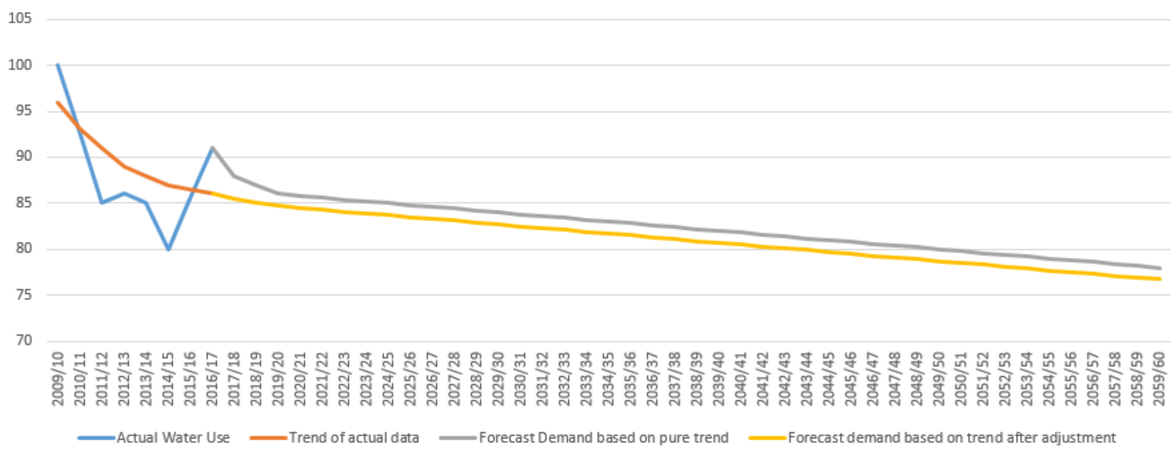
Sensitivity

Different ways of forecasting will produce different forecast volumes. We tested our demand forecast based on individual trend forecasts for individual customers against what the forecast would look like in 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 our starting assumption that all existing identified non-household customers will remain open, unless otherwise publicised.

Our overall 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 our largest customers. The forecasts for our largest non-household customers have been reviewed individually to ensure that they take account of the latest information we have about them, 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 our trend based approach ensures that the forecast demand is not based on the peak or lowest demand. In this case our recent demand is slightly higher than the trend would indicate so the forecast used is adjusted slightly upwards to by the “step change adjustment” as previously described.

Figure 4.13: Example demand forecast for variable demand at anonymous larger customer.



Our forecast would be sensitive to demand for this customer if we used either the 2016/17 peak demand or the lower demand of 2014/15. The trend gives us a clear way to make a decision on where to pitch demand and which can be consistently applied across all customers.

Should we hear 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, we can then build this information into our 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 our forecast methodology in several ways, we feel confident that it provides a reasonable forecast that is based on sensible assumptions.

4.5.3 Potable Water Demand by Sector

At this stage we have not analysed demand by Standard Industrial Classification (SIC). This is because our methodology of looking at smaller customers as a group means we do not need to look at different types of smaller customers. Small customer demand is discussed in more detail below.

Each of our 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 4.10: 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 & 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 industrial customers on Teesside.	

Defined industrial sectors

Figure 4.14 illustrates 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 45% of all demand.

Figure 4.14: Make up of non-household demand in the North East in 2016/17

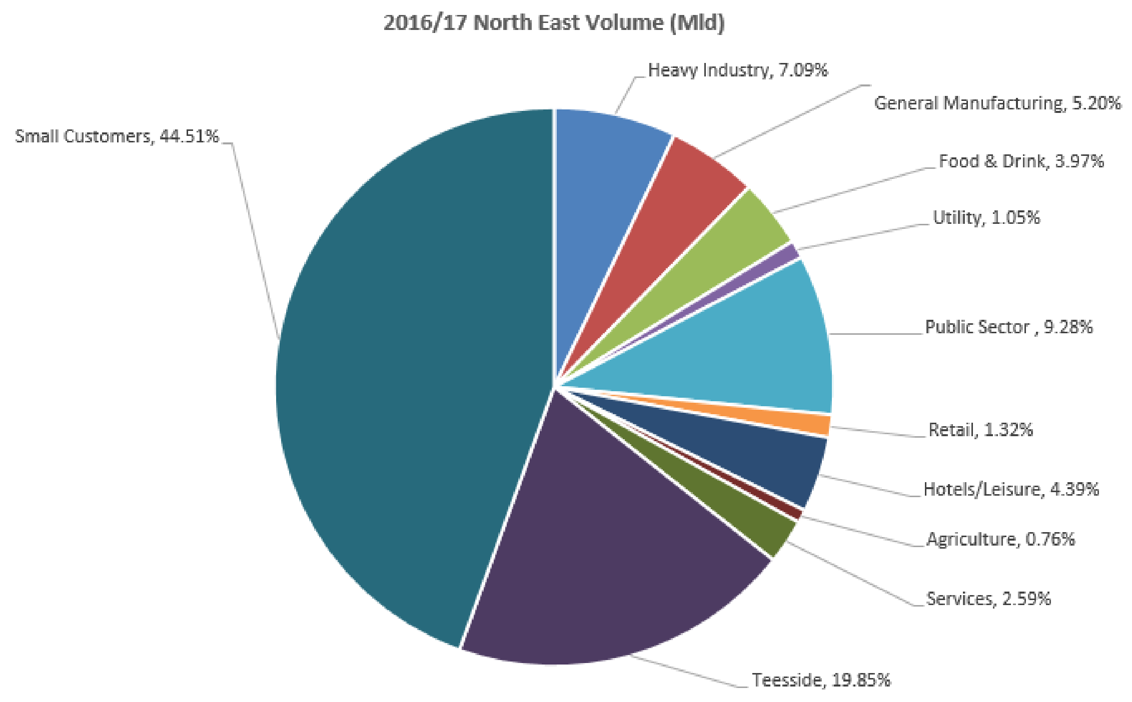
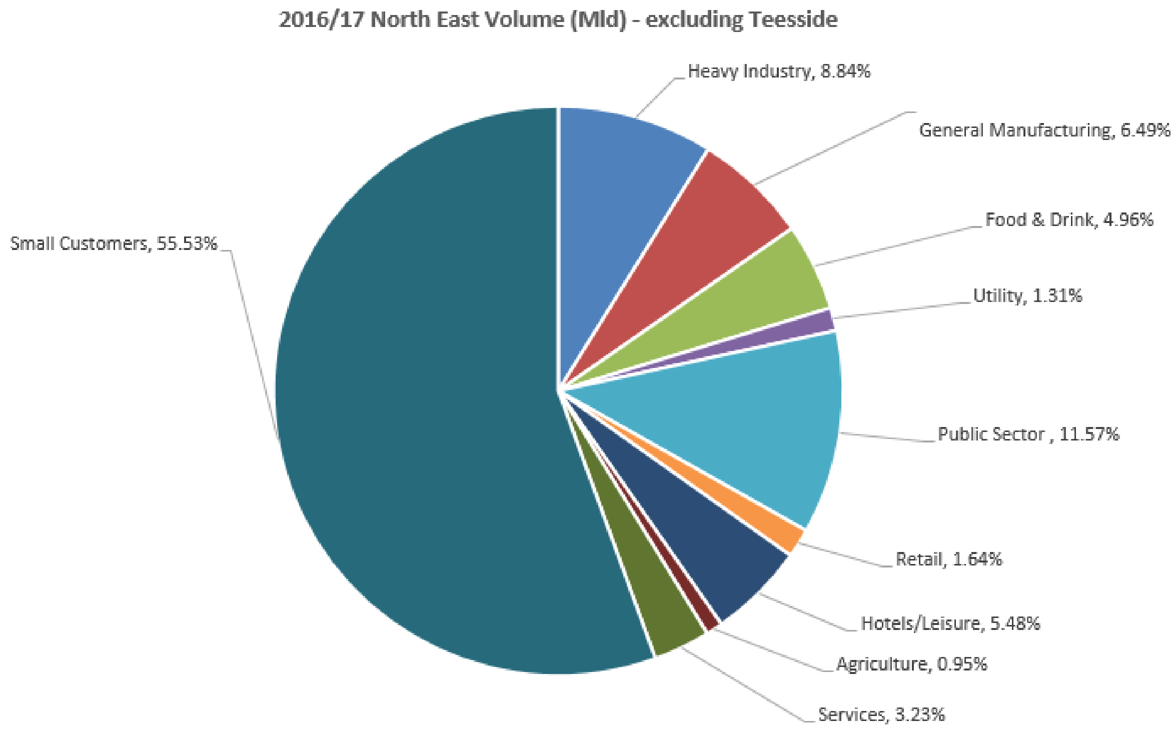


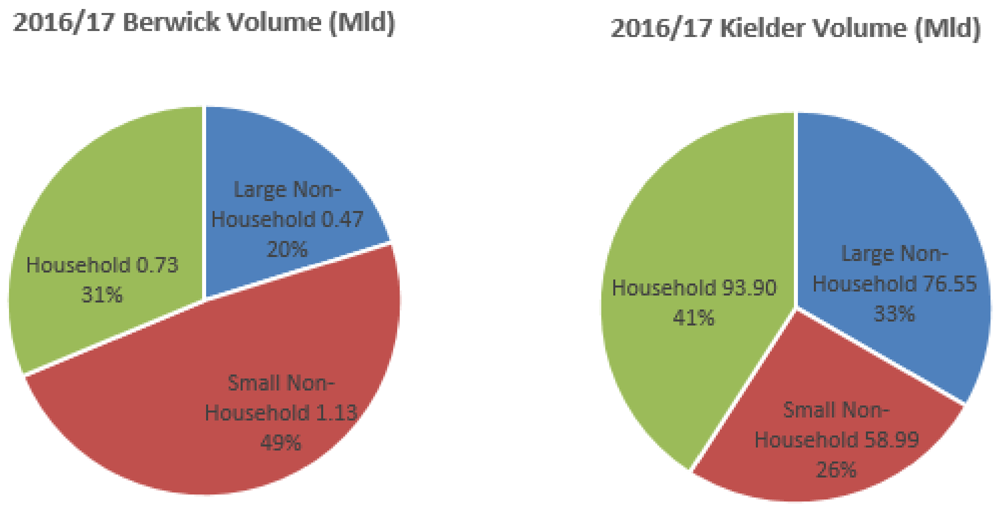
Figure 4.15: Make up of non-household demand in the North East in 2016/17, excluding Teesside.



In the North East we have identified a sector of customers as "Teesside" as show in Figure 4.15. This is a group of very large industrial customers based in a small area of Teesside, some of whom are dependent on one another to survive, and who have a significant impact on the overall demand in the North East, at about 20%.

4.5.4 Demand by Water Resource Zone

Figure 4.16: Breakdown of measured demand in North East Water Resource Zones for 2016/17.



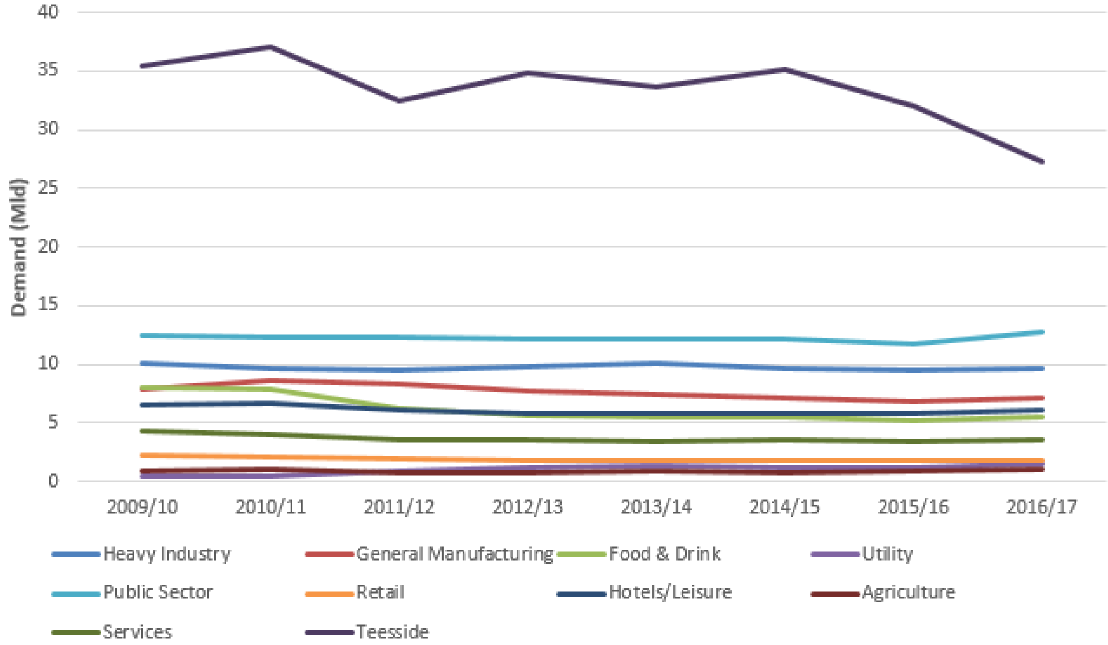
Comparing the two WRZ as in Figure 4.16 above shows that small non-household demand is a large proportion of the Berwick zone demand, whereas in the Kielder zone, household demand makes up the largest proportion of measured demand.

Large customer historical demand

Historically non-household demand has been quite stable, other than for closures of properties as illustrated in

Figure 4.17. Only demand from Heavy industry has been reducing, which is due to a mixture of customer closures and reducing usage.

Figure 4.17: Large Non-Household demand 2009/10 - 2016/17 - changes in volumes

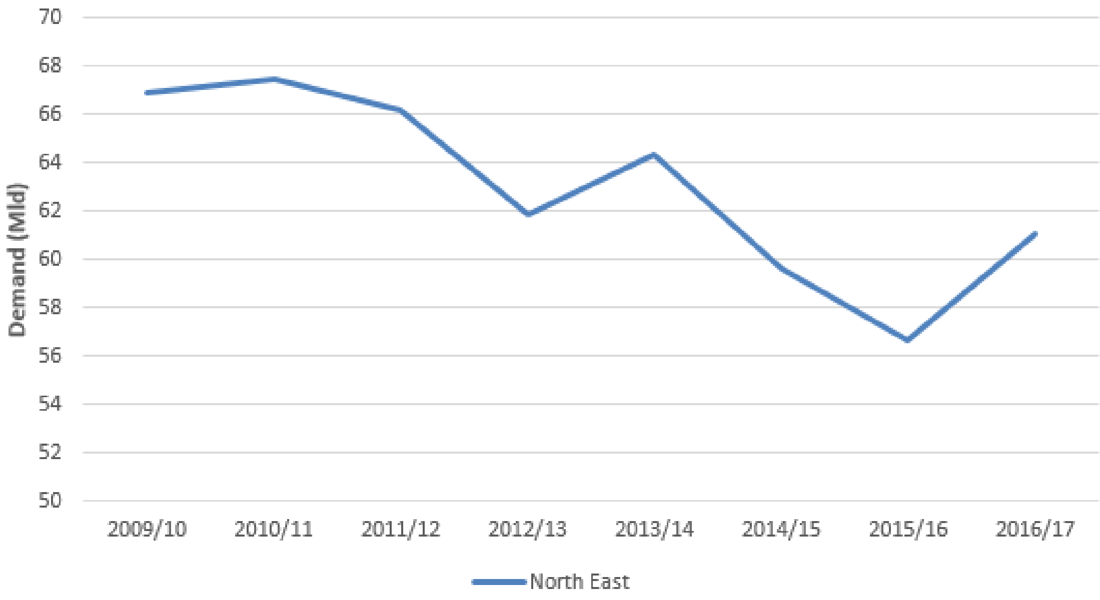


Demand in all sectors is now lower than it was in 2009/10, other than utility and public sector. The significant growth in the utility sector is due to a single large customer who has opened in 2010/11 and proportionately uses most of the water in the utility sector. The largest proportional reduction in demand can be seen in Teesside, which is largely due to one large customer closure.

Small customer historic demand

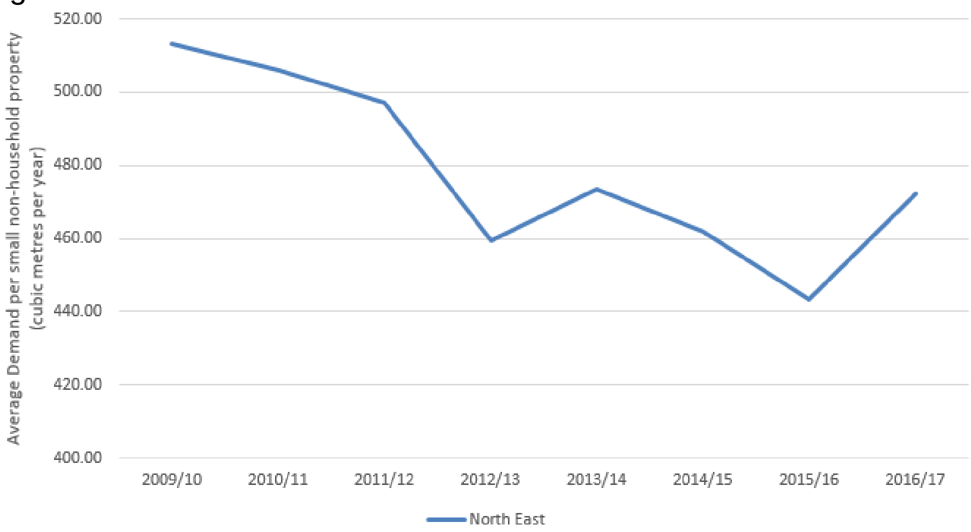
Since 2009/10 there has been a clear reduction in demand from smaller non-household customers, as shown in Figure 4.18, which we believe will be permanent.

Figure 4.18: Historic small non-household demand.



This reduction in demand is also reflected in the average demand per property, which is illustrated in Figure 4.19 below. The most significant change can be seen between 203/14 and 2015/16, where demand fell, however demand then increased in 2016/17.

Figure 4.19: Historic small non-household demand.



It is not possible to exactly determine the cause of the change from stable demand to reducing demand and then back to an increased demand, however given that it has occurred a couple of years after the economic climate changed in 2008 and after the harsh winter of 2010, we would suggest that this reduction is a combination of customers finding and repairing leaks, and more attention being paid to water usage.

As such we would expect the lower demand average demand per property to continue into the future.

While the reduction in average demand per property seems relatively small, accumulated over all small non-household properties this can add up to a significant change in total demand.

