Dŵr Cymru
Welsh Water

Final Water Resources Management Plan 2019

March 2019

dwrcymru.com

Table of Contents

Table of Figures

Table of Tables

Executive Summary

A. Introduction

i. Our Water 2050 Vision

Dŵr Cymru Welsh Water provide an essential public service to over three million people across most of Wales, and adjoining parts of England. We are the sixth largest of the ten regulated water and sewerage companies in England and Wales and are unique in that we are a not-for-profit business with no shareholders. This means we can focus exclusively on what is in the best interest of our customers.

We have a clear vision in Welsh Water, which is to earn the trust of our customers every day. This will not be achieved by great customer service alone but by also understanding our customers' needs and expectations and building future plans to meet these.

In May 2017 we presented our customers with our vision for the business and sought their views on our strategies to meet future challenges through our "Welsh Water 2050" consultation. After consideration of the comments received, in March 2018 we published our final Welsh Water 2050 document and have now also published our Business Plans for Ofwat's Price Review 2019. One of our most important functions is to ensure that our customers will always have sufficient water supply to meet their needs now and into the future and so we have set out a strategy of 'Enough Water For All' to achieve this. It is clear that having a reliable supply of water is important to our customers and that we should fully understand the capability of our systems including how we will respond to future trends.

Welsh Water's operating area

The factors that will impact upon the levels of water resource required to meet customers' needs are:

- Demographic and economic changes that affect water demand. We need to use the best available information to predict our customer's water use;

- Climate change which is recognised by Welsh Government's Future Generations Act as a significant challenge facing Wales. We need to address the potential impact of this within our Plan;

- Our environmental obligations, in the way that we take water from the environment, as an eco-system service. This is controlled through legislation to ensure that our activities are not environmentally damaging particularly during the driest years when the impact of abstraction can be at its greatest.

In line with our 2050 strategy, this Plan describes the water resources risks that need to be overcome between 2020 and 2050, whether this be from the balance between our ability to supply water against the demand from our customers, the need to invest in our water resource infrastructure to maintain resilient water supplies or to meet the expectations of our regulators and customers.

The investment needed to deliver improvements to meet these risks are presented in our Business Plan 2019 as part of the Office for Water's (Ofwat's) 5 yearly Price Review process. The outputs of the Business Plan are then delivered over the subsequent five year Asset Management Plan (AMP) period. For the 2019 Price Review (PR19) which will be delivered during AMP7 (2020 – 2025), Ofwat are separating the costs associated with each company's water resource function and are considering the cost associated with this to customers. Unlike previous Plans, we have taken a wider approach to identifying some of the key water resource infrastructure that we intend to improve to ensure that our strategic objectives are met.

ii. The Water Supply to our Customers

Over the last 25 years, the quantity of water we supply to our customers has reduced in a 'normal' year from an average of over 1000 million litres per day (Ml/d) to about 800 Ml/d today. About half of this is down to reduced leakage, the rest is due to reduced demand from heavy industry and our customers increasing appreciation of the value of their water supply and subsequent reduction in their usage. Around 80% of this demand for water is from the major cities and towns of south Wales around Cardiff, Swansea, Newport, Bridgend, Carmarthen and the surrounding Valleys.

Wales has a significant amount of rain: we estimate that our infrastructure captures only some 3% of the effective rainfall, leaving some 97% for the environment, compared to the South East of England where up to 50% is used for public water supply. Most of our water is supplied from our impounding reservoirs although we abstract significant volumes from our lowland river sources such as those on the Rivers Wye and Usk in south east Wales, the Rivers Tywi and Cleddau in south west Wales and the River Dee in north Wales. Groundwater accounts for less than five percent of our supplies at a Company level but at a local level, may be the whole supply.

On the face of it then, we should not have a water resources problem in Wales, however, for the reasons highlighted above, we need to look at the future pressures on our water supplies.

In the last 5 years we have worked towards meeting the requirements of a variety of new environmental obligations, such as the European Water Framework Directive and the Habitats Directive. These have driven new and much tighter standards which effectively require more water to be left in our rivers for the environment.

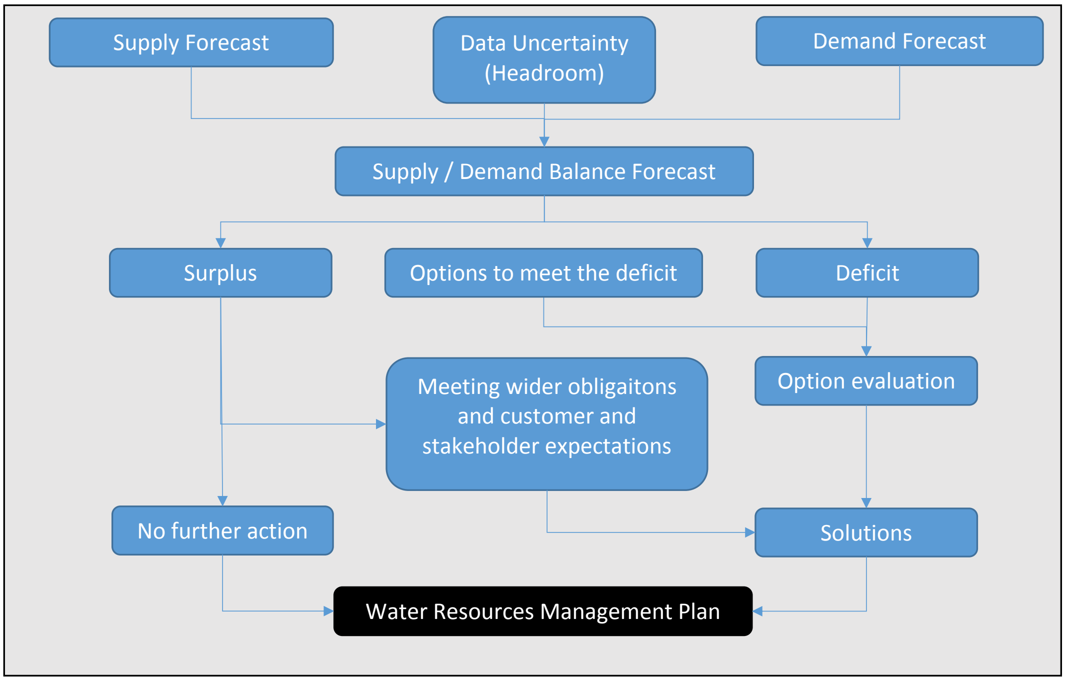
As a result, by 2020 improvements will have been made to over twenty of our sites to reduce their environmental impact. We continue to work closely with our environmental regulators to understand whether further changes to our operations are needed but we do not currently foresee anything significant over the next 5 years.

B. Objectives for the Plan

i. Zonal supply demand balances

For operational purposes we divide our water supply area into three regions; North Wales, South West Wales and South East Wales. However, for water resource planning purposes we further subdivide our regions into Water Resource Zones (WRZ). A WRZ is defined as the largest area in which all resources can be shared such that all customers, with some limitations, experience the same risk of supply failure.

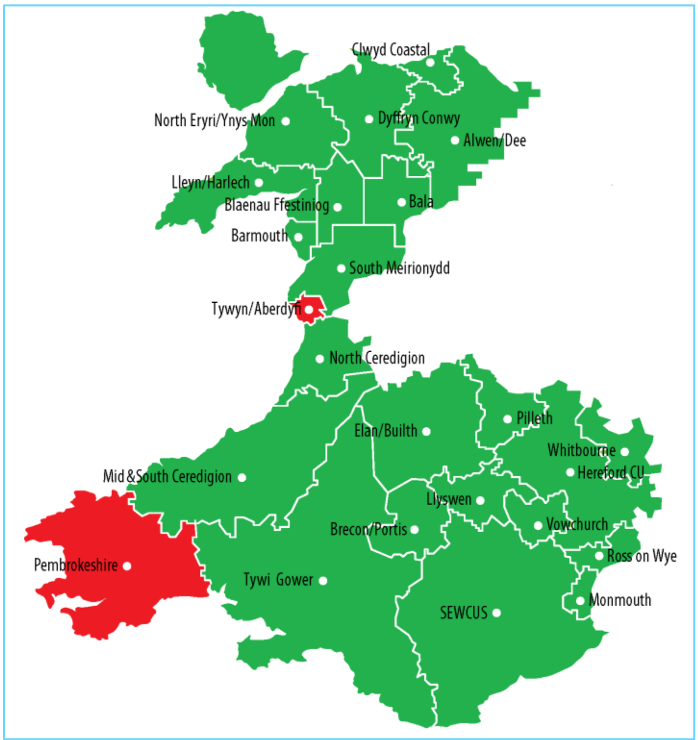
The basic approach to the water resource planning process is shown in the diagram below. In order to develop the Plan, we have projected the future demand for water from our domestic and business customers and leakage from our supply system. We then calculate how much water will be available from current sources in each water resource zone. Long term water resource planning is a complex process involving the analysis of large amounts of data that have varying degrees of certainty related to them. We therefore need an allowance for risk to account for the inherent uncertainties.



The Water Resource Planning Process

Our Plan demonstrates where we believe we have sufficient water to meet demand into the future and where we do not. Where the zonal supply demand balance, including uncertainty, shows a potential shortfall, the Plan identifies the options that either reduce demand or increase supplies to resolve the imbalance. The Plan puts forwards best value options by looking at the cost and benefits of options and support for these from our stakeholders and customers.

The figure and the table below show the Supply/Demand balance position for each water resource zone. There are two zones where we forecast a water resource deficit during the planning period, namely Tywyn Aberdyfi and Pembrokeshire.