Forecast Demand

Overall measured non-household forecast demand to 2060 is relatively flat. This is due to the assumption built into our forecast that individual customer demand will trend to a flat line over time. In the short term the forecast shows reducing demand compared to recent years, and there is some question about when this is likely to flatten out. Given the current views of government and HM Treasury, that the UK economy is likely to continue as it is for the next 3 to 5 years, the flattening of demand within this timescale seems reasonable. See Figure 4.20.

We do not believe that demand is likely to suddenly begin increasing again, unless new large water users open. Our forecasts do not assume that this will happen because assuming new demand is uncertain until the new site actually starts operation.

Figure 4.20: Forecast demand in the North East by sector - volumes are cumulative, so the gap between each line is the size of each sector.

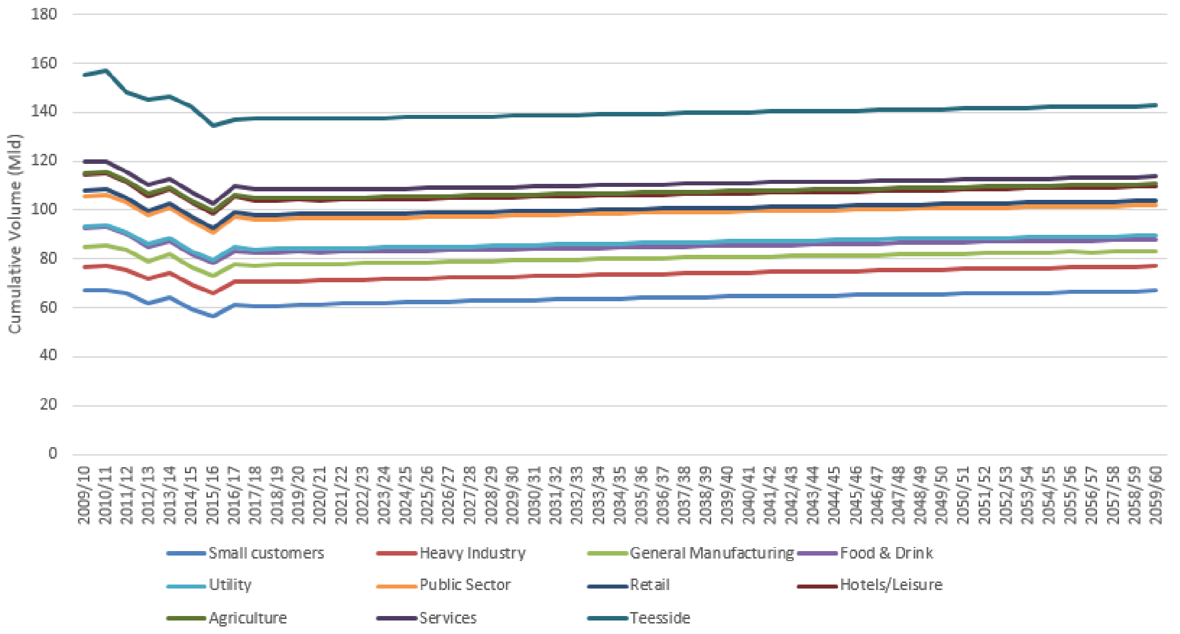


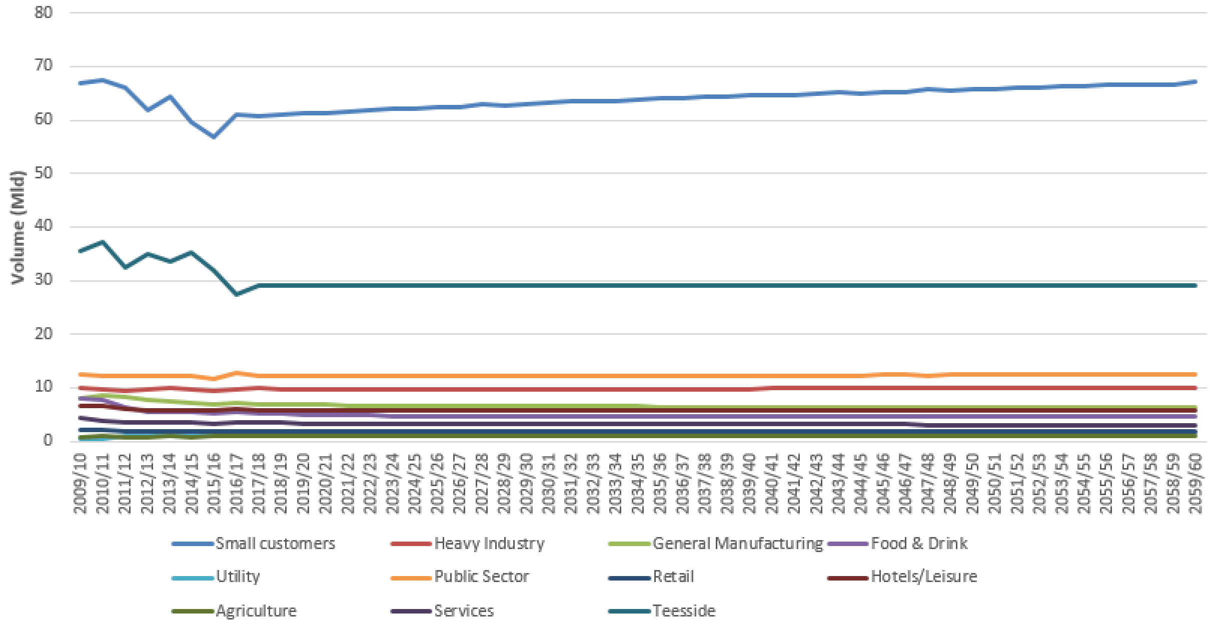
Table 4.11: Change in measured non-household demand by sector between 2016/17 and 2059/60.

Sector	Demand (Ml/d)		Change (Ml/d)	% Change	Notes
	2016/17	2059/60			
Small Customers	61.0	67.0	6.0	9.8%	
Heavy Industry	9.7	10.0	0.3	3.1%	
General Manufacturing	7.1	6.3	-0.8	-11.3%	

Food and Drink	5.5	4.7	-0.8	-14.5%	
Utility	1.4	1.7	0.3	21.4%	Increase is due to 2 large customers with increasing consumption
Public Sector	12.7	12.4	-0.3	-2.4%	
Retail	1.8	1.7	-0.1	-5.6%	
Hotels/Leisure	6.0	5.9	-0.1	-1.7%	
Agriculture	1.0	1.0	0	0%	
Services	3.6	3.1	-0.5	-13.9%	
Teesside	27.2	28.9	1.7	6.3%	
Total	137.0	142.7	5.7	4.2%	

The largest areas of change in forecast demand are due to expected growth of smaller non-households as shown in Table 4.11 and Figure 4.21. Other changes in the forecast demand is a result of the trends of each individual customer, and where the sector trend is decreasing this will be because more individual customer demands have decreasing trends than increasing, and vice versa.

Figure 4.21: Forecast demand in the North East by sector.



4.5.5 Non-Potable Demand

In the north east we supply a significant volume of non-potable water to a small group of customers on Teesside. To forecast demand for this non-potable water we have applied exactly the same methodology as applied for the potable water. A trend, based on non-potable demand, has been generated for each of these customers, and used to forecast demand into the future. As each of these customers are large, changes from any one customer can significantly affect the forecast. Nevertheless we have used the same principles as the potable forecast, and have only forecast a change to a customer's demand where it is based on robust, public domain information.

4.6 Dry Year Forecast

4.6.1 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 us.

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. A weighted average demand forecast is required as the basis of the company's revenue forecast[12]. 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[10]. 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.

Climate change

Please refer to section 6.4 for information on how climate change has been included in demand forecasts.

4.6.2 Dry Year Data Analysis

A project has been undertaken to review the dry year definitions available and also examine the relationship between weather and demand. The project also identified years of specific interest due to unusual weather and demand patterns with the peak summer period (June-September) which were examined in greater detail. This identified historic dry years determined by the number of days above 25°C and yearly cumulative rainfall. It also determined the weighted average number of dry years which may occur in a 10 year period. For more detail on the data analysis from this project please refer to the technical report Defining Dry Year Factors.

[12] Water Resource Planning Guideline, (2016), EA, OFWAT, DEFRA, welsh government.

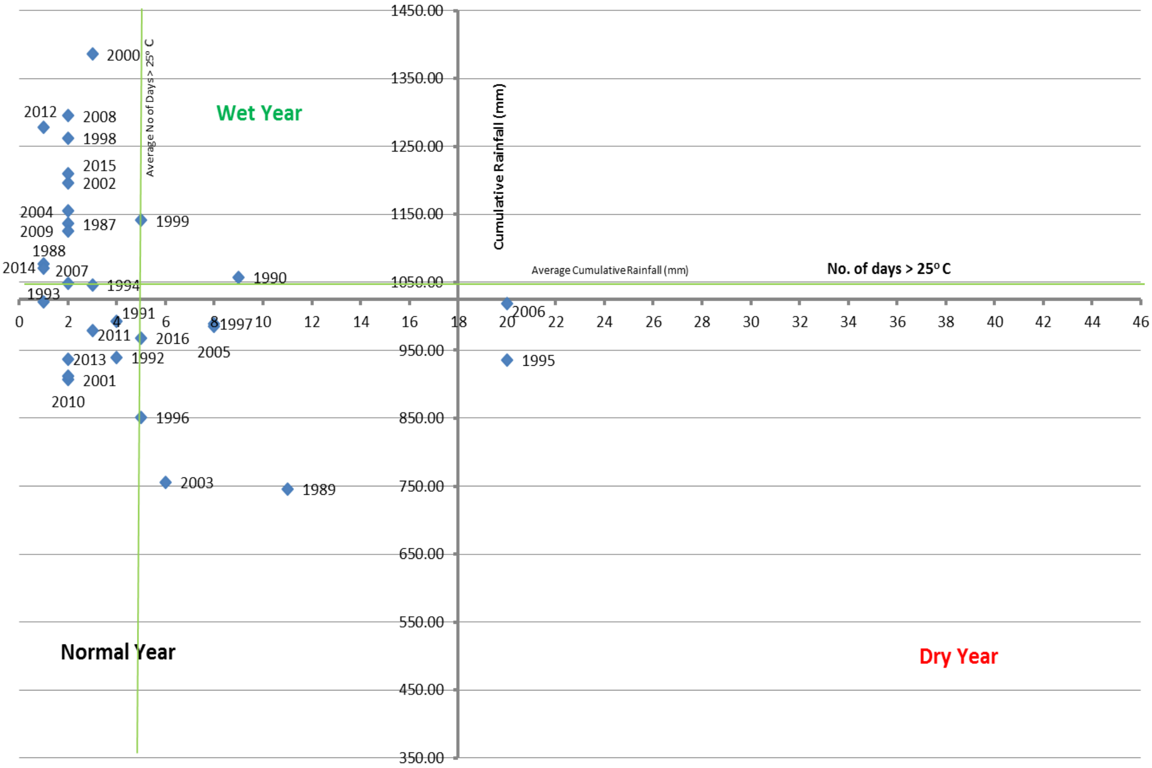
Various statistical analyses are available to apply to weather data to clearly define the weather conditions for a particular year or seasons of that year but there seems to be no universally accepted method to employ.

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.

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 as shown in the figure below. The quadrants for the graph were drawn where the number of days greater than 25°C equalled 19 as this is regarded as a significantly higher than average number of warm days, and secondly that cumulative rainfall equalled 1025mm, as rainfall less than 1025mm would be considered as on the dry side of the average year in the Northumbrian Water supply region. Thus the 'dry' quadrant would be where the number of days greater than 25°C exceeded 19 and the cumulative rainfall was below 1025mm and years placed within this quadrant would be defined as 'dry years'.

The results from this graphic representation approach show that the two years defined as dry years are 1995 and 2006 in our customer supply area. The green lines indicate the average temperature and cumulative rainfall for the period 1987-2016. The axes indicate the split of quadrants which are named either 'wet', 'normal' or 'dry' according to the likely conditions experienced.

Figure 4.22: Days greater than 25°C against cumulative rainfall.



4.6.3 Dry Year Baseline Forecast

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 PR09 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. 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. Results are shown in table 4.36.

Table 4.12: Increases in PCC

	Unmeasured PCC l/hd/d	Measured PCC l/hd/d
NW	3.1	1.24

5. BASELINE WATER EFFICIENCY, METERING & LEAKAGE CONTROL

5.1 Water Efficiency

5.1.1 Overview

Water efficiency has remained a key strand of our demand management undertakings throughout AMP6. Having initiated the first water efficiency retrofit programme in 1997, we are 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 our 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 our water efficiency retrofit projects, the strong emphasis on the measurement of water savings (at a more detailed level 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. We have 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 our 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, we designed our 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 Agency and Defra accepted our water efficiency proposals to annually reduce PCC by 0.12 l/head/day (equating to 0.33 Ml/day) by delivering water efficiency activities in AMP6; a target that we are 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 our 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, we have completed 5,856 home retrofit audits and 58 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 our 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 124,733 litres of water per day.

On an annual basis, we deliver 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. We 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, we are 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

We fully understand 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. We have understood this for many years and therefore behaviour change underpins all projects and initiatives.

Through each of our 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, we 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.

We 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, we delivered an educational play and workshop named Little Green Riding Hood. Working with a local theatre company, the programme was delivered to 106,535 pupils through 580 performances in 503 schools. It was a successful project that resulted in sustained behaviour change in primary school aged children.

  In 2016 Water Saving Week, we 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 our 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, we 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 encouraged to wear a t-shirt provided by us, 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.

We also recognise 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 Wingrove in Newcastle. Howard Nurseries Ltd won the Waterwise 2016 UK Water Efficiency Awards where they received both the Farming and Horticulture Award and the 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, Essex & Suffolk Water (the southern operating arm of Northumbrian Water Limited) 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, 67,686 water saving kits have been distributed to customers, upon request, following introduction in 2010. Water Saving Kits are promoted on our website, at events and by Customer Advisors in our Call Centre.

We also offer 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 our 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. We recognise this and have 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 our focus on both aspects in parallel. Also, as described in the 'Collaborating with Trusted Third Parties' section below, we have 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

We fully understand the importance of undertaking research in order to appreciate better the effectiveness of the projects carried out by us and to help shape future strategies. We collect 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 we better understand 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 us 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, we worked with leading professors in the field of behavioural economics to undertake research to understand how and whether financial incentives would encourage participation. Using our 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, we have 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

  We commissioned Artesia Consulting Ltd to perform an in-depth statistical analysis of the datasets for Phases 1-9 of our 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 our water efficiency programmes and also formed a key component to the Environment Agency's 'Water Efficiency Evidence Base; Review and Enhancement (2012) and the UKWIR: The Links and Benefits of Water and Energy Efficiency Joint Working project (2012).

- Seasonal effects on measured water savings

  We have routinely carried out water efficiency projects since 1997. As part of these projects, we have 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 we have produced a measurable decrease in our 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

We recognise the importance of delivering water efficiency in collaboration with trusted third parties. We have 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.

We are 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. We also have 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, we have 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

We have 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. Our evidence of measured savings to date indicates that the volume of wastage suggested in the industry-wide research is conservative. That aside, for us specifically this equates to approximately 57,000 properties with leaking toilets potentially wasting 12.29 Ml/d. In response to this finding, we have proactively focused on the identification and repair of leaking toilets through its water efficiency retrofit programmes and in response to high consumption queries.

We deliver approximately 5,000 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 forwards, we have 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 we distributed the first edition of Water Efficiency News. Since then, we have produced a further nine issues. The purpose of this newsletter is to keep stakeholders and other interested organisations up to date with our 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 we are undertaking. 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.

We remain actively involved in the water efficiency arena taking a lead wherever possible. We remain 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. We also actively support Waterwise (a not for profit organisation), continue to sit on and contribute to the Water Efficiency Strategy Steering Group and are also influential in scoping and seeing to fruition the development of the Collaborative Fund. Lastly, our Customer Director sits on the newly formed Leadership Group for Water Efficiency and Customer Engagement.

We have received industry recognition through receipt of numerous awards. Below is a list of awards that we have 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.
- Highly Commended in Sustainability & Society Award of the UK Excellence 2017 submission and awards
- Winner of Community Engagement Campaign of the Year at the 2018 PR Moment Awards
- Winner of the Research & Evaluation Award at the 2016 Waterwise UK Water Efficiency Awards for the H_2eco 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

We 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 we are able to maximise our effectiveness in terms of participation and water savings in target areas. The home retrofit programme will continue to be offered to a minimum of 5,000 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 we are able to engage with future generations and will be delivered to a minimum of 100 schools per year. We 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 us to offer our 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.

We 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, we have considered the numerous and varying drivers for water efficiency that now exist. In response, we 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, we are 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 we deem important in developing the water efficiency programme for AMP7, highlighting the projects that we will deliver and the anticipated water savings resulting from such activities.

5.1.13 Drivers for Water Efficiency

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 we are 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.

The Government's 25 Year Environment Plan ('A Green Future: Our 25 Year Plan to Improvement the Environment', 2018), calls for water companies to take bold action to reduce water demand, both now and for the future. It states that it will work with water companies to set ambitious personal consumption targets and agree cost effective measures to meet them. It also commits to working with the industry and the Leadership Group for Water Efficiency and Customer Participation

The National Infrastructure Commission, in their 'Preparing for a Drier Future' (2018) report, highlight their central finding as being that government should ensure increased drought resilience, requiring a twin-track approach including demand management programmes to reduce PCC to 118 litres per person per day.

WaterUK's 'Water Resources Long-Term Planning Framework (2015-2065)' 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.

5.1.14 What Customers Have Told Us

On average, our customers estimated that average consumption was half of what it actually is. This suggests that they see consumption levels as 'high'. Customers also told us that they expect us to do more to encourage water efficiency in future. This gives us clear direction to do more to encourage water efficiency and reduce consumption.

The majority of customers believe they are already doing what they can to be water efficient. Most of our customers see themselves as being responsible for their consumption, not their water company. They do not want us being 'pushy' about reducing their consumption. Some customers are even distressed by the thought of intrusive attempts to get them to change their behaviour.

We are mindful that plans to reduce consumption rely on customer participation and being too ambitious could lead to putting unwanted pressure on customers to change their behaviour.
Our position is therefore to commit to sustained gradual reductions in consumption which will enable us to put customer experience first. The reductions we are proposing will require significant investment in both existing and new approaches to incentivising water efficiency and we will be looking to innovative new approaches to deliver the long term targets we have set.