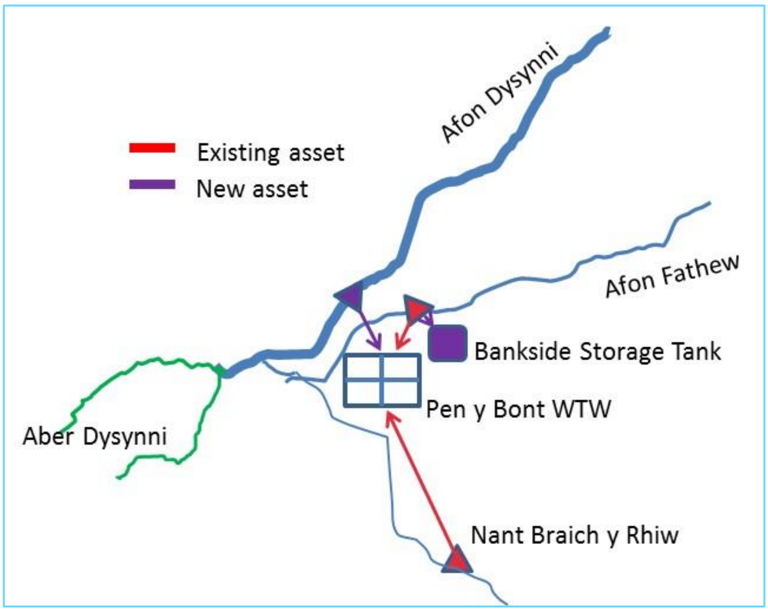
Water Resource Zone Supply Demand Position

WRZ	AMP7 Surplus Ml/d	2050 Surplus Ml/d
NEYM	9.0	12.9
Clwyd Coastal	2.0	6.6
Alwen Dee	3.0	9.7
Tywyn Aberdyfi	-1.1	-2.0
Bala	0.3	0.6
Blaenau Ffestiniog	0.3	0.6
Barmouth	0.0	0.0
Lleyn Harlech	3.4	5.6
Dyffryn Conwy	4.2	10.6
Sth Meirionydd	0.5	0.9
Ross	3.4	4.6
Elan	1.1	2.0
Hereford	9.5	15.7
Llyswen	1.6	2.0
Monmouth	0.7	1.4
Pilleth	0.4	0.7
Brecon	0.5	1.3
Vowchurch	0.0	0.4
Whitbourne	0.0	0.8
SEWCUS	27.4	98.1
Tywi	25.4	60.4
Mid & Sth Ceredigion	3.5	6.7
Nth Ceredigion	2.1	3.8
Pembrokeshire	-3.9	-6.6

ii. Tywyn Aberdyfi Water Resource Zone

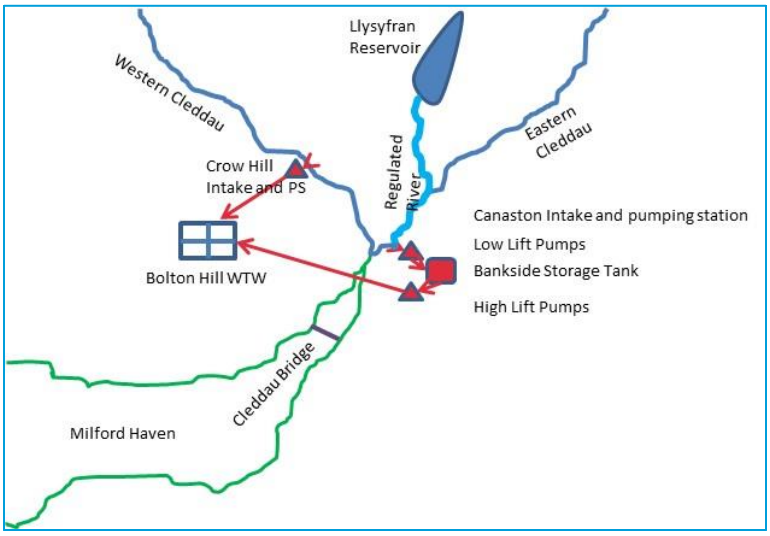
The Tywyn Aberdyfi zone is currently supplied from two small stream sources which feed the Penybont water treatment works (See figure below). New resilience analysis shows that the flow in these streams will not be able to meet demand during severe drought periods with a supply demand deficit reaching 1.1 Ml/d by the end of AMP7. There is also a risk of poor stream water quality during storm events which is predicted to cause treatment issues.

Our preferred solution is to construct a new abstraction point on the Afon Dysynni as this is the best value option which provides the volumes of water required for the lowest costs, with the least environmental impact, that will meet future demand needs. The Afon Dysynni is much larger than our existing sources and will be more resilient to severe droughts and the effects of climate change. It is proposed to support this solution with a raw water bankside storage reservoir to enable short term shut down of the stream sources. The overall scheme cost is estimated to be approximately £7.5 million.



iii. The Pembrokeshire Water Resource Zone

The Pembrokeshire zone is primarily supplied from Bolton Hill water treatment works. The main feed to the works is from the river abstraction at Canaston which is supported by regulation releases from the Llysyfran reservoir (See figure below). The supply demand position in Pembrokeshire will reduce significantly in 2018 due to Habitats Directive driven abstraction licence reductions. The zone falls into supply deficit in AMP7 with a shortfall of around 4 Ml/d by 2025.



The Pembrokeshire Water Supply System

The Canaston pumping station has fixed speed pumps and operation within the abstraction licence means that we over regulate the Eastern Cleddau River every time the pumps are on and release too much water from our Llysyfran reservoir. The installation of variable speed pumps will enable more efficient river regulation to preserve Llysyfran reservoir storage during critical dry years. This scheme was identified as the best value solution as it was by far the lowest cost option of those available that resolved the forecast deficit and provided additional resilience against climate change and severe drought. The estimated cost of this option is around £13 million.

iv. Water Resource Resilience

The long term supply demand balance is intrinsically linked to the level of service (LoS) supplied to our customers. If we anticipate that we might be unable to meet the demand for water during a drought we will put measures in place to limit demand. We have used measures such as hosepipe bans and non-essential use bans during the droughts of 1976, 1984 and 1989-90. How often we would put these in place is a measure of our water resource LoS and our customers accept that it is reasonable to impose such sanctions during a drought as long as this does not happen too frequently. Our current stated LoS is:

- Not to have a hosepipe ban (now called temporary water use bans) more than once in every 20 years (1-in-20), on average.
- Not to restrict water for commercial purposes (non-essential use bans limiting use of car washers, building cleaning, dust suppression etc.) more than once in every 40 years (1-in-40), on average.
- To never impose more extreme measures such as standpipes and rota cuts

We have sought the view of our customers who support this approach regarding hosepipe and non-essential use bans. Government is understandably keen for the industry to be able to assess what ‘never’ means for the imposition of more extreme drought measures. The industry is currently considering how to measure this and has asked water companies to make an assessment of the resilience of their water supply systems to more extreme droughts than has been witnessed within their records.

To help answer this question, we have used some innovative statistical methods to examine whether our supply systems could cope with a drought that might occur 1 in every 200 years. The result of this analysis is that we have some confidence that all but 3 of our water resource zones are resilient to a 1:200 year type of drought without resorting to extreme drought management measures. These are our Pembrokeshire, Tywyn Aberdyfi and Vowchurch zones. The solutions put forward to resolve the supply demand balance for the Pembrokeshire and Tywyn Aberdyfi zones will dramatically improve water supply resilience. We are proposing to increase the resilience in our Vowchurch zone.

v. The Vowchurch Water Resource Zone

We have assessed the susceptibility of the Vowchurch zone to severe droughts using an ‘extreme value’ statistical analysis and this indicates that the zone is not likely to be resilient to a drought event that might be seen in only 1 in every 200 years. This is worse than we have witnessed in our historic record which includes the droughts of 1976, 1984, 1989/90 and 1995. In such an event, we estimate that there is a possibility we might need to resort to extreme demand management measures such as rota cuts but we would only undertake such actions in this relatively small zone if our tankering operations were found to be inadequate.

Although the risk is low the impact to our customers in the area is unacceptable. We have asked for our customers views on the level of resilience that might be acceptable and they would be willing to pay for an improved level of resilience to droughts more severe than would be seen in 1 in 100 years.

There are limited options to resolve this issue and demand management efforts such as leakage reduction would not on its own resolve the situation. Our plan is therefore, to lay a main between our Hereford and Vowchurch zones to improve the situation. This would be at a cost of around £6m.

In addition, the Vowchurch site has been subject to environmental investigations and we are aware that the current abstraction licence is viewed at its limit of sustainability by the Environment Agency. We will look to ensure that we have a limited impact on the site under severe drought conditions through this improvement plan.

vi. Dry Weather 2018

May to July 2018 was a period of exceptionally low rainfall coupled with high temperatures with June being the hottest on record in Wales. This caused demands to increase to almost 20% higher than normal, peaking at over 1,000 Ml/d. Our water supply systems were severely tested but due to effective long and short term planning, customer supplies were maintained without the need to impose restrictions. This is in a year that arguably has been hotter and drier across our whole operating area than we have seen previously with Wales as a Country in developing drought for a prolonged period.

During this time we delivered 108 temporary capital schemes that have provided greater flexibility of our water supply systems, supported by a fleet of 40 tankers to both maintain supplies during peak demand periods but also latterly to preserve our supply side positions. There is a strong case for these infrastructure schemes to be made permanent to reduce the need for tankering and human intervention, which will enhance our drought resilience and this is proposed during the early part of our next investment period from 2020.

The benefits of these schemes will be incorporated into our next Drought Plan, due in March 2019 but the introduction of this new infrastructure will also support us to meet our 2050 strategy by reducing the number of water resource zones and providing greater flexibility in our conjunctive use within zones. This would result in the linking of the Barmouth and Lleyn Harlech zones to parts of the North Eyryi Ynys Mon zone, the Hereford and Vowchurch zones and the SEWCUS and Tywi zones.

The drought of 2018 has reinforced our understanding of the peaking in demand above normal levels during hot dry years and has provided additional data regarding reservoir and river inflows. Work now needs to be concluded to understand the context of the drought against other historical events. More importantly our drought plans need to take account of the raw water challenges we face against maintaining modern wholesome water quality standards as reservoirs empty.

We will undertake a review of the 2018 drought, using new modelling software and applying advanced statistical techniques, to understand how our supply systems performed and where there are any areas of risk. Our SEWCUS zone is a key area for review as we are mindful that when the new Habitats Directive abstraction licence conditions take effect, they will significantly reduce the amount of raw water resource available to us when compared to the volumes available this year.

vii. Asset resilience

a) Dam safety

Our dams are an essential component of the water resource system in the majority of our zones. These dams function to store water when readily available during the wetter part of the year, which is then used to meet water supplies during drier periods of the year. The full use of our dam assets is critical during the driest years when we aim to maximise available storage.

Many of our dams and the pipework and valves within them, are over 100 years old. They require ongoing and significant investment to ensure they continue to satisfy modern safety standards and maintain water resource resilience.

All of our dams under the Reservoirs Act receive regular investment and work to maintain them. These are ongoing activities into AMP7 and beyond for as long as the dam remains under the scope of the Reservoirs Act. These activities include;

- Routine and regular inspection, monitoring and surveillance
- Studies and investigations
- Routine maintenance to fixed assets and surrounding grounds
- Small scale works e.g. fencing, signage and improvement to provide safe access and egress

In April 2016 Welsh Government introduced amendments to the Reservoirs Act. These changes included reducing the threshold volume of the Act from 25 million litres to 10 million litres. This introduced additional dams and reservoirs to this regulatory framework. This legislative change also placed additional obligations on reservoir managers in the interest of public safety. Recent examples of changes in industry guidance include;

- Changes to the guidance which determines the hydraulic capacity of the dam spillways to ensure they are able to safely pass the design flows. *'Flood and Reservoirs Safety' 4th Edition, 2015;*

- New guidance to ensure the reservoir water level can be lowered at the required rate should there be an emergency incident. *'Guide to drawdown capacity for reservoir safety and emergency planning': Published 11 August 2017.* This will require over time, the replacement and upsizing of pipes and valves in many of our dams.

In response to the requirements of the amended legislation, plus continued advancements in new industry guidance and best practice, we need to make significant investments across Wales. We use the Risk Assessment for Reservoirs Safety Management guidance from Defra and Environment Agency, as the basis for establishing a Portfolio Risk Assessment for each Dam. The structured risk assessment process has been carried out on our dams using current industry best practice. It provides a risk based tool for prioritising investment decisions, as well as capturing the benefit of this investment by demonstrating a reduction in risk.

This ensures that we continue to target our investment to effectively reduce the risks at our dams, increase public safety and improve the resilience of the water resource system. We have developed programmes of work;

- To repair or replace dam spillways to ensure they can safely pass the design flows in accordance with the 2015 guidance - *'Flood and Reservoirs Safety' 4th Edition, 2015;*

- To refurbish and replace pipework and valves in dams to ensure we can continue to operate them safely – '*Measures in the interest of Maintenance' Reservoir Act amended April 2016*;

- To increase the size of pipework and valves to ensure we satisfy the 2017 guidance on emergency drawdown capacity - *'Guide to drawdown capacity for reservoir safety and emergency planning': Published 11 August 2017.*

We anticipate the need for more significant dam safety works during the AMP7 period, above and beyond our regular activities. We estimate that the cost of this investment in AMP7 will be circa £110m.

Without this investment we can expect regulatory notices requiring us to undertake works to meet our legal duties in the interest of dam safety and in many circumstances we need to lower the storage within our reservoirs prior to undertaking this work. Any reduction in reservoir storage within our WRZs has the impact of reducing our supply capability. Given the overriding importance of the water resource gained from our reservoirs we would either fall into a supply demand deficit in zones or have significantly reduced resilience to drought without this investment programme.

b) Water Quality

Welsh Water abstracts water for supply from 120 catchments covering an area of almost 11,000km². Land within these catchments is subject to a variety of land use types and management practices. We have limited land holding across the catchments and consequently we have little control of land activities. Modern land use with the use of chemicals presents an increasing risk to raw water quality and treatment challenges for our water treatment works. Our engagement with land owners is essential in our understanding of the risks we face but more importantly in the reduction of this risk through education and fostering of improved land management. We believe that a 'catchment as a first line of defence' approach is crucial to the future safeguarding of drinking water quality.

Our strategy therefore, is to maintain or improve the water quality in the catchments we rely on for our water supply so that our ability to supply water is not impacted. In response, we have instigated our 'WaterSource' initiative, the name given to our Catchment Management approach and are currently undertaking a number of schemes through co-creation partnering in line with Welsh Government's Well Being of Future Generations agenda. In AMP7 we will continue with this work including specific initiatives such as:

- Building Resilience into Catchment (BRICS – Eastern and Western Cleddau rivers)
- PestSmart – our pesticide disposal scheme and the Weed-wiper Partnership
- Tree planting to reduce landslip impact
- Promoting source 'Safeguard Zones' where appropriate
- Developing partnership working in the Brecon Beacons 'Mega Catchment'

Our investment in this area will increase in AMP7 to around £18m.

As well as working to improve the water quality within the catchments from which we take water we need to ensure that our water treatment works are resilient in delivering wholesome water to our customers. These assets require significant ongoing maintenance and investment so they can continue to provide the quantity of water needed to meet customer demands, whilst achieving ever higher drinking water quality standards. Any reduction in the performance of these assets will directly affect the water supply of our zones and leave us vulnerable during periods of high customer demand.

Of particular note within the SEWCUS zone is our project to replace up to five of our existing treatment works with a new larger works in the Merthyr Tydfil area. The existing works were originally built in the early part of the 20th century, and these ageing assets have difficulty in providing a good service in the face of deteriorating raw water quality. The current configuration also provides limited resilience to manage supply in the event of problems with poor raw water quality or drought.

We are therefore proposing to construct a new treatment works capable of supplying 350,000 households and businesses with water. The new works would consist of comprehensive and advanced treatment processes capable of treating water to current quality standards as well as being capable of meeting potential future regulatory changes and emerging new risks to drinking water quality. We will also reconfigure the existing pipeline network to feed the new treatment works from existing reservoirs and ensure treated water is supplied to the areas currently served by the existing works.

viii. Demand Management Strategy

We sought our customers and stakeholders views on our draft WRMP19. The comments received were supportive of our approach to demand forecasting, however they did challenge us to be more ambitious in our demand management strategy including leakage performance.

As a key part of our Innovation portfolio during AMP6 we have developed technology that has indicated that our understanding of the components of demand and more importantly the split between leakage and per capita consumption has changed. This has shown a greater proportion of leakage is on our customers pipework both in their homes and on their supply pipe and this has previously been allocated as distribution losses and per capita consumption. To tackle this we have set ourselves some challenging targets to reduce both leakage and customer consumption by taking a greater ownership of customer side losses through our Project Cartref initiative.

c) Leakage

In response we are developing a more innovative model for leakage reduction, approaching it in three ways; tackling upstream losses on trunk mains, on the distribution system through innovative methods, and a new focus on customer side losses. We will proactively identify leaks beyond the customer boundary which enables us to carry out repairs or replacements where required. Our investigations in AMP6 have shown that around 5% of all properties in Wales have some form of continuous water use, a significant proportion of which is likely to be leakage due to dripping taps and faulty toilet cisterns. This is far higher than previously thought and therefore has challenged us to rethink our historic leakage practices.

We will still base our activity on what is known in the water industry as a 'sustainable economic level of leakage' (SELL). This measure is based on the principle that the cost of reducing leakage rises significantly as the level of leakage reduces and that there comes a point at which the production of water is cheaper than the additional effort and cost needed to reduce leakage further.

Our recent analysis which is based upon new evidence, indicates that the economic level of leakage lies around 15% to 20% below the level we aim to achieve by the end of AMP6. We consider that a 15% reduction over the course of AMP7 is the appropriate level we should aim for due to the need to make significant changes to working methods and technology. We will use AMP7 to improve confidence in our cost – benefit analyses with a view to making further reductions in future. We will include a greater focus than ever before on customer side losses tackling leaking pipes and appliances within households through what we are calling our Project Cartref programme (meaning 'home' in Welsh).

In conjunction with Project Cartref we will continue with our policy of repairing leaking or damaged supply pipes for free and replacing lead supply pipes when they are found.

We have built this challenging leakage target into our baseline demand forecast within this Plan.

d) Water Efficiency

In its Water Strategy for Wales (2015), Welsh Government sets out how it will look to work with water companies to drive action and engagement on water usage and to promote the benefits of water efficiency.

We have also taken note of the responses received to our draft Plan consultation regarding the way we are able to influence our customers behaviour in encouraging the wise use of water, which over time can lead to lower impacts on the environment and lower water supply costs as less water is needed to be delivered. In this area, we are committing to a programme of schemes that will encourage our customers to take less water for their everyday use.

We plan to substantially increase spend on water efficiency initiatives in AMP7 in comparison to that in previous periods. In line with this investment, we have set ourselves challenging PCC targets as we believe that this will drive innovation and our own awareness that water efficiency should be brought into conversations with our customers wherever these arise. Our target is to reduce average PCC from 145 l/hd/day to 138 l/hd/day by the end of AMP7, with the longer term aspiration of a reduction to 100 l/hd/day by 2050.

We have built a framework of initiatives which we bring together where there are synergies geographically and or where we need to target effort in our least water resource resilient zones. A current example of this is our Rhondda Fach Resilient community's project where our zonal studies programme is driving significant water supply projects in a local area. We are engaging with the local community to raise awareness of the water supply projects and are also using this opportunity to engage on water efficiency.

Some of our key initiatives include; the building of efficiency messaging and education into our Cartref leakage initiative, an increase in our Domestic Audit Programme, to continue to deliver and improve upon our award winning schools outreach programme and to work collaboratively with developers and planners. We will ensure our own premises are water efficient through the implementation of the Waterwise Checkmark at all key sites.

We believe that communicating the right messages to our customers at the right time in the right way is important to building strong relationships to facilitate our collaborative projects. We underpin our engagement programmes with research to improve our understanding of relevant technological innovations, the behavioural economics driving water use, and appropriate communication channels. This ensures we are well placed to advise our customers and build on our reputation as a trusted service provider.

We will work with our customers to improve understanding of the value of water and reduce their demand by offering advice on water-saving devices and water harvesting. We will harness research to identify smart technologies to reduce water use for both domestic and business users, helping them to save money and improving the sustainability of our services.

ix. Water Trading

We believe water trading can play a part in supporting the economy, as long as it is done in a sustainable way. We support the position set out by the Welsh Government that water trading must benefit Wales and the people of Wales, and not jeopardise our own business and the customers we serve.

As part of the 2014 Price Review, Ofwat introduced water trading incentives to encourage water trading between incumbent water companies. Welsh Water's Trading and Procurement Code was approved by Ofwat in February 2016. The code is intended to provide reassurance that any trades we conduct will be in accordance with the code and that in contracting for the provision of water resources we will purchase from the most economical sources available, having regard to the quality, quantity and other relevant aspects. As part of our PR19 Business Plan submission we have produced our Bid Assessment Framework. This Framework confirms that we are open to receipt and assessment of competitive bids for the provision of solutions for our deficit water resource zones as set out in this Plan.

Our Plan shows that we are open and transparent when considering supplies of water to us from 3rd parties and support the use of competitive processes. The majority of our supply region has water surpluses making water exports more likely. Any potential export would need to comply with the following conditions:

- No water resource zones placed into deficit as a result of the export
- No impact on our ability to supply water during periods of drought
- No impact on our company's level of service
- The environmental sustainability of supply (no deterioration of raw water source)

With the potential to benefit customers and the wider Welsh economy we have scrutinised the plans of neighbouring water companies and the potential for water exports. We discussed potential high level options for export to Severn Trent Water and Thames Water but we have not reached the stage of agreeing specific terms as this will need further detailed work. Once this work is complete and if these are to be taken forward then we will discuss these options with Welsh Government and present these in our Final WRMPs.