5.1.15 Our Commitment

We are able to demonstrate the Company's commitment to encouraging our 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 and in conjunction with the smart metering proposals outlined in section 5.2.5, we will commit to

- deliver a programme of water efficiency activities that will reduce PCC from 138.1 litres per person per day in 2019/20 to 130.5 by 2024/25, representing a 5.6% reduction and equating to 7.7 litres per person per day;
- and reducing PCC to 114.9 in the NW operating area by 2040, representing a 17% reduction.

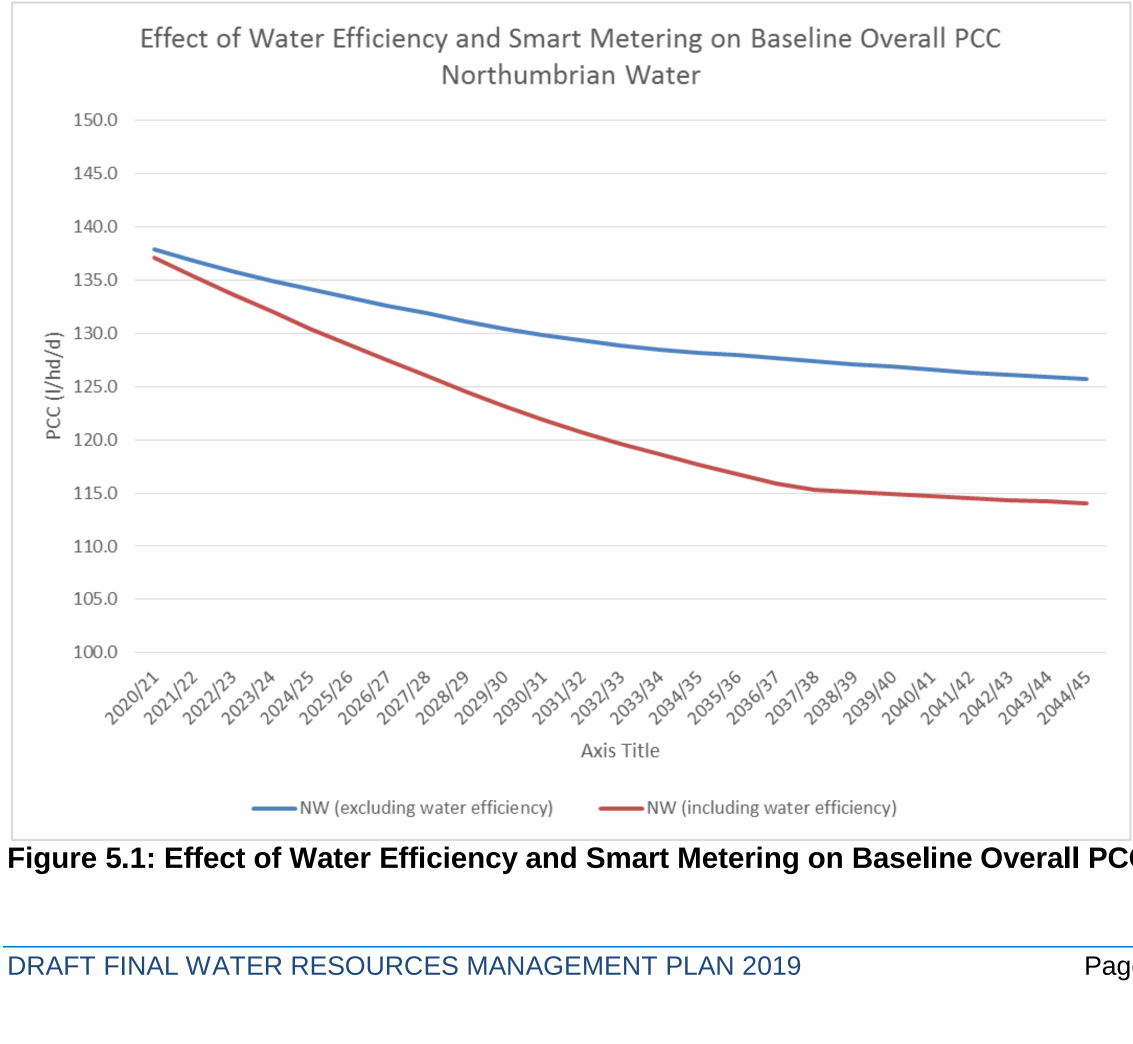


Figure 5.1: Effect of Water Efficiency and Smart Metering on Baseline Overall PCC

5.1.16 Options Appraisal

The Water Resources Planning Guideline and the Water Resources Management Plan (WRMP) Direction 2017 requires water companies to complete an appraisal of options to ensure security of supply whilst protecting the environment at a cost acceptable to customers.

We do not have a supply deficit in any of our Water Resource Zones (WRZ). However, we are required by our regulators to reduce per capita consumption. Appendix 3 provides the demand management options appraisal. The output from it has identified the options which should be included in water efficiency strategy.

We will achieve the ambitious demand reductions stated above through a continuation of the range of activities currently delivered (detailed in sections 5.1.3 – 5.1.9) although at a far greater scale. In addition, we will install smart meters (see section 5.2.5) and deliver two further programmes that were selected through the options appraisal:

- Work with developers to require new properties to be built to the Building Regulations Part G Optional Requirement, where possible and appropriate.
- Introduce a high efficiency toilet rebate scheme.

We 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 our activities in one town at one time. The whole-town approach ensures that we are able to maximise our 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 we are able to engage with future generations. We 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.

5.1.17 Other Considerations for Water Efficiency in AMP7

As part of the Mayor on London’s draft WRMP consultation response for the Essex & Suffolk Water plan (a trading division of Northumbrian Water Limited), the Mayor suggested that our WRMP should set out a plan for reducing non-household demand. Considering the same explanation applies to Northumbrian Water, we have included this section to provide further information. Following the introduction of retail competition to 1.2 million business, charities and public sector organisations in 2017, it was perceived that water efficiency would act as a key benefit for such customers and an opportunity for retail water companies. As a supporter of Waterwise, we agree with their finding in ‘Assessing water efficiency services offered by water retailers; March 2018’ which was that there is a wide variation in the number and types of services being offered by retail water companies. We also agree with their recommendation and proposal of a Water Efficiency League Table for retailers, given the lack of water efficiency services being offered and the issues with collaboration between wholesalers and retailers. We perceive that such a league table, and the creation of retail water efficiency forum, will ensure retailers deliver more water efficiency services. We commit to working with Waterwise and the retail water efficiency forum to push this forwards.

It is 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.

- There will be a transition whereby the importance of behaviour change grows exponentially.
- The delivery of home retrofits will need to become more targeted towards only those homes that will truly benefit from the programme. Our 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. We are 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.
- The use of smart metering/technologies will be deemed beneficial to water companies and an expectation of customers.

In response, we 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 we undertook in conjunction with Oxford University and the University of Chicago, will be implemented to intelligently incentivise customers. We will also deploy a series of smart technologies allowing more frequent and circular customer conversations around water efficiency.

5.2 Metering

5.2.1 Background

Our customer supply area has a large surplus of supply over demand in its Kielder WRZ and the area is not classed as seriously water stressed. Therefore compulsory metering cannot be considered. In the much smaller Berwick and Fowberry WRZ there is a smaller surplus until the full outcome of the NEP studies in to the sustainability of our ground water abstractions in AMP 6 reports. However we cannot compulsorily meter this area as it is still classed as not being seriously water stressed.

We intend to continue with our current programme of optant metering only for the AMP7 period. However we are keen to explore stimulating the number of optants, by targeted communications with customers, in areas such as Berwick, where higher metered densities would be more beneficial.

We started the year 2000 with a very low level of meter penetration. Up until this time, when the Water Act required a water company to provide a meter free of charge to any domestic customer who requested one (and it was not unduly expensive for the company to meter the property), a customer wanting a meter had to pay the full installation cost. Only new properties built since 1989 were metered. However, once free optant meters became available there was a pent up demand for meters with high numbers of requests through to 2010. By the start of 2010 (AMP5) over 20% of domestic properties had measured supplies

For the AMP5 period we had forecast new optant meter installations of 14,000 per annum and achieved an outturn for the AMP close to 70,000 total. This raised the level of metered customers to 30.6% by the end of 2014/15.

For AMP6 we again forecast an average 14,000 optants per annum for each year as even towards the end of AMP5 we were still seeing this level of optant meters being installed. So far in AMP6 we are seeing this level of optant meters being installed, partially inflated by one of the Local Authorities removing the water rate from the overall rent on their social housing. This means for the first time these customers now receive a water bill and a number realise that being measured would reduce their water charges. We believe that another of our LA's intends to follow suit next year meaning the AMP6 total is likely to be met, if not exceeded. The forecast meter penetration by April 2020 is 39.61%.

5.2.2 Customer opinion on metering

Customer attitudes towards metering appear to be mixed to favourable. Quantitative research conducted in 2011 gives an inconclusive picture with 53% of our customers stating they felt positive towards metering as a means of charging. A more positive attitude is apparent across three programs of qualitative research conducted for PR09 and PR14. Favourability towards metering primarily seems to be concerned with three factors. On a personal level some respondents believe that the installation of a water meter would bring their water bill down; *"I want to get a meter because I think my bill is too much"* (NW, 2012). Secondly, on a societal level respondents have suggested that metering is the fairest method of charging for water consumption across customers. A third factor cited in support of metering is that metered systems make customers more aware of how much water they use, and so encourage water saving behaviour. This is supported by qualitative evidence that metered customers seem more aware of their bill amount than non-metered customers.

Despite this positivity towards metering there is evidence that customers are against enforced metering. Quantitative work conducted in 2011 showed that 82% of our customers were against enforced metering. Qualitative research conducted in 2012 indicates why this is the case, these respondents were against enforced metering on two grounds; firstly that it restricts consumer choice, which is considered to be unacceptable. Secondly concerns were expressed that bills would increase following the installation of a meter either instantaneously or as a result of unanticipated increases to the household size; *"They would cost more money when you have children" (NW, 2011).* This is supported by two programs of recent qualitative research (May 2012 and December 2012) which suggest a customer requirement for education around metering and potential bill savings.

Further customer research in to their attitudes towards metering were carried out in 2017 to inform this WRMP.

We undertook qualitative research about metering, supply and demand with customers from a variety of backgrounds at two locations in North East England in April 2017. We ran deliberative workshops at Stockton-on-Tees and Gosforth in Newcastle, using an independent agency to facilitate and analyse the results. Senior members of our water team were present to engage directly with customers and customers were segmented by metered status.

Customers were asked about the same topics as those in our Essex and Suffolk customer supply area, but the information presented to them was tailored to North East England, e.g. leakage was at 20%, the network of pipes was twice the length, we spend 50% more per year on metering in the north, and average estimated consumption is slightly different. Although compulsory metering would not be permitted in the north due it not being water stressed, we wanted to ask customers about the extent to which they wanted us to impose metering on them in the same way as we had done in the south, so that the results would be comparable. On a qualitative level, no significant differences were found between the opinions of customers in our Essex & Suffolk customer supply area and customers in our northern supply area about any of the topic areas.

Some quotes that show some customer views in the north include:

"In this part of the country we aren't short of water... It should be a lot cheaper. We've got that much that now they've put pipelines from here down …south. You shouldn't have to worry about how much water you use. You're never gonna run short. We're the North East of England. We're part of the country we shouldn't have to worry about what we do with our water. We've got some of the biggest reservoirs."

Some customers who have inherited meters when they moved, would like the opportunity to revert to unmeasured tariffs.

There can also be high levels of worry caused by being on metered tariffs among lower income customers*: "I am using it, probably not like I did in my old house, washing my bins out every fortnight, I'm doing them monthly. I am cutting back, because I'm conscious of the water and I don't want to be like that. I don't want to be shouting at the kids and saying you've ran the bath and it's full up, like that. It's habits of a life time probably. But I have seen the cost rise. I had a sleepless night, as daft as it sounds, because I had a leaking tap. Until I got it sorted. Just the fright of the bills."*

5.2.3 Compulsory metering

Northumbrian Water does not operate in any areas classed by the Environment Agency as Seriously Water Stressed. As such permission to compulsory meter customers, under current legislation, cannot be granted by the Secretary of State. As such this option has not been considered or costed.

5.2.4 Selective metering on change of occupier

Legislation allows all water companies to meter a property if the occupier changes and that occupier has not paid for water on an unmeasured basis. We have never selectively metered in NW on change of occupier but have experience from introducing this in Essex from 2003.

Forecasting the number of properties coming forward to selectively meter as the occupier changes is notoriously difficult due to the strength of the secondary housing market, the volume of rented property and the current meter penetration.

In the North East the primary housing market is stronger than the secondary market which lowers the number of opportunities. However there is a large rented market and meter penetration at 43% both give greater opportunity for metering. Experience shows that over the first 5 years many of the rented accommodation changes occupier but in subsequent years these keep coming round but we will have already metered them. The pool to meter on change of occupier then predominantly becomes the secondary market creating much lower numbers.

Selective metering, because of difficulty of access to properties, and on occasion hostility from those being metered, we fit all meters externally. Either in an existing empty meter chamber or by installing a new chamber.

Table 5.1: Number of selectives for AMP7

	2020/21	2021/22	2022/23	2023/24	2024/25
Selectives	20,000	19,500	19,000	18,000	17,000

Table 5.2: Selective meter numbers over 25 year planning horizon

	AMP7	AMP8	AMP9	AMP10	AMP11
Selectives	93,500	50,000	30,000	10,000	5,000

Water saved in AMP7

We assume that selectively metering a customer stimulates them to reduce their water use by 8% compared to the average unmeasured customer.

Therefore, using 2016/17 baseline figures the following water savings for selective metering have been calculated.

Table 5.3: Water saved through selective metering in AMP7

Water savings for selective metering	
Average unmeasured PCC (l/h/d)	143.42
Average selectives consumption (l/h/d) (8% saving)	131.95
Average water saving (l/h/d)	11.47
Average unmeasured occupancy over AMP7	2.67
Total number of AMP7 selectives	3,500
AMP7 Water Savings (Ml/d)	2.862

Cost of Selective metering in AMP7

We have assumed 30% of customers will have an empty meter chamber (Drop in). The remaining 70% will require a new meter chamber to be installed externally in the public highway (pavement)

The total costs for selective metering using the 2016/17 prices are as follows.

Table 5.4: Costs for selective metering in AMP7

	Price per installation	Percentage split between meter installation location	Total number of meters	Cost (£m's)
Drop In	£ 94.04	30%	28,050	£2.64
External public	£ 438.79	70%	65,450	£28.72
Total AMP7 cost (£m's)				£31.36
Cost per Ml water saved (£m's)				£10.96

Given the water supply situation in the North East and our customer research findings that choice is what they value, we intend to retain our current optant metering strategy.

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. NW 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 NW 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.

In AMP7 we have estimated that five customers per annum in will be selectively metered because of their high use of water. Any demand savings would only come from them being more careful with their other water use and in total is negligible.

5.2.5 Proposed metering strategy going forward

Given the current rate of meter installation from the AMP6 optant programme, and the views of customers, optant only metering will continue for AMP7 and AMP8 at the current rate of 14,000 properties per annum. Achieving these numbers will see us reaching a meter penetration of 48% by the end of AMP7 and 55% at the end of AMP8. Achieving an average of 14,000 optant meters per annum in AMP8 may require a more targeted promotion of meters to customers. Experience in Essex & Suffolk by using personalised communications and the use of pre-metering (installing meters at properties that remain unmeasured but providing them with the equivalent bill they would receive if measured) makes us confident we can maintain 70,000 optant meters over AMP8.

The more active promotion of meters to potential optants, by either personalised communications or pre-metering already installed but empty meter chambers, may be trialled during AMP7 in the Berwick and Fowberry WRZ to further increase the level of metering in this ground water fed WRZ.

Table 5.5: Meter Optant Rates

	AMP7	AMP8	AMP9	AMP10	AMP11
Optant	70,000	70,000	50,000	50,000	30,000
Total	70,000	70,000	50,000	50,000	30,000
End of AMP Meter penetration	48%	55%	61%	66%	69%

Changes to the draft WRMP optant metering

Following the above figures used in the draft plan we have taken account of our customer research that showed there was still a significant number of customer who remained unaware that they could request a meter free of charge. Although it is advertised on our website and within billing literature it was not being seen as widely as possible. Our customers thought we should advertise free meters more widely. In addition our ambition to remove all customers from water poverty, detailed within our Business Plan, metering will play a part in this. As such there is likely to be an increase in the number of meter optants over AMP 7. To cater for this we have increased the number of optants each year by 25%. In AMP7 this will equate to 17,500 per annum.

Table 5.6: Revised Meter Optant Rates

	AMP7	AMP8	AMP9	AMP10	AMP11
Optant	87,500	70,000	50,000	50,000	30,000
Total	87,500	70,000	50,000	50,000	30,000
End of AMP Meter penetration	49%	57%	62%	68%	71%

Water saved by optant metering

From studies we have calculated that households that opt for a meter tend to be lower users of water than the average unmeasured. Their average use before being metered is 90% of the average unmeasured and then a meter causes a further 5% reduction in use.

Therefore, using 2016/17 baseline figures the following water savings for optant metering have been calculated.

Water savings for selective metering	
Average unmeasured PCC (l/h/d)	143.42
Average pre-switching consumption (l/h/d)	129.08
5% further saving (l/h/d)	6.45
Average optant occupancy over AMP7	1.71
Total number of AMP7 meter optants	87,500
AMP7 Water Savings (Ml/d)	0.966

This assumes the daily consumptions and occupancies remain constant over the AMP7 period which for ease of calculation is a reasonable estimation.

Cost of optant metering

The cost of installing a meter varies according to where on the property NW 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. Our new location policy will enable us to make significant efficiencies in metering and has been developed through consideration of a number of key factors including cost, customer impact, suitability for smart metering, and calculating/identifying PCC and leakage. The order of preference is:

1. Drop in
2. Wall box
3. Internal
4. External private

We will no longer carry out installations in the public highway as this is becoming extremely costly and causes delays to the installation process – reducing customer satisfaction with the service.

The total costs for optant metering using the 2016/17 prices are as follows.

	Price per installation	Target %age split between meter installation location	Total number of meters	Cost
Drop In	£150.41	20%	17500	£2.632
Wall box	£284.91	40%	35000	£9.972
Internal	£218.00	20%	17500	£3.815
External private	£369.14	20%	17500	£6.460
			Total AMP7 capex (£m's)	**£22.879**

5.2.6 Long Term Metering Plan

In NW, our metering programme is almost entirely focused on delivering installations through optant requests. Our rdWRMP assumes that only five meters will be installed selectively each year in AMP7 for large users who are resistant to having a meter fitted. We have no plans to introduce change of occupier metering.