We are also working with the Canal and Rivers Trust on a raw water export solution to support the Brecon & Monmouthshire canal during periods when their abstraction from the River Usk is restricted.

C. Conclusions and next steps

i. Governance

We have developed our Plan in line with Welsh Government Guiding Principles for Water Resource Planning and have worked closely with our regulators to ensure that we have met the guidance for developing our Water Resources Management Plan 2019.

In developing our Plan, we have engaged with our customers and other stakeholders so that their views are taken into account.

We have pre-consulted our regulators, local authorities, neighbouring companies and some other key stakeholders such as the Consumer Council for Water to seek their views on what they saw as the important factors to consider within the Plan. The consultation ran for 6 weeks from the 23rd January 2017 to the 7th March 2017.

We have worked closely with our key environmental regulators, Natural Resources Wales and the Environment Agency who will report back to Welsh Government and the Department for Environment, Food and Rural Affairs (DEFRA) on the efficacy of our Plan. This engagement has been through regular technical meetings and the use of method statements so that there should be no surprises in either our approach in meeting guidance or in the results of analysis presented.

In addition to our environmental regulators we have also sought the views of environmental organisations across Wales through the Independent Environmental Advisory Panel (IEAP) which Welsh Water set up in 2012. We have consulted this Panel during the Plan preparation and have presented them with initial results for discussion and comment.

We have publicly consulted with our customers and stakeholders on the draft Plan to confirm that our proposals meet with expectations, are based on robust methodologies and complied with relevant legislation. The consultation ran for 12 weeks from the 16th March 2018 through to the 8th June 2018 and in total we received 11 responses. Alongside this, we utilised the Welsh Water 'Online Community' to gain more in depth customer views on our proposals. We have amended our Plan in line with comments received.

ii. Environmental sustainability

We aim to provide water services in an equitable, sustainable and affordable way, based on regulatory control and environmental laws to ensure that environmental ecosystem services are preserved while at the same time ensuring customer wellbeing and economic development. The water resource planning process reflects this through a range of measures, including:

- The protection of environmental flows, via our environmental regulators' Catchment Abstraction Management Strategies process;
- The aim of achieving Good Ecological Status as required by the European Water Framework Directive;
- The protection of habitats and species of international importance via the enactment of the European Habitats and Birds Directives;
- The need to identify the least cost, most sustainable solution for maintaining a balance between supply and demand, taking account of carbon costs of schemes, and wider environmental issues via SEA and HRA; and subsequently to identify the best value option and,
- The statutory duty placed upon water companies to promote water efficiency and biodiversity. We have recently published our first Biodiversity Plan ("Making Time for Nature") which contains a range of targets that support this draft Plan.

iii. Assurance

Jacobs's consultants in their role as Company auditors have undertaken a compliance audit of our Plan against regulatory guidance and have fed back comments where our planning could be improved. This suggests that our processes are consistent with the WRMP guidelines, that the Plan adequately reflects the Welsh Government's guiding principles and Ofwat's key themes and that our processes incorporate an appropriate level of quality assurance.

The Plan has been presented to the Dŵr Cymru Board for approval. In terms of commitment to the Plan, the WRMP19 is fully reflected within our Water Resources and Network Plus PR19 Business Plans which have been submitted to Ofwat and are also on our web-site. These plans have also passed Board scrutiny.

1. Introduction

1.1. Dŵr Cymru Welsh Water

Welsh Water is proud to provide an essential public service to over three million people across most of Wales, and adjoining parts of England (Figure 1). We are the sixth largest of the ten regulated water and sewerage companies in England and Wales and are unique in that we are a not-for-profit business with no shareholders. This means we can focus exclusively on what is in the best interest of our customers.

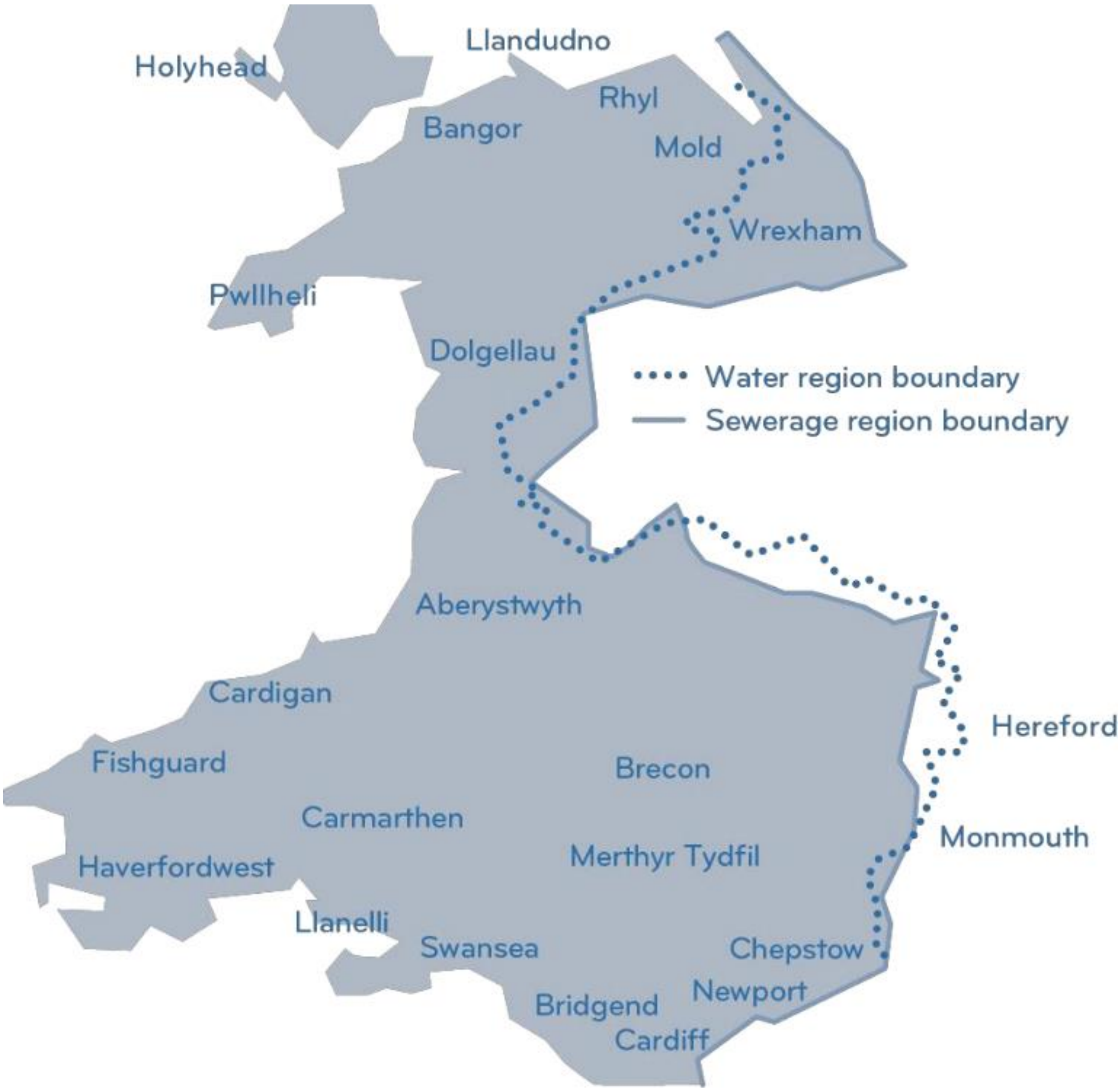


Figure 1 - Welsh Water's operating area

1.1.1. Our Company 2050 vision

In May 2017 we presented our customers with our vision for the business and sought their views on our strategies to meet future challenges through our "Welsh Water 2050" consultation Document. Our mission statement is "*To become a truly world class, resilient and sustainable water service for the benefit of future generations*". Following the consultation exercise, the final Welsh Water 2050 document now sets out our vision of what a truly resilient and sustainable water service might well look like in 2050. Figure 2 shows the development of "Welsh Water 2050" which identifies significant future trends over the next 30 years, how these will impact on us and our customers, and how they will be addressed through our 18 Strategic Responses.

Our customers expect us to anticipate future trends so that we can provide a resilient service, in the long term. In order to mitigate the challenges presented by future pressures, we have developed a series of strategic responses, which form a plan for action. Our Resilience Framework identified four ‘Resilience Pillars’ - “Safe”, “Smarter”, “Sustainable” and “Supportive”. One of the key actions identified under the “Sustainable” pillar is for Welsh Water to continue to undertake and review its water resources management plan. The WRMP19 therefore fulfils this requirement and helps support our aim of becoming sector-leading in our approach to resilience.

One of our most important strategic responses is to ensure that our customers will always have sufficient water supply to meet their needs now and into the future. This Water Resources Management Plan builds on our customer promises and describes how we plan to maintain a secure and resilient water resource position until 2050, taking into account the factors that we anticipate could impact on the provision of water supply. These trends include:

- Demographic change and changes to the economy;
- Environmental change;
- Climate change;
- Policy and regulatory change;
- Change in customer expectations.