Optant rates in Northumbrian Water remain high despite the fact that we do very little to promote meters beyond the basics of providing information on our website and on unmeasured customers' bills. In AMP6 we have consistently seen optant rates above the forecast level.

	2015/16	2016/17	2017/18	2018/19
Forecast optants	14,000	14,000	14,000	14,000
Actual optants	14,219	15,247	17,880	16,386 (forecast)

After seeing a remarkably constant optant rate over many years we are confident that the rates will continue at similar levels at least until 2030 given our comparatively low level of meter penetration. In the coming years we will also do more to improve customer awareness about the potential financial benefits of switching to a meter as part of our commitment to eradicating water poverty. This will be done in a targeted way to stimulate optants through time in areas where customers are likely to benefit from switching to a meter. We will promote water efficiency alongside this to further support customers with reducing their bill and maximise the benefit to reducing consumption.

From 2030 we expect optant rates to start declining in line with increasing meter penetration. We observed a decline in optant rates in ESW which coincided with reaching meter penetration of around 60% and we will reach this level in NW in about 2032. However, with continued targeted promotion of meters we expect the decline in optant rates will be slight and gradual through the remainder of the planning period in NW.

The costs of our optant metering programme up to 2045 are summarised below (in 2017/18 prices). The capex costs are for meter installations only and do not include the cost of meter replacement. The opex costs are cumulative and reflect the escalating opex costs associated with all the meter installations made from 2020 onwards.

	AMP7	AMP8	AMP9	AMP10	AMP11
Installation numbers	87,500	70,000	50,000	50,000	30,000
Capex £'m	£22.879	£19.245	£13.915	£13.915	£8.677
Opex £'m (cumulative)	£0.739	£1.330	£2.166	£2.901	£3.460
TOTEX £'m	£23.618	£20.575	£16.081	£16.816	£12.137

Smart Metering

Our PR19 plan includes a proposal to install smart meters with every new meter installation from April 2020. The long term strategy is to reach a position where all our meter stock is smart by 2035, which means that replacement meters from 2020 will also be upgraded to a smart meter. The primary purpose of the smart metering strategy is to improve customer service. Smart meters will enable us to introduce a greater selection of tariffs and enable quicker resolution of issues like customer side leaks. Our customers also want better visibility of their usage so that they can save water and save money. From the small amount of data available from the industry on the benefits of smart meters, we are assuming an additional 3% water saving on top of that gained from a dumb meter installation. Further details will be provided in the WRMP Annual Updates as the programme evolves.

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 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 us, the changes and their potential impact are explored below.

5.3.2 Summary of Approach

In the course of preparing our WRMP, we have 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.

We have 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 underway to ensure we are fully compliant with all aspects by 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 our “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) Non-Household Night Use Study – A company specific night use model is required derived from a minimum of 1000 logged customer results, each over 14 days.
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) Extension of Small Area Monitor (SAM) – The SAM will be extended to ensure that it is representative of the demographic characteristics.
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

In 2007, we 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.

We have also complied with most of the recommendations of the 2012 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 Environment Agency, Ofwat and Defra. Specific actions NW has taken include:

- We have considered all operational leakage options to reduce leakage. We have also included a stand-alone optimisation of pressure management. However we have 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.
- We have 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 we have 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.
- We have 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 our leakage cost curves, we have assumed that we will achieve substantial future improvements in the efficiency of our active leakage control processes.
- We are 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 Economic Level of Leakage (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 below 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: Trade off between increasing volume of water and level of ALC

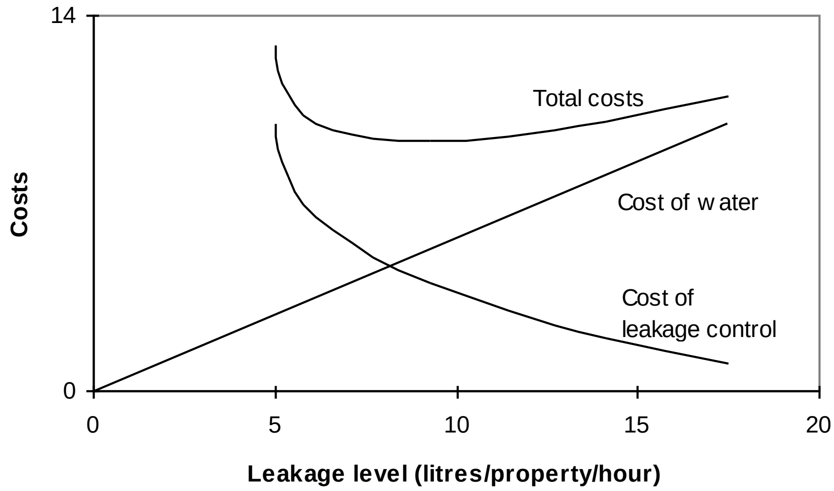


Figure 5.3: represents the hypothetical behaviour of leakage in a DMA

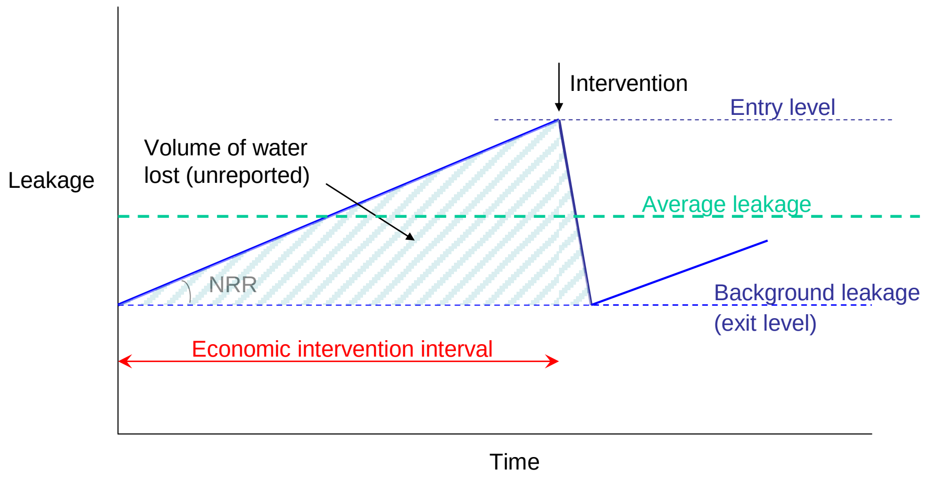


Figure 5.3 above represents the hypothetical behaviour of leakage in a DMA. At time zero an intensive leak detection and repair campaign has just been completed, and leakage has been reduced to the background level. Thereafter leakage rises at a gradient equal to the natural rate of rise. Eventually 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 our customer supply area 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. In our customer supply area a programme has commenced to maximise the coverage of pressure management schemes during the AMP6 and AMP7 periods. These schemes will be constructed typically at sub-DMA level, often where there is significant variance in ground levels.

Previous submissions and current positions

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 141.2Ml/d and for AMP6 was 137.74Ml/d. The leakage targets since 2015/16 have been below the SELL value.

The following leakage targets through the AMP5 and AMP6 periods were agreed with OFWAT.

Table 5.7: Leakage targets for AMP5 and AMP6.

Annual Reporting Period	Leakage Target (Ml/d)
2010/11	150.0
2011/12	147.0
2012/13	144.0
2013/14	141.0
2014/15	141.0
2015/16	139.0
2016/17	137.0
2017/18	137.0
2018/19	137.0
2019/20	137.0

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 4 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 shown in Table 5.8.

Table 5.8: Comparison between background and 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)
70.90	74.86	67.08	59.51	52.44	39.67	26.42

This work shows that the Background level of leakage calculated of 70.90 m3/day is equivalent to an industry value of approximately MAL_{47}. In other words, the overall level of minimum achieved leakage levels in our customer supply area is equivalent to the 47th percentile of values achieved at UK national level. This is appropriate for a company with leakage levels which are slightly below the UK national average.

Results of ALC modelling

The resulting leakage-cost curves for active leakage control are shown in Figure 5.4 below.

Figure 5.4: ALC cost curve for the North East.

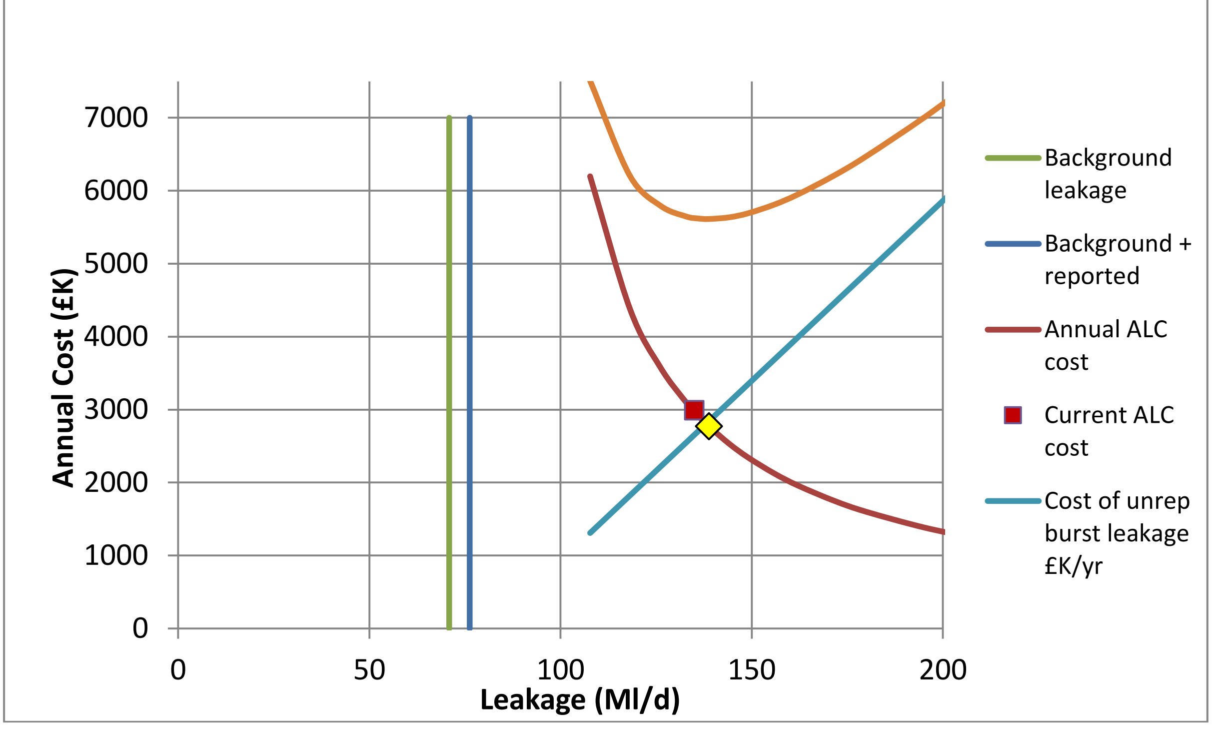


Figure 5.4 shows that the current SELL is 138.8 Ml/d. This SELL is a short-run economic level, and is marginally higher than both the current leakage level and the current target.

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

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 we have 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 137 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 138.5 Ml/d. However our scenario analysis shows that the actual value of this PC could range from 130.8 to 142.4 Ml/d.
For AMP7, the planned percentage reduction over five years is 15.0%. Therefore the range of Performance Commitments through the five-year period for the three scenarios is as shown in Table 5.9.

Table 5.9: Performance Commitments through AMP7

AMP	Year	Leakage Performance Commitments (Ml/day)		
		Most Probable	Upper Scenario	Lower Scenario
AMP6	2019/20	138.5	142.4	130.8
AMP7	2020/21	134.4	138.1	126.9
	2021/22	130.2	133.8	123.0
	2022/23	126.1	129.6	119.1

	2023/24	121.9	125.3	115.1
	2024/25	117.7	121.0	111.2

These leakage reductions will be achieved by a combination of the following measures:

- Optimisation of all existing pressure management installations
- Additional pressure management installations with flow controllers where appropriate.
- Increased efficiency within the active leakage control process, especially through the use of noise loggers. We already make use of temporary noise logger deployments, but from 2018 onwards we intend to invest heavily in the latest generation of correlating noise loggers for permanent or semi-permanent installation.
- Increasing the level of committed resources for leak detection and repair.
- A programme of leakage driven mains renewals.
- Other innovations (see Section 5.3.6 below)

Leakage Reductions beyond AMP7

For each of the four periods of five years, we propose 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 Table 5.10.

Table 5.10: Performance Commitments beyond AMP7

AMP	Final Year	Leakage Performance Commitments (Ml/day)		
		Most Probable	Upper Scenario	Lower Scenario
AMP6	2019/20	138.5	142.4	130.8
AMP7	2024/25	117.7	121.0	111.2
AMP8	2029/30	106.0	108.9	100.1
AMP9	2034/35	95.4	98.0	90.1
AMP10	2039/40	85.8	88.2	81.1
AMP11	2044/45	77.3	79.4	73.0

By the end of the AMP7 period it is envisaged that all opportunities for pressure management, including the optimisation of all existing schemes will have been completed. Throughout AMP7 we will seek to identify innovative techniques and further customer focussed activities. It is envisaged that these initiatives will deliver leakage savings and each will be analysed to understand individual and combined costs and benefits. Beyond these initiatives, the only remaining option is to replace sections of the distribution network. This option is both costly and is seen as the least favourable to the environment. It is important, therefore, to maximise the benefits of all other initiative before adopting a large scale programme of mains renewals.

5.3.6 Innovations for Leakage Management

In addition to the measures listed above, we 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 our very successful Festival of Innovation held in Newcastle in 2017.
- Detailed review of operational leakage survey strategy to understand the most efficient balance of techniques, including designating specific tasks for the most experienced technicians.
- Investigations into the impact of pressure transients.
- Trials of new leak detection equipment and pressure management flow controllers.
- The use of drones and satellite technology, particularly to identify leaks in rural locations and on long trunk main lengths.
- The development of customer plumbing loss evaluation technology.
- The potential use of leakage sniffer dogs.

We will also continue to take the lead role in UKWIR's "Zero Leakage by 2050" research programme

5.3.7 Benchmarking

International benchmarking typically utilises values derived using the ILI "Infrastructure Leakage Index." This is a relatively crude index based on the derived leakage value, the number of connections, the length of mains and the system pressure. This allows data for various companies internationally to calculate a notional ILI value. The World Bank presents the results in four sections A (0-2 best) to D (8-10 worst). The industry last calculated all company's data in 2011/12. At that time all UK companies (except Thames) fell within categories A and B with NW in category A. This situation will not have changed significantly in recent years. The main deficiency in the process is that the index makes no allowance for the age, condition or material of the mains network.

The 2016 UKWIR study on "Factors Affecting Minimum Achieved Leakage Levels" (Report No. 16-WM-08-58) was far more detailed and allowed us to benchmark our performance within the UK industry alone. This provides a much better indication of the condition of the network and is considered a much better benchmark for comparison purposes.

6.0 CLIMATE CHANGE

6.1 Introduction

This chapter outlines how we have assessed the risk and possible impact of climate change on the deployable output of current sources of water and on customer demand. Our assessment has been undertaken following guidance set out in the Water Resource Planning Guidelines (WRPG) 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

The WRPG states that a climate change vulnerability assessment should be undertaken to understand how vulnerable each Water Resource Zone (WRZ) is to changes in deployable output as a result of climate change.

This information can then be used to decide which method should be used to assess the effect of climate change on WRZ deployable output. Our PR14 climate change assessment modelled the effect of the mid-climate change scenario on deployable output but not the effect of the wet and dry scenarios. Consequently, it is not possible to use the magnitude versus sensitivity plot to assess vulnerability.

The guidance states that the methods a water Company uses to assess the effect of climate change on Deployable Output (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 both WRZs will have a supply demand balance surplus across the full planning period. Consequently, climate change poses a lower risk to security of supply than otherwise would have been the case. Additionally, our 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. We therefore believe that given the points summarised above, that a low vulnerability classification is likely to be appropriate for our WRZs. Consequently, it is acceptable to use the Future Flow method for the Kielder WRZ.

6.3 PR19 Climate Change Assessment

6.3.1 Approach

We only have rainfall-runoff models for 11 of 22 of the catchment flows in the Kielder System, this constrains the range of potential options available for climate change modelling.

For WRZs at low vulnerability to climate change and there are no rainfall runoff models, the WRPG recommends that a tier 1 analysis is carried out, that being the use of Future Flows (FF) Hydrology change factors for the 2080s.

The approach set out in the guidance is detailed below:

- For surface water the Agency has generated monthly change factors for each future flows station representing change against the 1961 to 1990 climate baseline.
- Select the change factors for the station nearest the source but still within the same catchment and with similar BFI where possible.
- Perturb baseline flow sequences using these factors.
- Complete this analysis for all 11 scenarios of FF

The monthly change factors from each of the 11 FF scenarios were applied to all the catchment time series flows in Aquator, the English and Welsh DO analysis module was then ran. Using this approach, the impact of climate change on DO can be estimated.

6.3.2 Selecting FF catchments

Table 6.1 NW catchments requiring climate change factors.

Catchment Model Reference	Catchment Name	Assigned time series
CM1	Fontburn Catchment	Fontburn Catchment
CM2	R Coquet Catchment	R Coquet Catchment
CM3	Kielder Catchment	Kielder Catchment
CM4	Catcleugh Catchment	Catcleugh Catchment
CM5	South Tyne Catchment	South Tyne Catchment
CM6	Colt Crag/Little Swinburn Catchment	Colt Crag/Little Swinburn Catchment
CM7	Hallington Catchments	Hallington Catchments
CM8	Whittle Dene Catchment	Whittle Dene Catchment
CM9	Derwent Catchment	Derwent Catchment
CM10	Hisehope Catchment	Hisehope Catchment
CM11	Smiddy Shaw Catchment	Smiddy Shaw Catchment
CM12	Waskerley Catchment	Waskerley Catchment
CM13	Tunstall Catchment	Tunstall Catchment
CM14	Upper Wear Catchments	Upper Wear Catchments
CM15	Burnhope Catchment	Burnhope Catchment
CM16	Lower Wear Catchment	Lower Wear Catchment
CM17	Cow Green Catchment	Cow Green Catchment
CM18	Upper Tees Catchment	Upper Tees Catchment
CM19	Selset Catchment	Lune & Balder
CM20	Grassholme Catchment	Lune & Balder
CM21	Balderhead Catchment	Lune & Balder
CM22	Blackton Catchment	Lune & Balder
CM23	Hury Catchment	Lune & Balder
CM24	Middle Tees Catchment	Middle Tees Catchment
CM26	North Tyne Catchment	North Tyne Catchment
CM27	Mid Tyne Catchment	Mid Tyne Catchment
CM28	Burnhope Burn	Burnhope Burn
CM30	Rede Catchment	Rede Catchment
CM31	Lower Tees Catchment	Lower Tees Catchment
CM32	Pont Catchment	Pont Catchment

Of the FF sites in the North East region only 4 can be directly applied to catchment time series in Aquator as shown in table 6.2.

Table 6.2 Catchments containing FF sites.

FF Station No.	FF River	FF Station	Aquator Time Series
23004	South Tyne	Haydon Bridge	South Tyne Catchment
23011	Kielder Burn	Kielder Burn	Kielder Catchment
22001	Coquet	Morwick	R Coquet Catchment
24009	Wear	Chester Le Street	Lower Wear Catchment

For the other catchment time series in Aquator the FF database was then interrogated to determine the geographically closest FF site to each of the catchments. Where there wasn't a FF site either on the same river or in close geographical proximity a site on a similar longitude was chosen as shown in table 6.3 below.

Table 6.3 Catchments using surrogate FF sites

Catchment Name	FF Station No.	FF Station
Burnhope Catchment	24009	Wear @ Chester Le Street
Catcleugh Catchment	23011	Kielder Burn @ Kielder
Colt Crag Catchment	22009	Coquet @ Rothbury
Cow Green Catchment	23011	Kielder Burn @ Kielder
Derwent Catchment	24005	Browney @ Burn Hall
Derwent Indirect Catchment	24005	Browney @ Burn Hall
Fontburn Catchment	22009	Coquet @ Rothbury
Hallington Catchment	22009	Coquet @ Rothbury
Honey Hill Catchment	24009	Wear @ Chester Le Street
Kielder Catchment	23011	Kielder Burn @ Kielder
Lower Tees Catchment	25007	Clow Beck @ Croft
Lune/Balder Catchment	23004	Sth Tyne @ Haydon Bridge
Mid Tees Catchments	23004	Sth Tyne @ Haydon Bridge
Mid Tyne Catchment	23011	Kielder Burn @ Kielder
North Tyne Catchment	23011	Kielder Burn @ Kielder
Pont Catchment	22009	Coquet @ Rothbury
Rede Catchment	23011	Kielder Burn @ Kielder
Tunstall Catchment	24009	Wear @ Chester Le Street
Upper Tees Catchment	23011	Kielder Burn @ Kielder
Upper Wear	24009	Wear @ Chester Le Street

6.3.3 Future Water Resources Plan Approach

We will further improve our approach to assessing the impact of climate change on our surface water resources. A full suite of rainfall-runoff models are being developed, for all catchments that are included in the Kielder WRZ Aquator model. These will cover the period from 1920 to date.

A Tier 2 analysis will then be carried out, which will use the UKCP09 climate change factors to perturb historic climate data in order to derive new river flow time series. It is felt this approach is more rigorous than that adopted for the draft plan, although it should be noted that no approach is perfect, and the drawback of using UKCP09 climate change factors is that it does not reflect the change in rainfall patterns over time, only the magnitude of change.

6.3.4 Kielder Resource Zone Results

The monthly change factors were applied to the four river flow time series in the Kielder Aquator model. Generally, the climate change scenarios are showing a predicted change in rainfall patterns with drier summers and wetter winters.

In total, 220 climate change perturbed time series were imported into the model, 11 for each of the catchment flow time series. The DO under each of the 11 FF climate change scenarios are shown in table 6.4 below with the associated change in DO relative to the baseline.

Table 6.4 Kielder WRZ Climate Change DO.

			Deployable Output (Ml/d)	Change from Baseline (Ml/d)	
Baseline (no climate change)			836		
Future Flows Climate Change Scenarios	1	FF-HadRM3-Q0_afgcx	835	-1	-0.1%
	2	FF-HadRM3-Q3_afixa	832	-4	-0.5%
	3	FF-HadRM3-Q4_afixc	830	-6	-0.7%
	4	FF-HadRM3-Q6_afixh	835	-1	-0.1%
	5	FF-HadRM3-Q9_afixi	840	4	+0.5%
	6	FF-HadRM3-Q8_afixj	792	-44	-5.3%
	7	FF-HadRM3-Q10_afixk	724	-112	-13.4%
	8	FF-HadRM3-Q14_afixl	771	-65	-7.8%
	9	FF-HadRM3-Q11_afixm	839	3	+0.4%
	10	FF-HadRM3-Q13_afixo	724	-112	-7.8%
	11	FF-HadRM3-Q16_afixq	840	4	+0.4%
Minimum climate change scenario DO			724	-112	-13.4%
Average climate change scenario DO			806	-30	-3.6%
Maximum climate change scenario DO			840	4	+0.4%

6.3.5 Scaling factor used to identify climate change over the planning period.

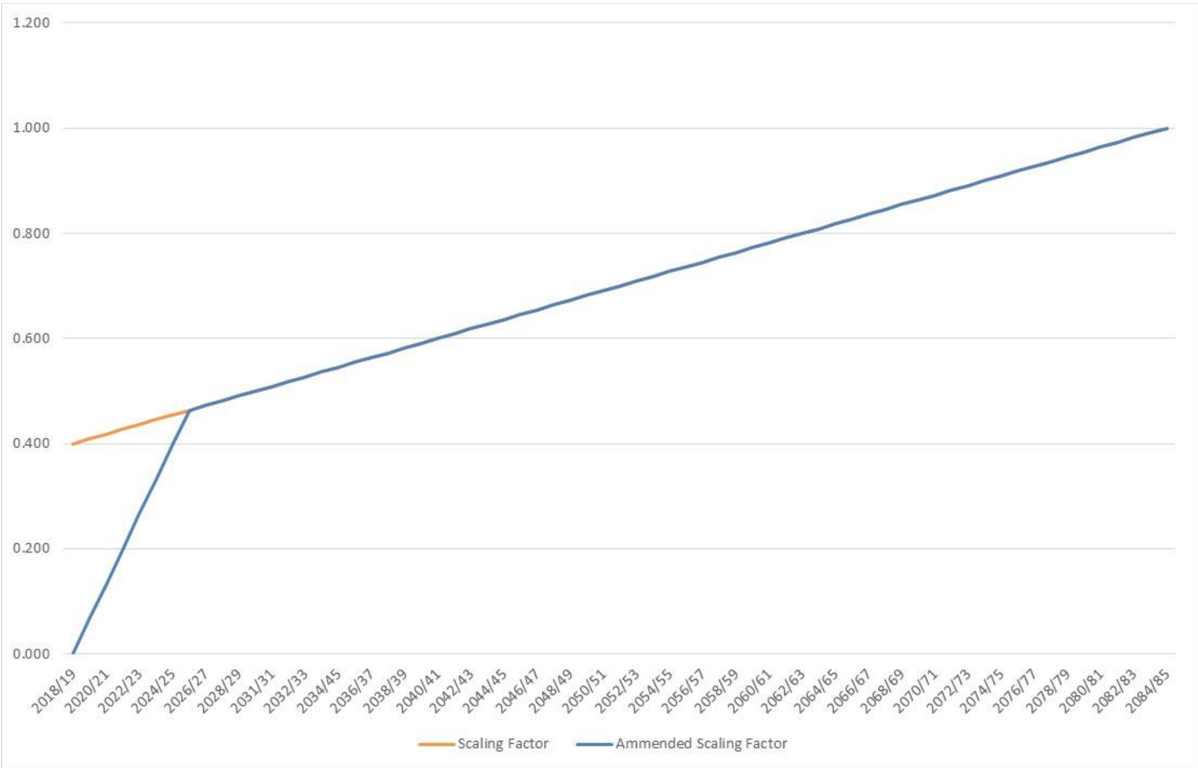
In order to analyse the impact of climate change on any year of interest, the effect of climate change in the 2080’s needs to be scaled back to base year to provide a change in DO for each year in the planning period. This also allows climate change uncertainty to be included in the target headroom assessment.

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:

$$\text{Scale factor} = \frac{\text{Year} - 1975}{2085 - 1975}$$

The year 2085 is required in the equation for the impact to be correctly scaled in the 2080s. This results in a loss of DO at the start of the planning period implying that climate change has already occurred in the base year.

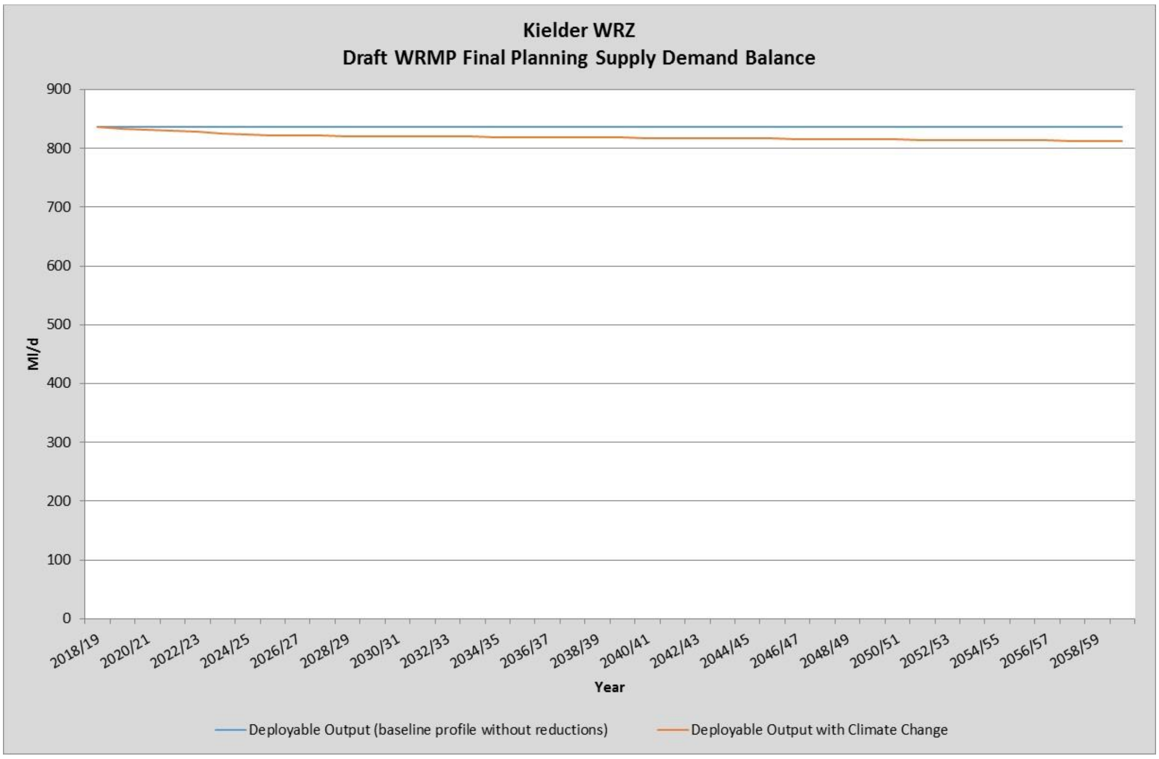
In order to take a more representative approach the scaling factor equation was used for 2025/26 onwards and pre 2025/26 the impact of climate change was scaled linearly from zero in 2018/19 to the impact calculated in 2025/26.



6.3.6 Climate Change Deployable Output

The Kielder WRZ appears to be relatively sensitive to reductions in summer flows, this is due to the fact that under the baseline scenario, during the design drought year, some reservoir levels are already extremely low and the decrease in summer flows means that the reservoirs empty prior to the winter refill period. High level assessment of the two worst case FF scenarios (FF-HadRM3-Q10_afixk & FF-HadRM3-Q13_afixo), suggest that a higher DO would be achievable with some minor alterations to the rules that govern the transfer of water between different zones in the model.

The climate change assessment indicates a reduction of 30Ml/d to the available DO in the Kielder WRZ in the 2080s. The graph below shows how DO changes over the planning period based on the scaling factor.



The impact of climate change on the DO of the Kielder WRZ is included in the supply demand planning tables.

The uncertainty of climate change impact on DO of the Kielder System is included in headroom. The required triangular distribution for the headroom calculation will use the minimum, average and maximum loss to DO from the figures derived.

6.3.7 Kielder WRZ Groundwater Climate Change Assessment

The impact of climate change on groundwater levels, and thus on the DO, was input into the DO calculations using the data from (AMEC, 2013). This report identifies the decrease in groundwater level in the Sunderland and Berwick areas in response to decreasing recharge as a result of climate change based on UK Climate Projections 2009 (taken from the UKWIR 2009 Rapid Assessment Report) which provides projections appropriate up to the 2030's.
For the Sunderland Groundwater Stations, the Sunderland Groundwater Model, developed on behalf of ourselves and the Agency by AMEC, identifies specific groundwater level reductions for each borehole. Where data are not available for a specific groundwater station, the value for the next nearest station has been used. Table 6.5 below shows the calculated reduction in water level.

Table 6.5 Reduction in water level in Sunderland GWS.

Sunderland Groundwater Station	Reduction in Groundwater Level (m)
Borehole 10	0.789
Borehole 11	0.789
Borehole 12	0.556
Borehole 13	0.835
Borehole 14	0.930
Borehole 15	0.940
Borehole 16	0.162
Borehole 17	0.162
Borehole 18	0.162

These new water levels were then used in the method to calculate DO as described in Section 3.1.3 above and produced no reduction in the DO of the boreholes as a result of the water level changes.

6.3.8 Berwick & Fowberry WRZ

For the Berwick and Fowberry WRZ, no groundwater model is available to undertake predictive calculations of the impact of climate change. In order to provide climate change predictions on groundwater levels in this area, a reduction of 1.4 m in the Berwick area and 1.0m for the Wooler area were estimated using Long Term Average recharge spreadsheet calculations.

Table 6.6. Reduction in water level in Berwick and Fowberry GWS

Berwick& Fowberry Groundwater Station	Reduction in Groundwater Level (m)
Borehole 1	1.0
Borehole 2	1.0
Borehole 3	1.4
Borehole 4	1.4
Borehole 5	1.4
Borehole 6	1.4
Borehole 7	1.4

Again these new levels were used to calculate DO and resulted in no reduction in output as a result of the changes.

The long-term groundwater level data we hold against which climate change calculations can be made have been quality checked in 2016, and converted to metres Ordnance datum to meet industry standard for groundwater level data. The long-term average (LTA) recharge spreadsheet calculations undertaken by Entec in the previous 2014 WRMP calculated the difference / percentage change in recharge from a baseline measurement. In the 2014 WRMP, data issues affected our groundwater level measurements but the Entec spreadsheet was calculated using Environment Agency groundwater level data for the Middle Ord borehole which were not affected by the data issues.

We recognise that the LTA recharge spreadsheet calculations represented the best available methodology to calculate the effects of climate change at the time (2014 WRMP). However, it is clear these calculations do not follow industry best practice and so we have undertaken a commitment to produce a numerical model for the Fell Sandstone that will allow the calculation of the effect of climate change on groundwater levels that meets industry best practice. We have awarded a contract to British Geological Survey (BGS) for completion in 2019. Any changes between the spreadsheet methodology used in the current WRMP and the results derived from the numerical groundwater model for the Fell Sandstone once this model is available will be reported in the WRMP annual review report.

6.4 Effect of Climate Change on Demand

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.

6.4.1 Methodology

The UKWIR Impact of climate change on 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 us the annual average demand criterion is the only one that applies to us, therefore this is the only set of rows that have been employed.
Table 6.7 below shows the river basin area and case study relationship chosen for each area.

Table 6.7 River basin area and case study relationship

Area	River Basin look-up table selected	Case Study relationship selected
North	Northumbria	Severn Trent

The Severn Trent case study relationship was selected for the North as the Severn Trent area is more rural than Thames and provides a better representation of the North.

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 2012-2040. 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 Per Capita Consumption (PCC)s 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).

6.4.2 Impact on Supply Demand Balance

After taking account of climate change on deployable output, both WRZs have a supply surplus across the planning period. Consequently, climate change is not driving any investment.

6.5 Carbon emissions from water operations

We report annually on the volume of greenhouse gas for which we are responsible and have 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 our 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 our Company-wide operational emissions by 2020.

The plan is based on a combination of actions to improve our efficiency in the use of energy, and the displacement of grid electricity by the development of renewable energy, in particular the use of biogas from sewage sludge and hydroelectric power generation.

The latest estimate of Greenhouse Gas (GHG) emissions for operational carbon as a result of providing drinking water to customers in our Northumbrian operating area is 46,902 tonnes CO2e. The Northumbrian region benefits from being able to use gravity in the provision of water services. Combined with effective energy management, the result is that the emissions intensity of the provision of water to customers is one of the lowest in the country at 191 kg CO2e/Ml. Only Thames Water of the larger companies has a lower emissions intensity, due to the way it accounts for the low carbon energy it sources from third party suppliers.

We expect emissions to continue to fall, partly as a result of our own efforts, and partly as a result of falling emissions linked to grid electricity. Most of our emissions result from our 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 as shown in table 6.8.

We have no projects for the further development of water resources in our plan, and no consideration of options or the carbon emissions resulting from them has been necessary.