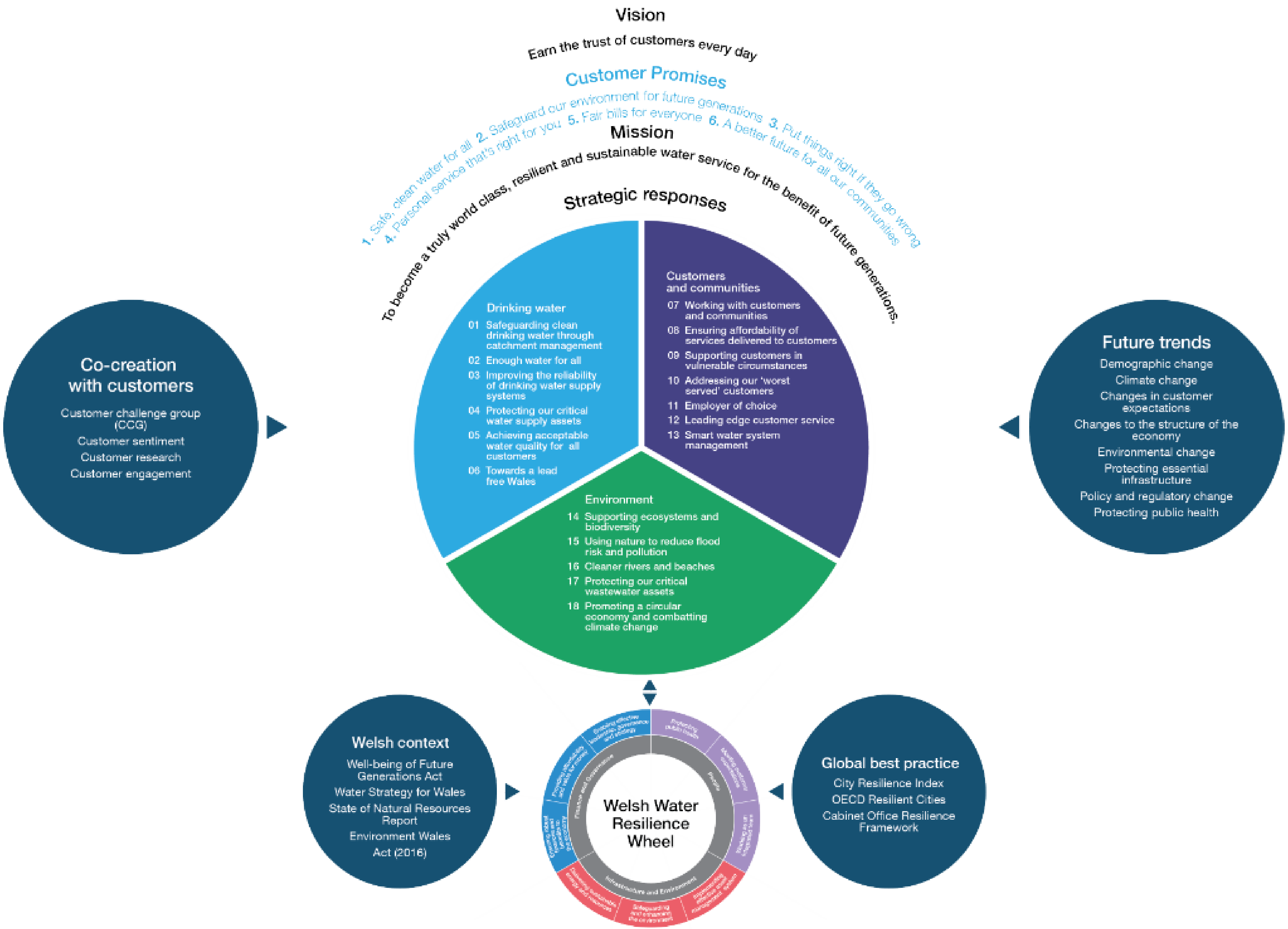


Figure 2 - Welsh Water 2050 at a glance

1.2. Water resources in our supply area

1.2.1. Introduction

We supply water and wastewater services to just over three million people. Around forty per cent are concentrated in the south east of Wales around Cardiff and Newport, with much of the remainder located in the main population centres around the coast. These are in sharp contrast to the sparsely populated areas of mid-Wales, where population densities are among the lowest in the UK.

Wales has a relatively wet climate when compared to other parts of the UK. We estimate that we only use some three per cent of rainfall, on average, for public water supply, which compares to fifty per cent in parts of South East England. However, the overall regional picture masks important geographical differences within our supply area: for example, at up to 3,000mm per year rainfall in Snowdonia can be more than four times the levels recorded in the border areas and Herefordshire, where 700mm per year is typical.

The diversity of our water supply systems reflects these regional variations, which can range from discrete small-scale local supplies, through to large scale multi-source integrated networks that are more typical of many other water company areas.

We operate a variety of water sources to supply our customers. Most of our water is supplied from our impounding reservoirs although we abstract significant volumes from our lowland river sources such as those on the Rivers Wye and Usk in south east Wales, the River Towy in south west Wales and the River Dee in north Wales . Groundwater accounts for less than five percent of our supplies at a Company level but at a local level, may be the whole supply.

1.2.2. Water resource areas

For operational purposes we divide our water supply area into three regions; North Wales, South West Wales and South East Wales. However, for water resource planning purposes we further subdivide our regions into Water Resource Zones (WRZ). A WRZ is defined as the largest area in which all resources can be shared such that all customers, with some limitations, experience the same risk of supply failure.

Figure 3 shows our 24 WRZs. The largest of these is our South East Wales Conjunctive Use System (SEWCUS) which encompasses some 40 per cent of our customers, and the second largest is the Tywi conjunctive use system, which covers another 24 per cent. By contrast, the eight smallest zones together cover just 1.6 per cent of our customers.

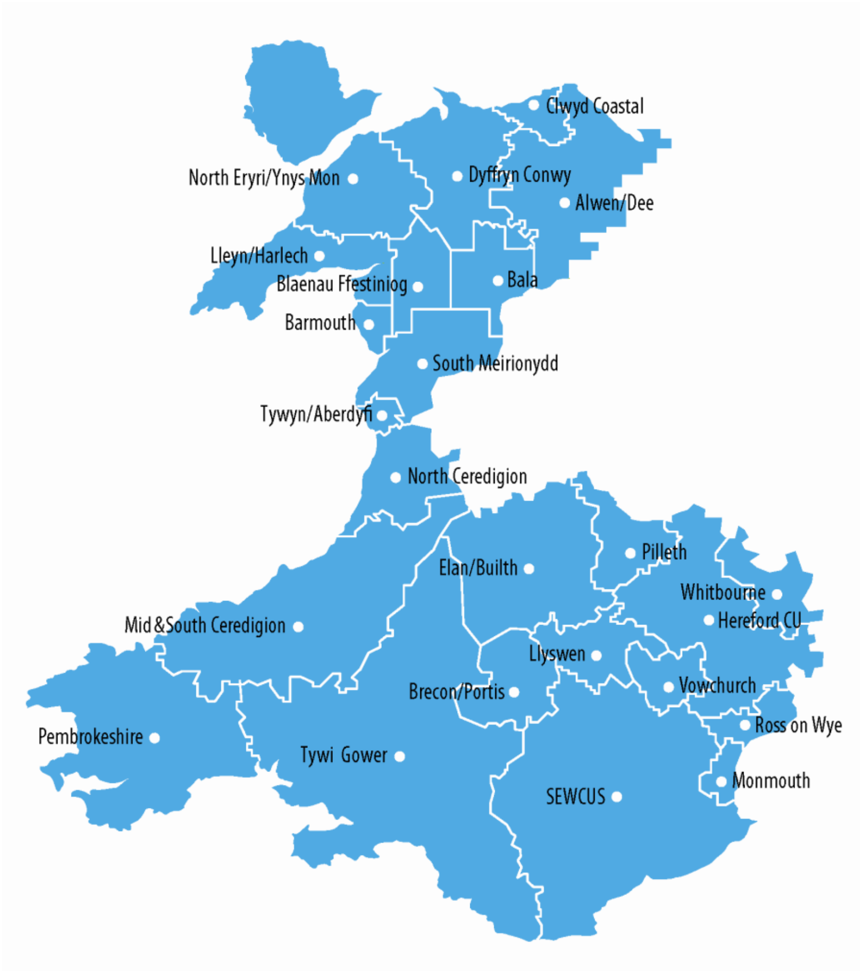


Figure 3 - Welsh Water's Water Resource Zones

1.3.What is a Water Resources Management Plan?

1.3.1. Balancing demand for water against available supply

Water resources planning is about trying to ensure there is enough water supplied to homes and businesses while protecting the natural environment. At the heart of this is our understanding of how much water we are able to take from rivers, reservoirs and boreholes and supply to customers, not only in 'normal years' when we expect good supplies of rainfall across our supply area but also in periods of drought. Our forecast of water resource availability takes account of environmental factors and climate change that reduce the amount of water that can be sustainably taken from our water sources.

We need to balance this supply forecast, available during a drought, against the current and future demand for water using the best data available to us. However, there will always be some level of uncertainty around the accuracy of the data that we use in our supply and demand estimates and we account for this within our supply demand balances.

We produce a future supply demand balance for each of our water resource zones. Where the supply demand balance flags a potential shortfall, to resolve it we identify options that either reduce demand or increase supplies. Where the supply demand balance demonstrates that an area is in surplus, we can examine options that might be taken to meet wider objectives such as maintaining good drinking water quality, meeting Government policy direction or customer's wider preferences. Figure 4 shows the basic supply demand planning process used in developing this Plan.

Our Plan demonstrates where we believe we have sufficient water to meet demand into the future and where we do not, explains what we will do to resolve any imbalances and justifies our choice of schemes.

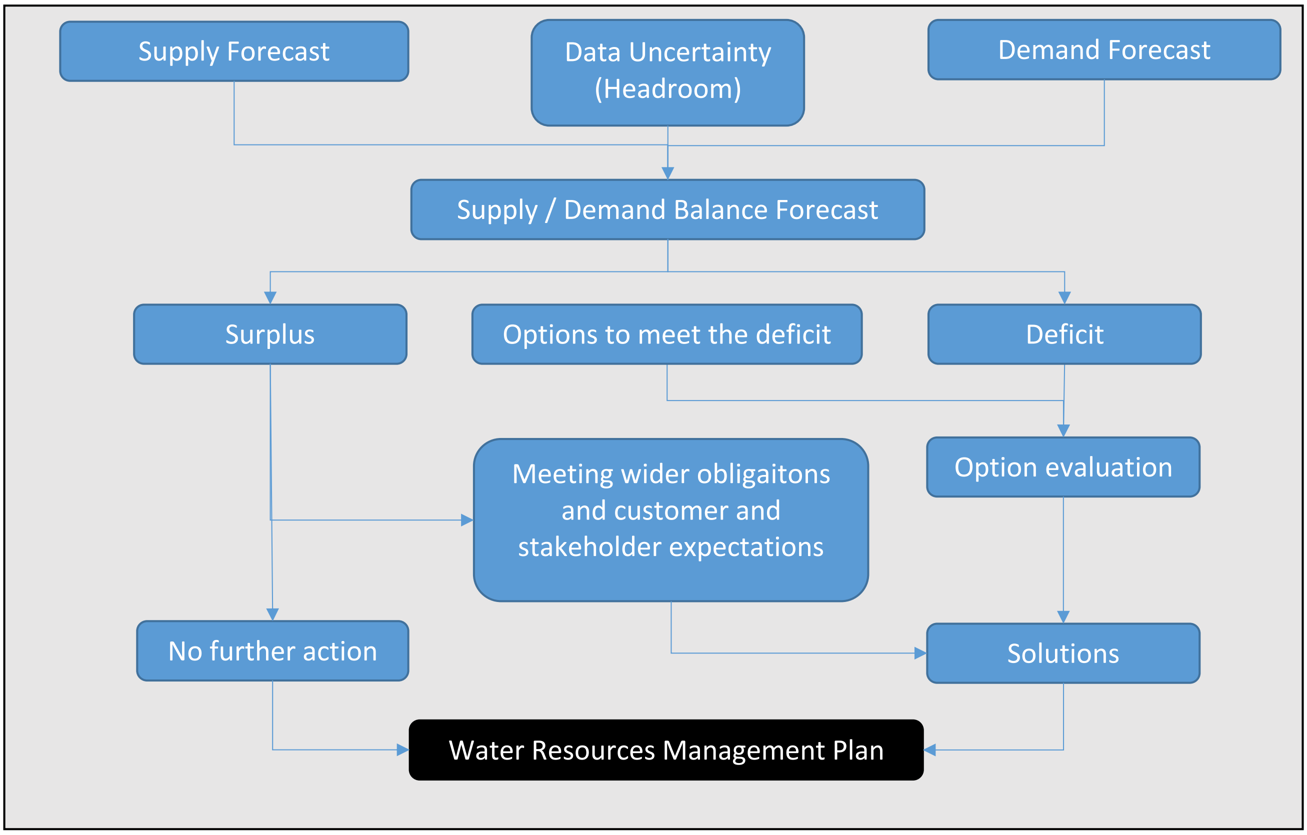


Figure 4 - Basic WRMP Process

1.3.2. Regulatory requirements

The development of this Plan is heavily regulated to ensure good governance and that the process is transparent. Legislation sets out the requirement for water companies to maintain plans (Water Industry Act 1991 as amended by the Water Act 2003). Welsh Government both directs[1] the timescale for the development of the plan and provides 'Guiding Principles' for developing WRMPs[2].

The water industry operates on five-yearly investment cycles called Asset Management Plan (AMP) periods. Following review, prices are set by Ofwat at the beginning of each period, following submission of our Business Plan that sets our investment needs for the next five years. We are currently in the 6th AMP period (2015 – 2020) and the majority of investment being sought in this Plan is to be delivered in AMP7 (2020 – 2025).

The following table indicates the policy areas and links to other plans that we have considered in developing this Plan.

[1] The Water Resources Management Plan (Wales) Directions 2016
[2] The Welsh Government Guiding Principles for Developing Water Resources Management Plans (WRMP's) for 2020, (April 2016)

Organisation	Document	Links to this Plan
Welsh Government	Water Strategy for Wales (2015)	Sets out Welsh Government's long term policy direction for water, with the aim of managing water and its associated services in a more sustainable and integrated way.
Welsh Government	Environment (Wales) Act 2016	This sets the broad framework for the adoption in Wales of the sustainable management of natural resources Also places us under a strengthened biodiversity and ecosystems reliance duty.
Welsh Government	Well-being of Future Generations (Wales) Act 2015	Requires public bodies to consider the long-term impact of decisions, to work better with people, communities and each other, and to prevent persistent problems such as poverty, health inequalities and climate change.
Welsh Government	Water Resources Management Plan (Wales) Directions 2016	Planning period and matters to be addressed in a water resources management plan, as well as submission, publication and representation requirements
Committee on Climate Change	UK Climate Change risk assessment 2017 Evidence report – Summary for Wales	This document summarises the Wales-specific evidence included in the UK Climate Change Risk Assessment (CCRA2) Evidence Report.
Natural Resources Wales/Environment Agency	Water Framework Directive River Basin Management Plans	How the European Water Framework Directive will be implemented to achieve 'good status/ potential'.
Natural Resources Wales/Environment Agency	Catchment Abstraction Management Strategies	Sets out the water resource availability status across surface water/ groundwater catchments in Wales and England. This determines the abstraction licensing policy.
Local Councils	Regional Development Plans/ Spatial Strategies	Aspirational development within the Councils' area.
Dwr Cymru Welsh Water	Making Time for Nature (July 2017)	Our Biodiversity Plan describes how our business interacts with nature and sets out a range of targets which support the WRMP.

Table 1 - Links to policy areas and plans

The Well-being of Future Generations (Wales) Act 2015 is about improving the social, economic, environmental and cultural well-being of Wales, to create a country that we all want to live in now and in the future. The Well-being of Future Generations (Wales) Act 2015 does not apply directly to Welsh Water, as we are not a public body. However, our approach set out in this Plan and in Welsh Water 2050, together with our mission statement, are closely aligned with the Welsh Government's own long-term policy agenda. The 18 Welsh Water 2050 strategic responses make a significant contribution to the seven well-being goals.

Our stakeholders consider protecting the environment and biodiversity as vital to the work we do. We agree that supporting nature aligns with our mission of being a sustainable water service. Encouraging a wider public engagement with nature can increase public health and social well-being, through reducing stress, and supporting social cohesion. An environment that supports thriving, biodiverse wildlife is likely to be high quality and unpolluted. We aim to protect the landscape, rivers and coasts we operate in and the 40,000 hectares of land which we manage directly aligning with our biodiversity duty under the Environment (Wales) Act 2016.

1.4. Priority areas of the Plan

We have been guided by our regulators (principally Welsh Government, Natural Resources Wales, the Environment Agency, and Ofwat) in what they see as important aspects and key considerations within our Plan. In summary our Plan aims to secure sustainable and affordable supplies to our customers whilst working to improve the resilience of our water supplies. We have also worked to improve the accuracy of the data and information on which this Plan is built as proposed in our 2014 Plan. This Plan looks at the period from 2020 to 2050 in line with our "Welsh Water 2050" strategy across our 24 WRZs. The key approaches for this Plan are:

- To ensure that the views of customers are properly taken into account, particularly on service levels and the cost of the Plan;
- To consider all available options to balance supply with demand when water supply deficits are forecast to exist over the planning period;
- To provide the reasoning on why options are selected and why they are best value for customers and the environment;
- To take account of Welsh Government policy in the Environment (Wales) Act 2016 and The Well-being of Future Generations (Wales) Act 2015 and align with its "Water Strategy for Wales 2015". Using the ecosystem services approach, we will work towards more integrated management of our water resources;
- To prioritise demand management over supply side options where the wider benefits of doing so provide a best value solution. As part of this, Ofwat is proposing to set a target for a further 15% reduction in leakage rates;
- To investigate the opportunities for trading water resources with 3rd parties where this is to the benefit of our customers and not to the detriment of the environment;
- To ensure that the Plan is compliant with all relevant European and domestic statutory requirements and to carry out a Strategic Environmental Assessment (SEA) and Habitats Regulations Assessment (HRA) for the Plan;
- To improve the resilience of supply systems to pressures such as drought and climate change;
- To be innovative in our approach to our Plan.

1.5. Plan Assurance and security

We instructed Jacobs's consultants to undertake a compliance audit of our Plan against regulatory guidance and to feedback comments where our planning could be improved. Appendix 1 is an assurance letter from Jacobs summarising their findings. This concludes:

- A good understanding of the WRMP guidelines and associated documents
- Processes consistent with the WRMP guidelines
- That the Plan adequately reflects the Welsh Government's guiding principles and Ofwat's key themes
- Our processes incorporate appropriate levels of quality assurance.

We need to ensure that our Plan does not contain information that could pose a security risk. We have provided a security statement in Appendix 1.

1.6. The Structure of our Plan

This Plan has been developed with a wide audience in mind. To this end, we have prepared a non-technical summary document as well as this technical report.

The Plan is a technical report which describes some complex methodologies developed by the water industry and our regulators. Our regulators want to be assured that we have employed appropriate methods and applied these correctly. In order to make the report accessible to enable better engagement, each section provides a basic narrative prior to providing technical detail. For those who want to explore our approach to specific areas of the Plan we have presented a number of technical Appendices.

Even though the direct supply demand driven output from the Plan is seemingly small, in that we only have 2 WRZs where new investment is needed to maintain a good water resource position, it is important that we also demonstrate within the Plan why we believe that the remaining 22 zones are in good order without increased funding of schemes or initiatives.

This document is structured as follows.

Chapter 1 – (this chapter) introduces the planning process, the regulatory context and the priorities for the Plan;

Chapter 2 – Describes the basic principles of how we undertake water resource planning and the factors that we need to take account of;

Chapter 3 – How we calculate how much water we have available from our water sources and supply systems and the factors that can change this over time;

Chapter 4 – How we forecast our customer demand for water;

Chapter 5 – The balance between supply and demand in each of our WRZs and the key factors which impact upon this balance;

Chapter 6 – How we decide the best action to take to resolve our future water resource issues;

Chapter 7 – Our Plan to resolve the water resource risks in Pembrokeshire and Tywyn Aberdyfi where we anticipate a supply demand deficit in the future and other water resource initiatives that we are proposing to meet wider customer priorities.

2. How we Plan

2.1.Introduction

Our Plan describes our ability to meet the future demand for water within our supply area, and where we predict that demand may outstrip supply, how we will meet this challenge. This chapter describes the building blocks for the Plan, how these are put together while taking account of the priorities described in Chapter 1, and summarises the methodology used.

This includes how we engage with our customers and regulators and how we decide on which technical methods we use to ensure a robust solution to future supply-demand challenges while meeting regulatory guidance.

2.2.Do we have a problem in the future?

2.2.1. Defining the problem

An understanding of the ability of our supply systems to meet future demand is at the centre of the planning process. The initial stage of this is to understand the worst case scenarios that we might encounter that could limit our capability to meet demand. For example, dry years when our ability to supply is largely determined by the amount of water flowing in rivers and into reservoirs, or peaks in demand when our supply is limited by the amount of water we can treat at our water treatment works. We then need to forecast future demand so that we understand whether our supply systems can cope.

2.2.2. Supply Demand Balance Scenarios

Although all of our water supply systems have their own characteristics, it is the level and timing of demand within any zone that defines the water resources planning problem to be solved. For our systems there are two primary planning scenarios that we need to consider.

The first scenario assesses our ability to meet demands that we would expect during an extended dry period. This is when our water resources are most stretched as we have less water flowing in rivers and into reservoirs coinciding with elevated demands. For the majority of our supply systems we are vulnerable to year-long droughts where low autumn, winter and spring rainfall is followed by a hot dry summer. This means that some of our reservoirs might not fill over the winter or have lower amounts of water stored than normal in the spring. We then have limited water stocks to meet prolonged high summer demands. The planning scenario in which we compare our water resource availability against demand over the year is called our "Dry Year Annual Average" scenario and is a measure of how much water resource we have through the reliability and resilience of our water sources.