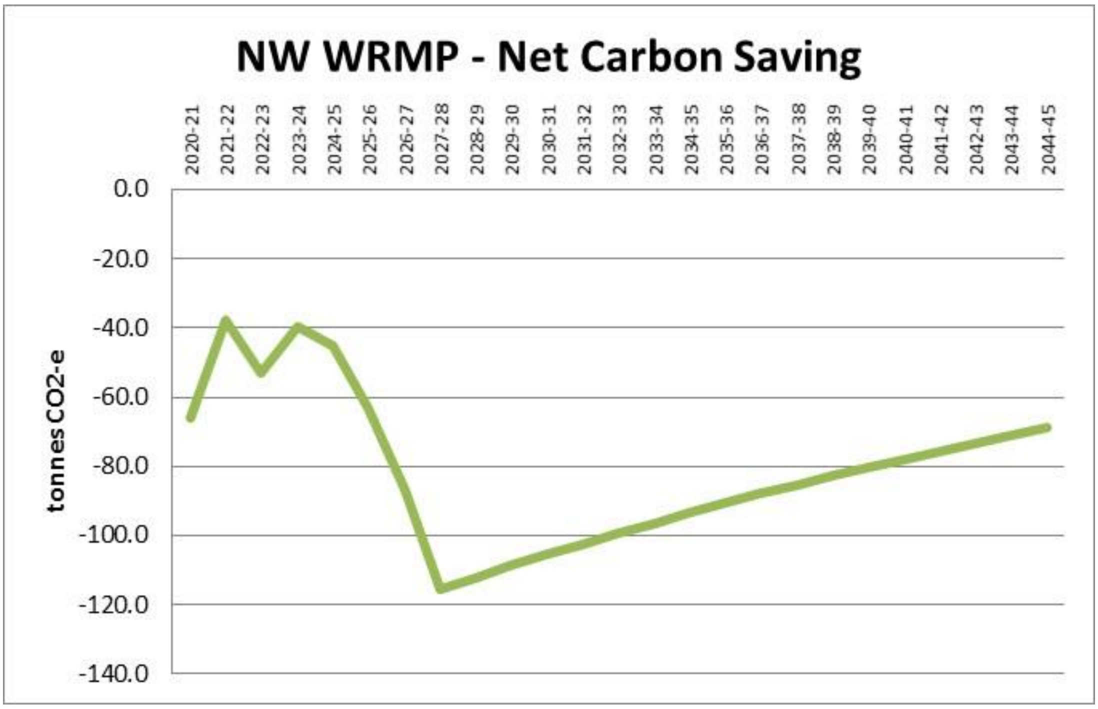
Table 6.8 Drinking Water Emissions Table

	2008	2017	2025	2045
Tonnes CO2e	52,370	46,902	22,600	12,900

6.6 The Impact of our Planned Actions on Carbon Emissions

We have provided in our Water Resources Management Plan a descriptive account of the environmental impacts of our planned actions, including those relating to carbon emissions. Here we set out the impact in quantitative terms.

Overall we expect to see our emissions increase over the period of the plan as a result of the actions we propose. How the emissions relating to plan will change over the period through to 2045 is shown in the chart below. Savings are viewed as positive; the negative figure indicates an increase in emissions. This will peak in 2027-28, then fall thereafter.



The overall increase is small, peaking at less than 120 tonnes CO2-e annually. To understand the small scale of this increase, our emissions for the water service for

NW were around 45,000 tonnes in 2017-18. The impact of the plan proposals adds less than 0.3% on the same basis.

However, any increase in emissions might seem surprising given that the proposals will reduce demand and with it the volume of water we need to supply. As such the projected increase requires explanation.

The main reason for the rise is that from 2018-19 there will no longer be any emissions linked to our use of electricity. This follows a switch in our energy supplier to Orsted who provide all their power from renewable sources.

Our emissions have fallen considerably since we first started routinely calculating these in 2008. Whilst some of this fall is due to actions we have taken to be more efficient in our use of energy, or through the development of low carbon renewable energy, much of this reduction has come from lower emissions linked to our use of grid electricity.

Grid electricity use has to date been by far the biggest single component of our greenhouse gas emissions. In recent years the emissions linked to each unit of electricity has been falling, as coal fired power stations have been replaced with cleaner gas and renewable power generation. This is set to continue and by the middle of this century the emissions linked to electricity use will be a small fraction of what they are today.

Some electricity suppliers are leading this switch to low emissions energy, which is a growing market in the electricity supply industry. In 2015, in order to encourage this growing provision, international and national reporting protocols were changed to allow purchasers of cleaner energy to reflect the lower emissions attached to it in their reporting, as long as the emissions were backed with certification of origin.

From 2018-19 we will adopt this ‘market based’ emissions factor approach, following a switch of supplier to Orsted, one of the companies leading the transition. As a result we expect the emissions linked to the provision in water in NW to be in the order of just 6,500 tonnes CO2-e this reporting year, then continue to fall through to 2027-28 when we expect to become carbon neutral. This is the point at which our operational activities no longer add to the problem of global warming. This change has a major impact on our estimate of the emissions impact of our water resources plan.

Although we have no supply side proposals in our plan, we will undertake a range of activities that will help to manage demand, under the three headings of leakage management, water efficiency and metering. For each of these areas we have assessed the impact of our proposed actions on the greenhouse emissions for which we are responsible.

Each of our proposed actions will deliver a saving in the volume of water we need to supply, and with that there will be a fall in emissions in the early years until we become carbon neutral. After that point any saving in water will not produce a reduction in emissions. Even in the early years of the plan the fall in emissions we will see will be a much smaller effect than had we continued to use the UK national grid emissions factor, because of the switch in our reporting approach.

Alongside this effect, with some of the actions there will be an increase in operational activity that might increase emissions. An example would be the employment of more technicians to find and fix leaks. Such staff will increase our emissions through their use of vehicles and vehicle fuel in carrying out their duties.

In each case the emissions linked to the action is changing over time. In the case of leakage technicians the development of cleaner vehicle technologies will mean that the emissions for a given level of activity will fall over time. We have made an assumption about the pace of this fall.

It is the effect in emissions terms of these two counter-acting factors that determines the projected emissions impact going forward, and results in the rise we expect to see. Had we continued to use the national grid factor our programme of work would have produced, in any year of the plan, a saving in grid related emissions of around twenty times the increase resulting from the work involved.

Emissions impact of each proposed measure

Within this overall context of the impact of our proposals on greenhouse gas emissions we can also quantify this for each specific measure proposed in our plan. There are no supply side proposals needed within the timeline of the plan. We do though have demand side proposals in the three areas of demand management, leakage management and metering. The way that these contribute to the overall carbon impacts previously set out is shown in the chart and table below.

The chart shows how each the proposed actions contributes to the change in overall emissions year by year. The table summarises this information for each future five year AMP period through to 2045.

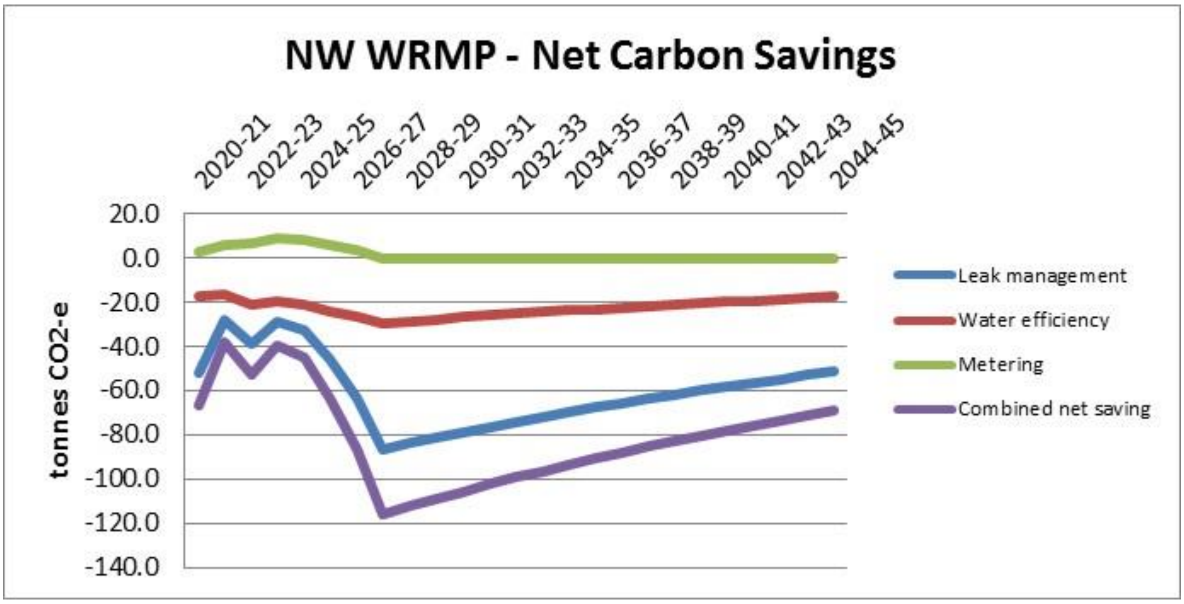


Table showing impact on GHG emissions of each demand side proposal

	AMP7 2020-2025	AMP8 2025-2030	AMP9 2030-2035	AMP10 2035-2040	AMP11 2040-2045
Leak management	-179.7	-360.5	-370.9	-318.5	-273.5
Water efficiency	-95.6	-136.1	-126.1	-108.3	-93.0
Metering	33.5	9.8	0.0	0.0	0.0
Combined net saving	-241.8	-486.8	-497.1	-426.8	-366.5

Valuing these carbon impacts

Alongside quantification of the impact in emissions terms we have also examined the economic impact of what we propose. Applying the latest projected carbon values published by UK government in line with the Treasury Green book there is a progressive rise in the carbon cost of the proposed programme of work. That said, by 2045 the carbon cost of the programme remains small, not even reaching £13,000 a year by the year 2045. Unsurprisingly, the value of carbon has no impact on decisions relating to the WRMP. This is true both in overall terms and for each of the proposed measures.

6.7 The Impact of Climate Change on the Proposed Measures

As well as examining how our proposals will impact on the greenhouse emissions that drive climate change, we have also considered what the implications for climate change might be on our proposed actions. We have looked at the potential impact on each of the demand side measures we propose on demand management, leakage management and metering.

Both for demand management and for metering we identify that any changes in climate will have no impact at all on our proposals. The actions we are taking are independent of any climatic effects.

Climate change may have an impact on future leakage, but no allowance has been made for this in this plan. The reasoning behind this assumption is set out below.

The predicted future climate is one of hotter drier summers and warmer wetter winters. More frequent and severe droughts are also expected. This has the potential to lead to changes in ground movement in clay based soils, which in turn can have an impact on burst frequency and leakage. In summer this movement is likely to increase burst frequency and leakage. Warmer winters will mean that freeze-thaw events causing ground movement will be less frequent. This means that burst frequency and leakage in winter is likely to fall.

This understanding is based on work undertaken in 2009 (Making the Earth Move: Modelling the impact of climate change on water pipeline serviceability by Goodchild, Rowson and Engelhardt). This established a relationship between burst frequency and actual evaporation, daily rainfall, minimum grass temperature, and soil moisture deficit. A change in burst frequency implies similar changes in leakage.

However, this relationship only holds for asbestos cement and cast iron pipes in clay and loam soils. This pipe/soil combination is seen only across a small proportion of our network, a figure that is falling as these older pipes are replaced. With other combinations of pipe and soil there is no established effect.

The quantification of these impacts that act in opposite directions across the seasons is not straightforward. In the short run the changes in temperature and their impact on soils will be too small to have a significant impact. It is only towards the end of the plan period that the potential effect will be greater, though even here this impact will be mitigated as the proportion of polyethylene pipe in the network grows as cast iron and asbestos cement pipe is replaced.

The analysis undertaken suggests that in the Northumbrian region there would be a net reduction in bursts. The projected increase in summer bursts is more than balanced by a reduction in winter.

In this plan we have not included for this impact. Instead we have assumed that leakage will not be affected by this climate driven effect. There are two reasons for this.

Firstly, as yet we are also unable to quantify the impacts of two other proposed actions to lessen leakage. These are the development of innovative techniques and customer-focused activities, which are neither defined at this stage, or their impacts quantified. We have allowed for no impact of either of these planned actions in reducing leakage, and have made the assumption that they will not be affected by the changing climate.

This assumption feeds into the second reason in that the Ofwat target for leakage is no longer based on an assessment of what is an economic level of leakage where the marginal cost of additional management actions equates to the value of water saved. Instead a fixed target is set. We intend to meet this target by a range of actions. With two of these – the deployment of new pressure management schemes and the installation of new semi-permanent correlating noise loggers – we are able to estimate the impact. However, this is not the case with either innovative techniques or customer-focused activities.

Any further leakage reduction to achieve the Ofwat target that exists after taking these actions will be met by a change in the rate of mains replacement. This is scheduled to take place from AMP 9. The impact of changes in the climate will be one underlying driver that affects the scale of replacement work needed. The success of the innovative techniques and customer-focused actions is another.

However, the leakage levels seen will not change. Instead we will vary the extent of mains replacement needed, to the extent required to hit the leakage target. As a result we are able to assume that the level of leakage will not be impacted by climate change, although our responses in terms of mains replacement may be. This also means that there is no wider impact on supply and demand.

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 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.

For the PR14 WRMP we followed the 1998 UKWIR document 'A Practical Method for Converting Uncertainty into Headroom'. The methodology is based upon the identification of the principal uncertainties in the supply/demand balance assessment and assigning scores to each of these categories of uncertainty. The total score for the Resource Zone is then converted into a Target Headroom value.

A probabilistic approach to determining target headroom in both of our resource zones has been adopted for this periodic review, utilising the latest industry standard methodology produced in 2002 (UKWIR, 2002).
A description of the methodology, the results produced and their interpretation has been 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 2020/2021 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, subdivided into respective supply or demand side components indicated as follows:

Supply Side Headroom Components

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

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

The supply side components known as S1 (vulnerable surface water licences) and S2 (vulnerable groundwater licences), have been excluded as the Agency has stated that no allowance for the risk of sustainability reductions should be made in target headroom.

S3 (uncertainty of renewal of time-limited licences) has not been included. All of our time-limited groundwater sources (Fowberry, Stonehaugh and Allenheads) have been reviewed, there is currently no evidence of any negative environmental impacts at either Stonehaugh or Allenheads, as both these licences have been recently renewed until 2030 the assumption is that these will be renewed as required throughout the planning period. Observations on groundwater levels in the Fowberry area adjacent to the River Till indicate there is no impact on base flow of groundwater into the River Till associated with our groundwater abstractions in the area. Therefore, the assumption is that this licence will be renewed as required through the planning period. Two surface water licences are also time limited including Ovingham and Waskerley Airshaft. Only the emergency provision of the Ovingham licence is time limited although this does not factor into any DO calculation so is excluded from this target headroom assessment. Waskerley airshaft is a transfer of raw water from the TTT to Waskerley reservoir. As the water is abstracted from the tunnel, there are no environmental implications and the assumption is that this licence will also be renewed as required throughout the planning period.

S4 (Bulk imports) has not been included as there are no imports into either of our WRZs and S9 (Uncertainty of new sources) was not included as no new sources are required over the planning horizon.

Supply side components generally require the identification of individual groundwater or surface water sources, which are likely to be impacted. 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 us 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>

S5 All of our 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 was undertaken to determine the uncertainty of point and diffuse pollution at all of our groundwater sources. The Berwick boreholes have been included as at high risk of point pollution. Due to the ongoing investigations into nitrates, this transfers to a 1 in 50 year (2%) chance of losing 100% of the DO in any year over the planning period.

The calculation of the uncertainty of point pollution additionally made use of the number of petrol and diesel storage sites currently within the total groundwater protection zone of each groundwater source.

Impounding reservoirs were excluded from S5 due to the extremely low risk of pollution given the remote location and isolated nature of the catchments. River intake treatment works were also excluded on the basis that the Kielder WRZ is sufficiently resilient to allow a short term shutdown of the river intake WTW to allow any pollution to pass by the intakes.

The uncertainty of dead storage in reservoirs was also considered for inclusion within S5, but was not carried forward to the final analysis as the estimated levels of sedimentation in 2060 were not at a level that would restrict the use of any of our reservoirs.

S6 All of our groundwater and surface water sources are constrained by either:

- 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 of our groundwater and surface water sources was assessed for the impact of climate change. All sources determined as being potentially impacted were included in the uncertainty of impact of climate change on DO.

Demand Side Components

D1 The accuracy of distribution meters was used to determine the accuracy of sub-component demand data for each of our resource zones, 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 our water resource zones 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 our 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 our organisation 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® 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 our 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). 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.

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.

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.

When interpreting such Crystal Ball® trend charts it should be recognised that:

- Headroom uncertainty has been defined for all years within the planning horizon;
- The various certainty bands indicated are represented by all 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, we have recognised that this choice is important given that it reflects the level of risk we are 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 table 7.1 below.
Table 7.1 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. The 90th percentile has been chosen throughout the planning horizon as the basis for defining 'target headroom' for both of our resource zones.

We believe that the use of the 90th percentile across the planning horizon is justified due to the supply surplus being present in all WRZs and the target headroom remaining essentially constant or only increasing slightly over the planning horizon.

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. A sensitivity chart has been created for the planning period using the data from the end of each AMP, for each resource zone. This shows how the percentage contribution of each target headroom component varies over the planning horizon.

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.

7.4 Headroom Uncertainty Results

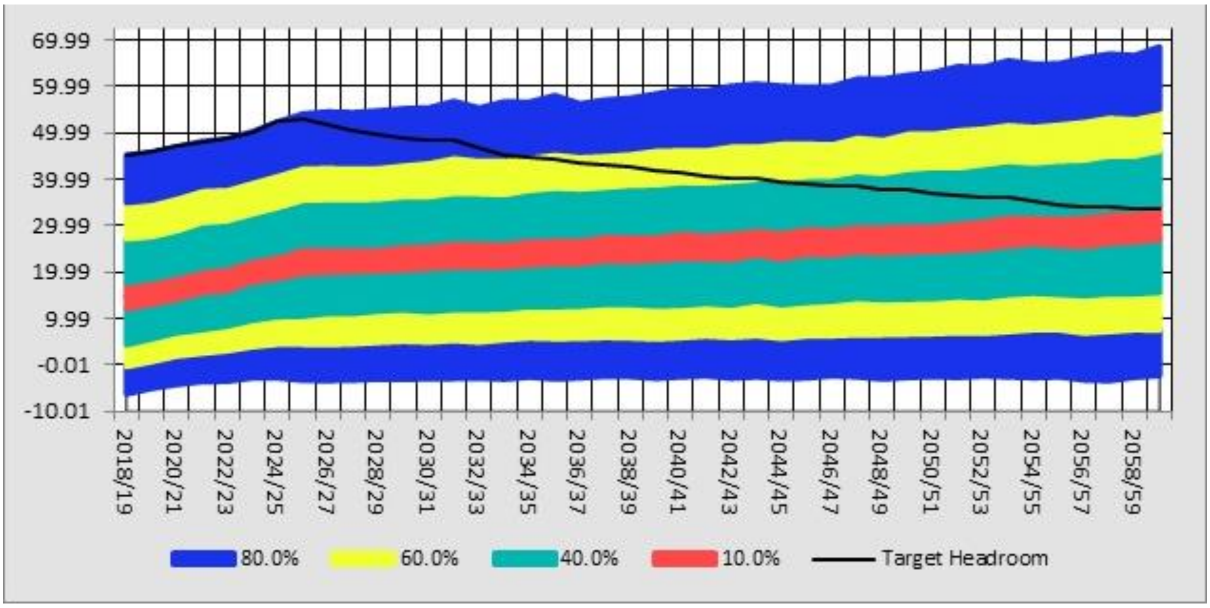
The results of the headroom assessment for each resource zone are indicated on the following pages, along with explanatory text.