The second scenario assesses our ability to meet peaks in demand which can occur during hot and dry summer periods when our customers' demand is at its highest. This challenges whether we have sufficient treatment and network capacity within a supply area. In this planning scenario we look at a supply against demand balance over a rolling 7 day period. This is called the "Dry Year Critical Period" scenario.

We have assessed all our water resource zones under the "Dry Year Annual Average" scenario and have chosen to assess the following four zones under the "Dry Year Critical Period" scenario:

- Tywyn Aberdyfi - to assess the impact of tourism upon peak demands and our ability to meet these
- Elan Builth – to assess the impact of the Royal Welsh Show Week upon demand
- Vowchurch – to assess the risk of peak demands coinciding with reduced abstraction licence limit
- Pembrokeshire- to assess the impact of tourism upon peak demands and our ability to meet these

As described above, we compare the amount of water resources in our rivers, reservoirs and boreholes over long periods to understand whether this is sufficient to meet demand over the same period. We test this by examining what our current response would be if we were to have to meet our worst historic droughts once again. The most critical events that we have seen historically across our supply area are the droughts of 1976 and 1984.

2.2.3. Our measure of supply availability

Within water resource planning the key measures of our supply forecast are termed Deployable Output (DO) and Water Available for Use (WAFU). DO is the available output of a water source, or group of sources, which can be constrained by a number of factors such as abstraction licence limits, pipework or water treatment works capacity or the quality of the raw water.

The amount of water that we can rely on to meet demand within a specific zone also relates to any inefficiencies in our systems such as temporary outages in available supplies due to equipment or water lost during processes at our water treatment works. We also need to account for the transfers of both untreated and treated water between areas. The term WAFU is used to describe the total amount of water available to meet demand within a specific zone, taking account of the above inefficiencies.

The methods for calculating DO and WAFU and how we adjust this component to take account of other factors including climate change impacts are described in Chapter 3.

2.2.4. Demand forecasting

We compare our supply capability (WAFU) against our forecast of demand for water. Demand forecasting is based upon the best data available to us and is calculated in line with guidance as outlined in 'Demand Forecasting Methodology' (UKWIR/NRA 1995). 'Dry Year' and 'Critical' Period forecasts have been produced for planning purposes.

The Demand Forecast is developed by breaking the demand down into its constituent parts which are:

- Household demand based on numbers of properties and population;
- Non-Household demand;
- Total Leakage;
- Other minor Components.

We initially look at the current position for each component of demand and then make a forecast of these into the future using appropriate methods. The detailed approach to our demand forecasting is provided in Chapter 4.

2.2.5. The supply demand balance and level of service

The long term supply demand balance is intrinsically linked to the level of service (LoS) supplied to our customers. If we anticipate that we might be unable to meet the demand for water during a severe drought we will put measures in place to limit demand. We have used measures such as hosepipe bans and non-essential use bans during the droughts of 1976, 1984 and 1989-90. How often we would put these in place is a measure of our water resource LoS.

Our customers accept that it is reasonable to impose such sanctions during droughts as long as this does not happen too frequently. Our current LoS is:

- Not to have a hosepipe ban (now called temporary water use ban) more than once in every 20 years (1-in-20), on average;

- Not to restrict water for commercial purposes such as car washers, building cleaning, dust suppression (called as non-essential use ban) more than once in every 40 years (1-in-40) on average.

Where the supply demand balance for a given zone is positive we term the zone in ‘surplus’ and where it is negative we term the zone in ‘deficit’. For zones where we have a deficit then there is a lower LoS than our policy position. Where a zone is in surplus then we would not need to impose demand restrictions as often.

When our supply demand balance is in deficit, this does not necessarily mean that we would be unable to supply water to our customers. It does however mean that we would need to use demand restrictions not only during our worst droughts but during less severe droughts as well, or in other words have restrictions more often, hence we would provide a poorer LoS.

Our supply and demand forecasts are not static but will change into the future due to factors such as climate change, environmental legislation and changing population demographics. The supply demand balance assessment therefore needs to consider a range of futures and make an allowance for the uncertainties associated with these. This is described in greater detail in Chapter 3.

2.2.6. Supply demand uncertainty

Long term water resource planning is a complex process involving the analysis of large amounts of data, with varying degrees of certainty applicable to each data source. Within each of our zonal supply demand balances we therefore need an allowance for risk to account for the inherent uncertainties. For example, water resource uncertainty includes the inaccuracy of hydrological data. Demand forecast uncertainties arise in population and water usage estimates.

There is a prescriptive industry methodology for the calculation of this allowance for uncertainty which is known as ‘Target headroom’. Chapter 3 describes headroom in more detail with full information provided in Appendix 3.

The data tables that accompany this Plan provide a detailed account of our supply demand balances for each of our 24 zones. These balances can be shown graphically over time. Figure 5 is an example supply demand balance plot which shows the demand for water as a yellow line against supply capability (blue bars). A second red line indicates the demand plus the level of uncertainty (target headroom) for the zone.

In the example shown there is a significant reduction in the supply capability from 2026. This type of loss is typical of that seen when the amount of water we take from a river is not sustainable and the amount we are allowed to take is reduced as a consequence. The graph shows that the demand plus headroom is greater than the available water resource in 2033 when the zone falls into a ‘deficit’ position. In this example, new investment will be required in the zone to balance supply against demand from the start of the deficit either through demand management such as leakage reduction or through the development of new sustainable water resources. The plot also shows how the inclusion of options feeds in to maintain a positive balance.

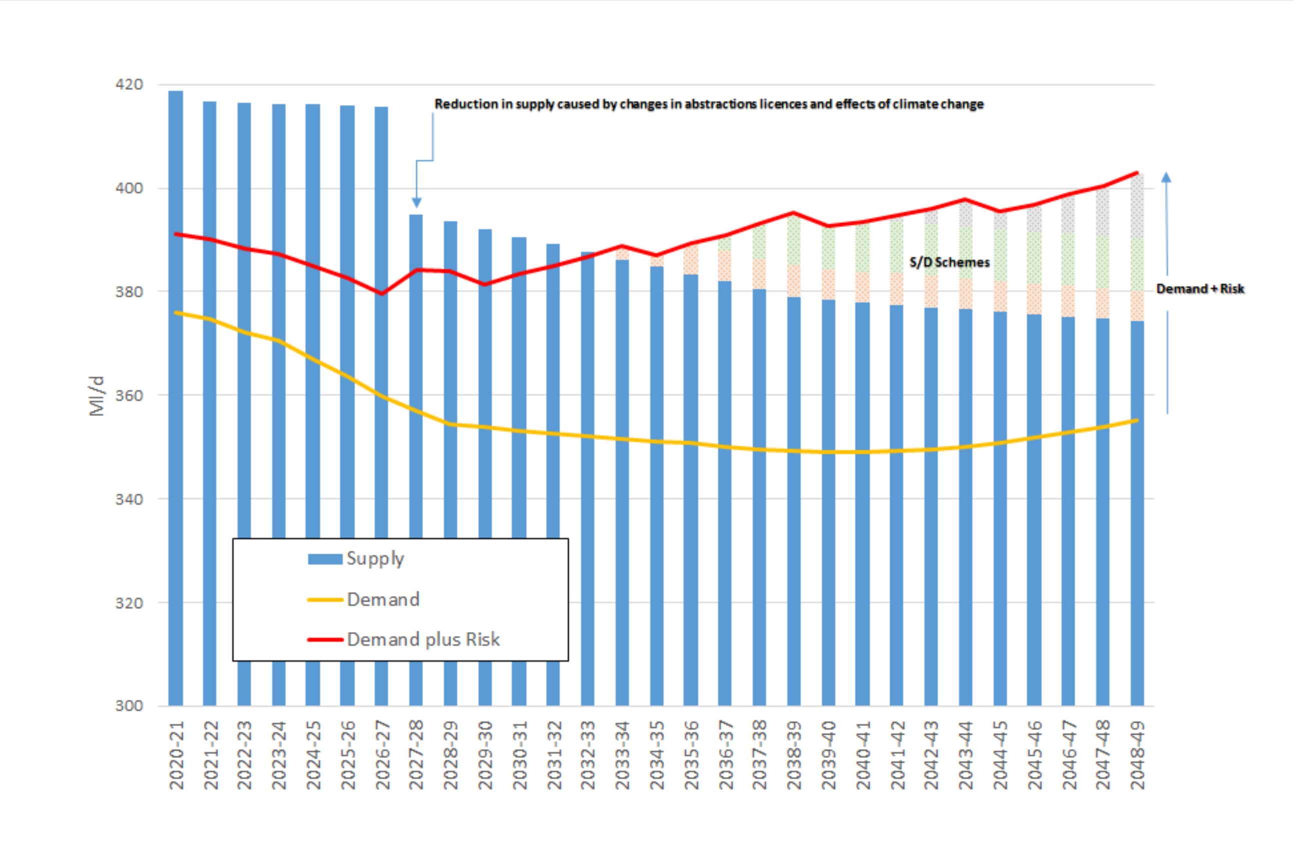


Figure 5 - Example supply demand balance plot

2.3.Drought Risk Assessment and Resilience

One of the key questions being asked of water companies in this planning round is the level of resilience of our water supply systems and water resources. One way resilience can be quantified is by determining how extreme a drought would need to be to strain our water resources to a point where we would require the imposition of severe restrictions to water supplies beyond the use of hosepipe and non-essential use bans. The last time this happened in our supply area was in 1976 when standpipes were used to preserve resources until the drought was over. Welsh Water's policy is to never resort to such measures again.

Government is understandably keen for the industry to be able to assess what 'never' is. The industry is currently considering how to measure this and has asked the water companies to make an assessment of the resilience of their water supply systems to more extreme droughts than has been witnessed within their records. It is possible to use statistical methods to examine this but there can be some considerable uncertainty in this approach.

To try and answer this question, in line with new guidance we have undertaken an assessment of whether our supply systems could cope with a drought that might occur 1 in every 200 years. We acknowledge that for many of our zones this assessment used Extreme Value Analysis rather than more advanced weather generation and stochastic modelling and so we are working to refine the analysis through the Drought Vulnerability Assessment work we are currently undertaking for our draft Drought Plan 2020.

Taking a risk based approach, we have used some innovative methods to understand the position within the four priority zones identified in the 'Problem Characterisation' assessment. For all low and medium risk zones we have used 'extreme value' statistical analysis to better understand the position, in line with UKWIR guidance[3], to provide an initial, high level view of our resilience position. The results of the analysis are provided in Chapters 6 and 7.