7.4.1 Kielder Resource Zone

Using the chosen percentile (the 90th percentile in 2018/19 reducing to the 55th percentile in 2059/60) the target headroom ranges from 45.25Ml/d in 2018/19 to 33.53Ml/d in 2059/60. This represents 6.8% and 4.3% of WAFU in 2018/19 and 2059/60, respectively.

Figure 7.1 below shows how the uncertainty in headroom varies throughout the planning horizon, along with the chosen headroom values.

Figure 7.1.Kielder Headroom Uncertainty



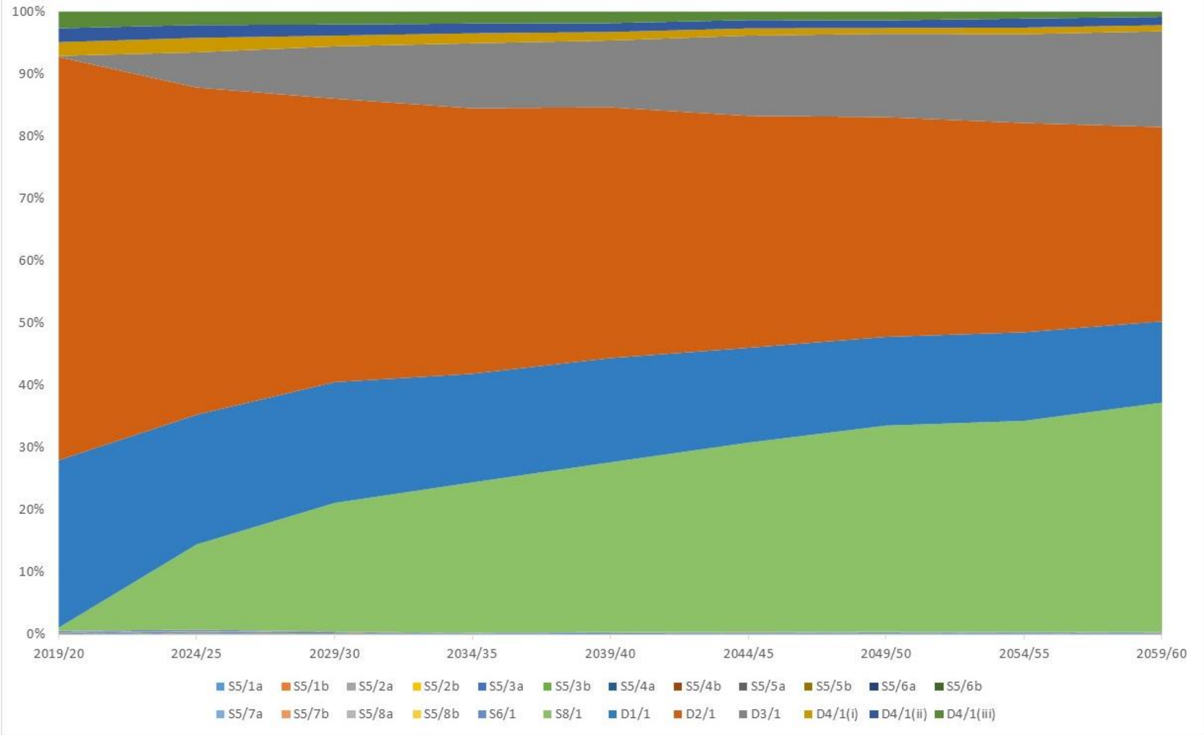
The gradual rise in uncertainty over the planning horizon is largely due to the increasing impact of climate change on supply side components.

At the start of the planning horizon demand forecast variation (D2/1) contributes the greatest proportion of overall uncertainty, with the significance of this component gradually decreasing from 65% in 2019/20 to 31% in 2059/60.

The significance of the uncertainty of supply and demand climate change components (S8/1 and D3/1) gradually increases over the planning horizon. The uncertainty of the impact of supply side climate change on the Kielder System increases over the planning horizon, from 0% in 2019/20 to 33% in 2059/60, and the uncertainty of the impact of demand side climate change on the Kielder System increases over the planning horizon, from 0% in 2019/20 to 14% in 2059/60.
The significance of the uncertainty of distribution input arising from meter inaccuracy (D1/1) gradually decreases over the planning horizon, from 27% in 2019/20 to 13% in 2059/60.

It is considered realistic that the components mentioned above are the most significant factors of uncertainty in the Kielder resource zone and are represented in figure 7.2 below.

Figure 7.2 Kielder WRZ Percentage Significance of Components

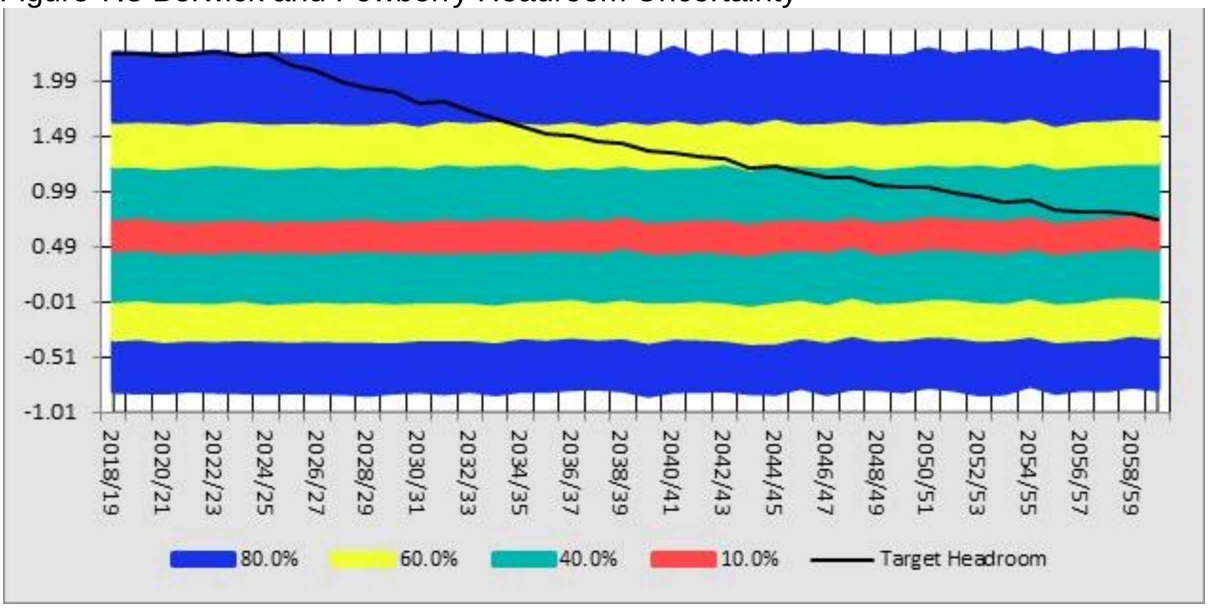


7.4.2 Berwick & Fowberry Resource Zone

Using the chosen percentile (the 90th percentile in 2018/19 reducing to the 55th percentile in 2059/60) the target headroom ranges from 2.24Ml/d in 2018/19 to 0.73Ml/d in 2059/60. This represents 19.3% and 6.4% of WAFU in 2018/19 and 2059/60, respectively.

Figure 7.3 below shows how the uncertainty in headroom varies throughout the planning horizon, along with the chosen headroom values.

Figure 7.3 Berwick and Fowberry Headroom Uncertainty

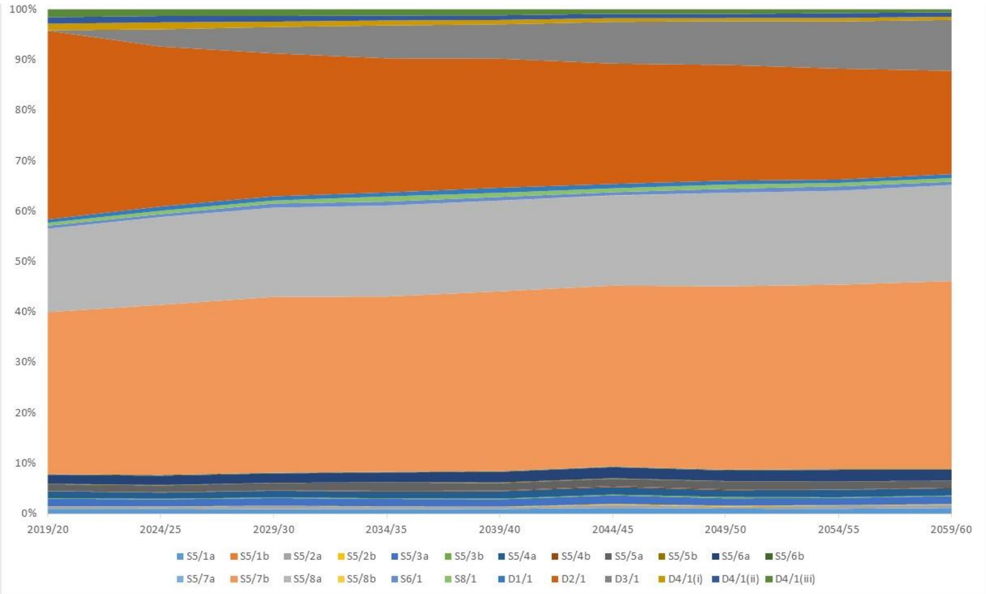


As can be seen the uncertainty over the planning horizon remains largely consistent.

At the start of the planning horizon demand forecast variation (D2/1) contributes the greatest proportion of overall uncertainty, with the significance of this component gradually decreasing from 37% in 2019/20 to 20% in 2059/60.
The significance of the uncertainty of the effect of climate change on demand (D3/1) gradually increases over the planning horizon, from 0% in 2019/20 to 10% in 2059/60.

It is considered realistic that the components mentioned above are the most significant factors of uncertainty in the Berwick and Fowberry resource zone and are represented in figure 7.4 below.

Figure 7.4 Berwick and Fowberry WRZ Percentage Significance of Components



7.5 Sensitivity Analysis of Climate Change

In the Kielder WRZ the difference between the headroom figures with and without the climate change components was found to be 18.3Ml/d in 2059/60, this is due to the increasing impact of climate change on source yields in the WRZ.

In the Berwick and Fowberry WRZ the difference between the headroom figures with and without the climate change components was found to be negligible, this is due to there being no impact of climate change on source yields, and only a minimal effect of climate change on demand in the WRZ.

The impact of climate change on the baseline supply demand balance is explained in more detail in chapter 8.

7.6 Comparison with 2014 Periodic Review (PR14)

Table 7.2 below provides comparison between the above results for PR14 and those determined for PR19:

Table 7.2 Target Headroom Comparison

Zone	Target Headroom (Ml/d)			
	PR14 base year	PR19 base year	PR14 end of planning horizon	PR19 end of planning horizon
Kielder	13.1	45.25	32.4	33.5
Berwick & Fowberry	0.72	2.24	0.75	0.73

The target headroom in the base year for each resource zone is higher for PR19 than PR14 for both water resource zones, this is due to utilising the more recent UKWIR guidance for this WRMP.

7.7 Options for Reducing Uncertainty in Planning Period

We believe that our approach to catchment management (see Section 3.11) will help reduce uncertainty in the planning period. Working in partnership with others, we believe it can reduce the risk of gradual pollution in the vicinity of our groundwater sources.

We will always use the latest information and data when preparing our supply and demand assessments.

Climate change remains a significant uncertainty. We will use the recently released PR24 guidance for completing our PR24 WRMP climate change assessments.

Demand variation is largely due to customer behaviour. However, our ambitious water efficiency programme aims to reduce pcc over AMP7 and beyond and further improve our already excellent understanding of water use.

8.0 BASELINE SUPPLY DEMAND BALANCE

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 Water Resource Zone (WRZ)s. 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, a 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;
- any sustainability reductions and other reductions on Deployable Output (DO) have been assumed as highlighted in Section 3;
- the demand forecasts include the assumptions on water efficiency savings from our 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.

8.1 Kielder Water Resource Zone

Figure 8.1 below shows a gentle decreasing trend in WAFU. This is due to climate change reducing the DO of the surface water treatment works due to licence constraints.

Figure 8.1 Supply Demand Balance – Kielder WRZ

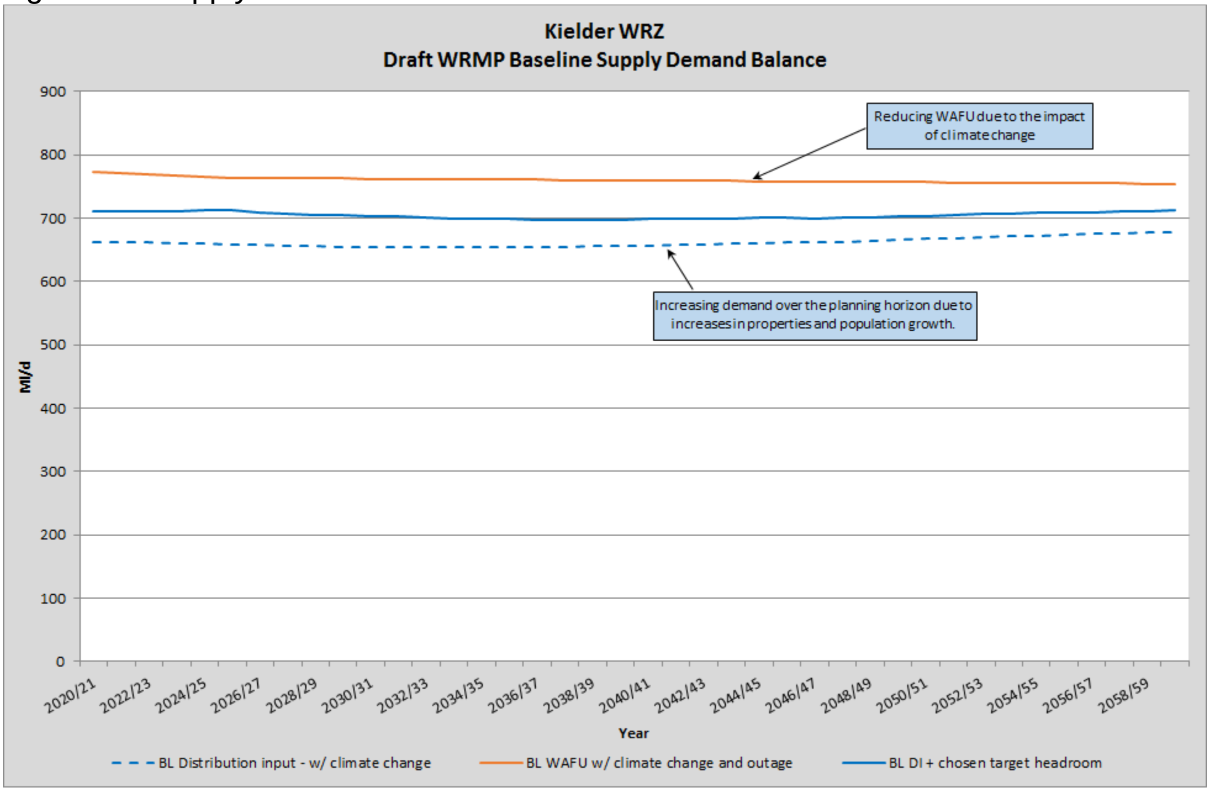


Table 8.1 Kielder WRZ Supply Surplus

Kielder 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)	94.55	87.77	89.07	88.60	84.59	78.31	55.36
Balance of Supply (including headroom)	48.72	35.42	40.12	43.67	42.85	39.06	21.84

Given the supply surplus, no supply schemes will be required.

8.2 Berwick and Fowberry Resource Zone

Figure 8.2 below shows WAFU remaining relatively level.

Figure 8.2 Berwick and Fowberry WRZ Supply Demand Balance

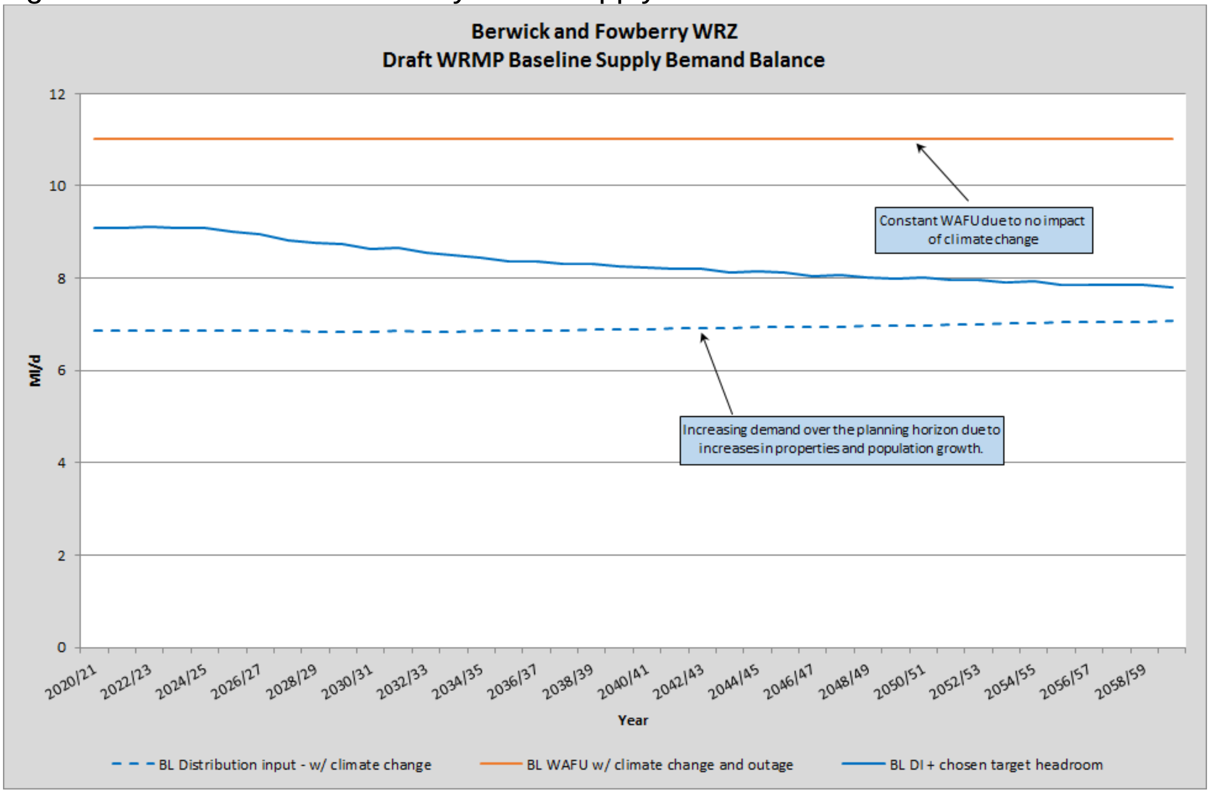


Table 8.2 Berwick and Fowberry Supply Surplus.

Berwick and Fowberry 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)	4.15	4.15	4.15	4.15	4.15	4.15	4.16
Balance of Supply (including headroom)	1.92	1.93	1.93	1.90	1.94	1.93	2.02

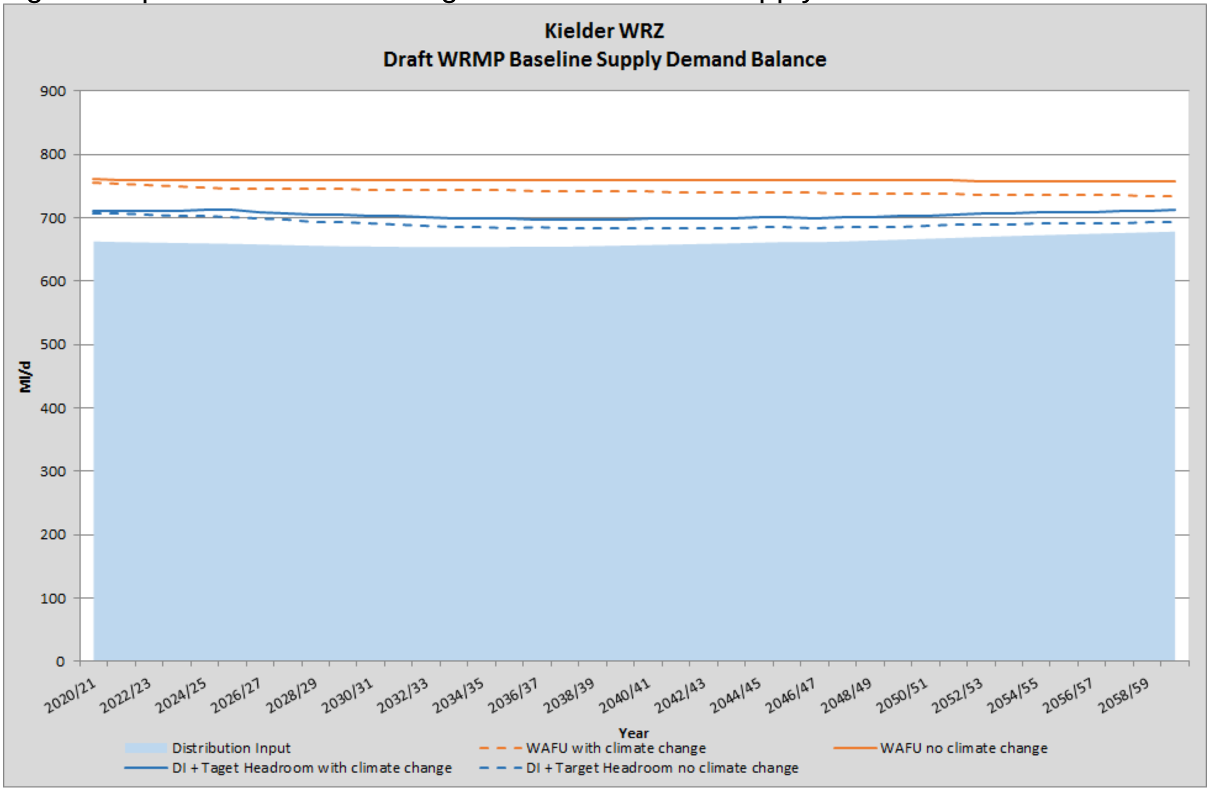
Given the supply surplus, no supply schemes will be required.

8.3 Impact of Climate Change on the Overall Supply Demand Balance

8.3.1 Kielder Water Resource Zone

As explained in the Climate Change section above the impact on the Kielder Zone is minimal with an estimated reduction in DO of 2.8% in 2059/60, therefore if climate change is not included in the supply demand balance calculation it would result in an increase of 41.7Ml/d to the surplus value in 2059/60. This is shown in Figure 8.3 below.

Fig 8.3 Impact of Climate Change on Kielder WRZ Supply Demand Balance



8.3.2 Berwick and Fowberry Resource Zone

The assessment of the vulnerability within the Berwick and Fowberry zone to climate change is low. Current information does not allow a detailed analysis of the effect of this on the performance of the aquifer, however based on the evidence of climate change on the remainder of our area of supply and the level of surplus in the zone we would not expect that climate change would affect the ability to supply water in the zone.

8.4 Sensitivity to Climate Change on the Baseline Supply Demand Balance

8.4.1 Kielder Water Resource Zone

There is no significant difference in the supply demand balance between the scenarios with or without climate change.

8.4.2 Berwick and Fowberry Water Resource Zone

There is no significant difference in the supply demand balance between the scenarios with or without climate change.

9.0 OPTIONS APPRAISAL

The supply demand balance demonstrates a surplus of supply for both Water Resource Zones over the planning horizon through to 2060. As such there are no plans to develop new water resources and therefore there are no resource schemes to appraise and no demand actions beyond our proposed water efficiency, leakage and metering strategies.

The options appraisal for our demand management schemes is presented in Appendix 3.

10.0 FINAL WATER RESOURCES STRATEGY

10.1 Final Planning Supply-Demand Balance

10.1.1 Overview

We have carefully followed the WRPG and believe we have 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 our 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 Kielder WRZ

The baseline supply demand balance graph for the Kielder WRZ showed that a supply surplus was maintained across the full planning period.

The final plan supply demand balance shown in Figure 10.1 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 our final plan water efficiency and leakage strategies.

Figure 10.1 Kielder WRZ Draft WRMP Final Planning Supply Demand Balance

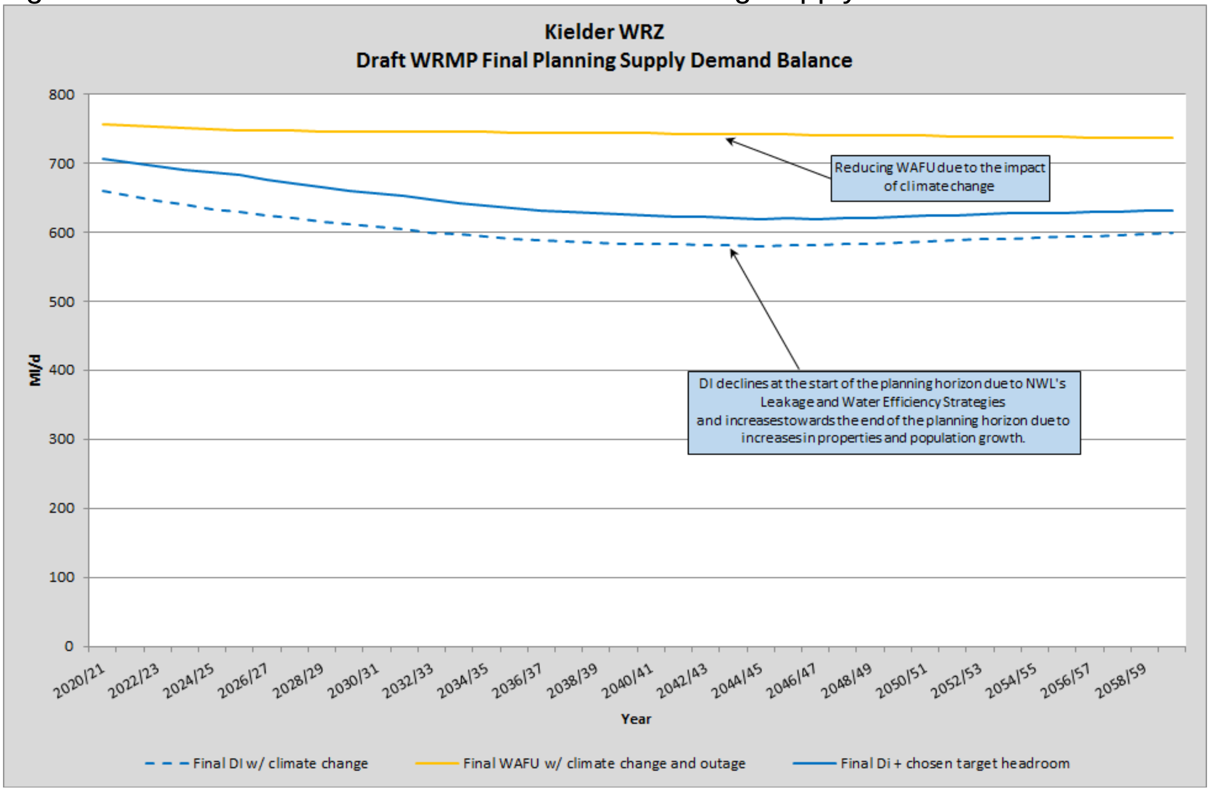


Table 10.1 Kielder WRZ Draft WRMP Final Planning Supply Surplus

Kielder 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)	94.49	97.10	101.69	105.99	158.76	159.29	137.40
Balance of Supply (including headroom)	48.66	50.10	53.55	57.26	117.02	117.67	103.88

10.1.3 Berwick and Fowberry WRZ

The baseline supply demand balance graph for the Berwick and Fowberry WRZ showed that a supply surplus was maintained across the full planning period. The supply surplus in the final plan supply demand balance shown in Figure 10.2 below is slightly higher reflecting our final plan water efficiency and leakage strategies.

Figure 10.2 Berwick and Fowberry Draft WRMP Final Planning Supply Demand Balance

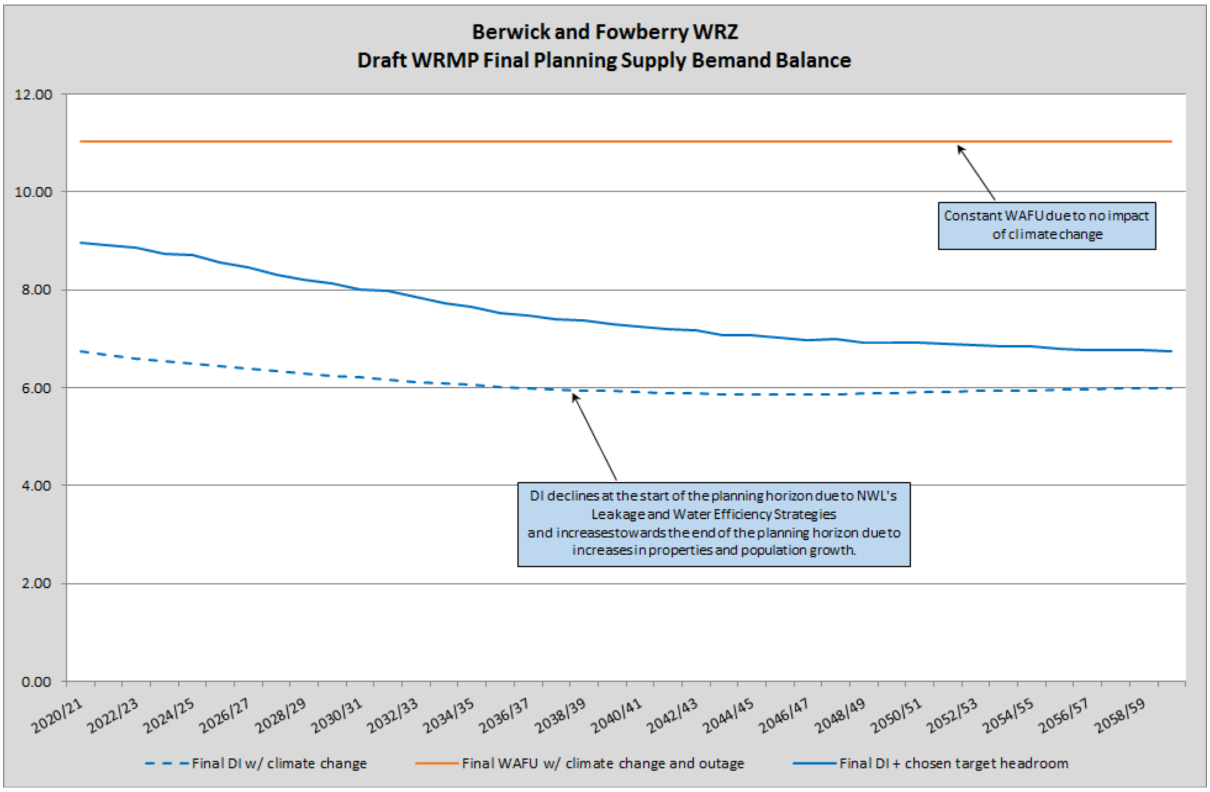


Table 10.1 Berwick and Fowberry WRZ Final Planning Supply Surplus

Berwick and Fowberry **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)	4.21	4.27	4.34	4.42	4.49	4.54	4.59
Balance of Supply (including headroom)	1.98	2.05	2.12	2.17	2.28	2.31	2.45

10.2 Water Framework Directive Water Body Deterioration Risk

10.2.1 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 (the Agency) 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 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 our 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.

Kielder WRZ

Our dry year distribution input in 2020/21 is forecast to be 660.50 Ml/d and calculated to fall by some 6% to 617.42 Ml/d by the end of the 25 year planning horizon. Further calculations show it to rise to 637.26 Ml/d by 2059/60 still below the current value.

Berwick and Fowberry WRZ

The dry year distribution input for 2020/21 is forecast to be 6.75 Ml/d falling to 6.25 Ml/d by 2045/46 and similar to Kielder increasing by 2059/60 to 6.50 Ml/d again still below the current value

10.2.2 Summary

Baseline distribution input forecasts for both the WRZs indicate that distribution input will fall during the statutory minimum 25 year planning period. Consequently, we conclude that there is not a risk of Water Framework Directive (WFD) water bodies in these WRZs deteriorating as a result of our abstractions.

11. SENSITIVITY TESTING

11.1 Overview

The Water Resources Planning Guideline requires us to assesses the sensitivity of our supply surplus to future uncertainties using scenario testing.

The resilience of our Plan to droughts is considered in detail in our Supply Assessment in Section 3 while flood risk and freeze / thaw events are considered in Section 2.11 In these sections of the WRMP, we conclude that we are resilient to drought, freeze / thaw events and to flooding and so these events are not considered further in this section.

11.2 Sensitivity to Indicative Sustainability Reductions

The Water Resource Planning Guidelines (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.

Our WINEP3 includes 7 Sustainable Change investigations in the Kielder Zone which will investigate alterations to compensation releases from a number of our impounding reservoirs. Currently there are no values placed on these changes so the effects cannot be assessed. With regards to reservoir storage, with the exception of Waskerley, we believe these changes overall will be neutral and will not affect our DO. In the case of Waskerley, the introduction of a compensation flow does alter the works DO and therefore we have applied for an increase in licence at Waskerley Airshaft to mitigate against the water lost to compensation. These flow variations are all subject to trials and part of the WINEP programme is that in discussion with the EA we undertake adaptive management on the releases by altering them as a result of any findings from monitoring which will be undertaken throughout the AMP7 period. We will report on the progress of the continued trials in the Annual Review of the plan.

Although not part of any sustainable reduction the alterations to the use of the Pont have already been modelled and taken into account in the production of the Kielder DO total.

In Berwick the ongoing investigation will determine our licensed abstraction limit which is currently assumed to drop to 9.5 Ml/d. Given that the DO for Berwick is not licence constrained this reduction will not affect the supply demand balance.

12.0 SUMMARY

12.1 Summary

A supply and demand forecast has been prepared for each of our Water Resource Zones (WRZ) for the following scenarios:

- Worst historic drought; and
- A drought with a return period of 1 in 200 Years.

Our final plan confirms that a supply surplus will be maintained under both scenarios in both of our WRZs across both the statutory minimum planning period (25 years to 2045) and the full planning period (40 years to 2060) which we have considered in this plan.

We have concluded that the volume of water we forecast we will need to abstract over the planning period will not lead to deterioration in the status of the water bodies from which we abstract. This is in part due to the demand savings and reductions in network losses that our water efficiency and leakage strategies will respectively bring.

12.2 Works Between Draft and Final Water Resources Management Plan

Once indicative values for the changes in compensation flows from some impounding reservoirs in the Kielder WRZ which are included in WINEP have been obtained we will assess the implications on DO although it is not anticipated there will be any negative implications.

We recognise that an improved approach is required to assessing the impact of climate change on its surface water resources. Therefore, a full suite of rainfall-runoff models are being developed, for all catchments that are included in the Kielder WRZ Aquator model, these will cover the period from 1920 to date will be developed between the draft and final Plan.

12.3 Annual Review of this Water Resources Management Plan

Once published, this WRMP will be reviewed annually in line with the Agency's guideline. All appropriate out turn data (for example, leakage, metering, abstraction and progress with implementing the WINEP) will be reported. We will consult with the Agency should we wish to make any material changes to our plan.

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APPENDICES

APPENDIX 1: 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 our Water Resource Zones (WRZ)s and also provides information for organisations to understand and appraise the plan.

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 our resource zones. The tables have been provided on CD to regulators in the first instance.

Copies of these tables are available on request.

APPENDIX 2: SECURITY INFORMATION

This draft WRMP has been independently security checked for us by our Security Certifier from Jacobs and was also subject to final approval by DEFRA prior to release into the public domain.

As a result of this process no information was removed from the WRMP.

APPENDIX 3: DEMAND MANAGEMENT OPTIONS APPRAISAL

Separate document.

APPENDIX 4: MAPS

For security reasons, detailed mapping is only available upon request to Defra and its agencies.

Appendix 5: DEFINING DRY YEAR FACTORS TECHNICAL REPORT

Available on request:

waterresources@nwl.co.uk

Appendix 6: MICRO-COMPONENTS TECHNICAL REPORT

Available on request:

waterresources@nwl.co.uk

Appendix 7: POPULATION, HOUSEHOLD & PROPERTY FORECASTS

Available on request:

waterresources@nwl.co.uk

Appendix 8: STUDY OF WATER USE

Available on request:

waterresources@nwl.co.uk