2.4.Solution Development

Where we have assessed that a zone may be in deficit over the period 2020 to 2050 or where the estimated level of resilience within the zone is low, we have undertaken a detailed assessment of potential options to resolve the deficit. The options may include a combination of supply schemes or demand reduction measures to maintain a positive supply demand balance and agreed LoS. This process is well established within the water industry in England and Wales and is called the Economics of Balancing Supply and Demand (EBSD). In this method the cost against benefit of each programme of options is examined to calculate a lowest cost way forward for each zone.

This approach, which focusses on the economic perspective, does not take wider factors into account such as our customers' views on the merits of each type of option or the link between the chosen schemes and other factors such as improving the water quality within our supply systems and the maintenance of our current infrastructure.

A more rigorous approach to decision making is therefore needed, which still takes account of the economic cost of schemes, (as this will impact our customers' bills) but also considers the wider factors. To do this, we initially take a standard EBSD approach to our assessment for all of our WRZs and then test our Plan against various criteria to ensure that the solution represents the most sustainable, resilient and best value plan for our customers. Chapter 6 of the Plan describes this decision making process for our deficit zones.

The Options Assessment process for this Plan includes the following key objectives:

- Develop and screen a comprehensive list of unconstrained supply side options;
- Design and develop feasible options including the following:
    i. Desk based engineering review;
    ii. Strategic Environmental Assessment (SEA), Habitats Regulation Assessment (HRA) and Water Framework Directive (WFD) Assessment; and
    iii. Cost Benefit Assessment (including carbon costings).

The process includes the use of an optimisation model to derive an initial 'least cost' solution. The outputs of this are then tested against the results of our stakeholder and customer engagement work to ensure the 'best value' solutions are taken forward for delivery. For this Plan we have not used a Natural Capital Accounting (NCA) approach as the methodology is still being developed for the water industry. The relatively 'simple' nature of our preferred solutions however means that even had the methodology been available, we would not have utilised an NCA approach.

2.5.Solution Testing

To ensure the outputs of our plan are robust we need to test them against not only our best guess of what the future will look like but against other future scenarios. In this way we reduce the risk that the solutions chosen become redundant if the assumptions made within our Plan turn out to be incorrect. A key theme in our Plan is to ensure that our systems are resilient.

[3] UKWIR (2016) WRMP 2019 Methods – Risk Based Planning. Report ref: 16/WR/02/11

A second way to ensure that our solutions are robust is to undertake a sensitivity analysis on the value of the parameters used. For example we look to see how the best value solution might change if demand from our customers increases by more than we have assumed. Chapters 6 and 7 show how we have tested our Plan.

2.6.‘Problem Characterisation’

For this Plan, our regulators have asked us to take a risk based approach to our assessments. This involves looking at the level of risk within each of our 24 water resource zones. Where the identified risk is highest, we use more sophisticated and innovative methods to understand the supply against demand position. Conversely, where we know our water resources are plentiful and our supply systems have large capacity then a basic assessment is more appropriate.

We have used the industry standard method to categorise our zones based upon our understanding of each zone as reported in our previous Plan and the additional data gained and reported on each year in our annual reviews. The results of this exercise, which was undertaken by Atkins in 2016, are shown in Table 2. Full details of this exercise are provided in Appendix 4.

		Strategic Needs Score ("How big is the problem")			
		0 (None)	**2 (Small)**	**4 (Medium)**	**6 (Large)**
Complexity Factors Score ("How difficult is it to solve")	**Low (<7)**	**All other WRZs in these categories**		**Tywyn Aberdyfi**	
	Medium (7-11)		**Ross-on-Wye**	**North Eryri, SEWCUS**	
	High (11+)			**Pembrokeshire**	

Table 2 - Matrix Summary of the WRZ Level Risk Assessment

Three zones were identified where more sophisticated methods for evaluating supply/demand components were recommended from the characterisation analysis – these were North Eryri / Ynys Mon, SEWCUS, and Pembrokeshire. As our Tywyn Aberdyfi zone was in deficit in our last Annual Update to our Water Resource Management Plan, this zone was also taken forward for application of extended methods. Figure 6 shows the locations of the zones identified for extended methods and more detailed analysis, which align with the 2014 Plan position.

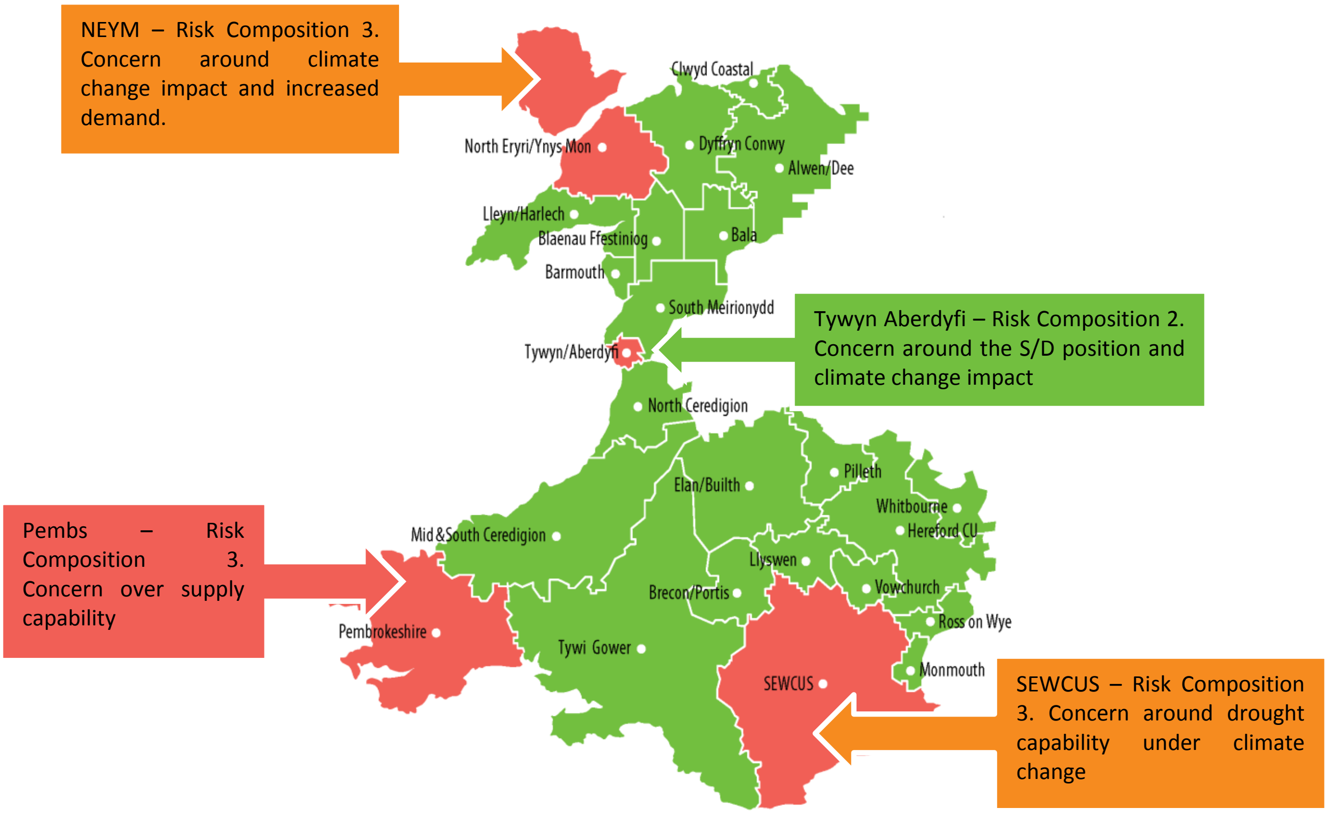


Figure 6 - Problem Characterisation

2.7. Water Resources Management Plan Consultation

2.7.1. Customer and Stakeholder Engagement

Planning guidance highlights the need to have effective engagement with our customers and other stakeholders so that their views are adequately taken into account when developing our plans. Overall consultation on the Plan is extensive and wide ranging, from technical 'one to one' meetings with our regulators to detailed engagement with our customers on specific aspects, and with full consultation on a draft plan being undertaken prior to the preparation of the final Plan.

The first stage of engagement has been pre-consultation, in which we have contacted our regulators, local authorities, neighbouring companies and some other key stakeholders such as the Consumer Council for Water to seek their views on what they see as the important factors to consider within the Plan. As part of this exercise, we asked three questions:

- Do you agree with our priorities for the development of WRMP19?
- Are you aware of any potential supply options that we should be considering within our WRMP19?
- Are there any key policies that you see as integral to the development of WRMP19?

The consultation ran for 6 weeks from the 23rd January 2017 to the 7th March 2017. Table 3 below summarises the responses received.

Consultee Type	Consultee Number	Consultee Reply	Feedback Summary	Meeting Held	Details
Government	5	0		0	
Councils	22	2	Concern over population forecast accuracy	0	Ceredigion Council, Swansea Council
Regulators	8	2	Ensure compliance with recent government guidance and consider extreme drought	2	Natural Resources Wales, Environment Agency
Utilities	8	1	Welcome transfer discussions	4	Thames Water, Severn Trent Water, United Utilities, Bristol Water
Other	8	0		2	Canal & Rivers Trust, Consumer Council for Water

Table 3 - Results of draft WRMP19 pre-consultation

Table 4 outlines the responses to our pre-consultation from NRW and the EA together with the actions we have taken to address these. The topics raised by these two key organisations, together with the feedback received from Ofwat, generally covered the points other respondents made.

Topic	Recommendation	Action by Welsh Water
	Natural Resources Wales	
Environment (Wales) Act 2016	Decisions affecting natural resources in Wales should seek the best overall outcome, taking account of economic, social and environmental factors and the underpinning resilience of ecosystems.	Requirement considered throughout the Plan
Well-being of Future Generations (Wales) Act 2015	Decisions affecting natural resources in Wales should seek the best overall outcome, taking account of economic, social and environmental factors and the underpinning resilience of ecosystems.	Chapters 6 and 7 detail our decision making process and planned outcomes in line with policy
Resilience	Consider scenario analysis of more challenging but plausible droughts for WRZ that have been identified as “risk composition 1”	Chapter 5 presents the results of our zonal extreme drought analysis.
Customer preferences	Set out how the views of customers have been taken into account and how they have influenced the Plan, particularly on service levels.	Included in Customer Engagement Chapter 6
Option assessment	Consider all options to balance supply with demand, taking a more integrated approach towards sustainable management of natural resources including managing leakage and providing services to help customers use water efficiently.	Included in Option Appraisal Chapter 6
Drinking water quality	Explore innovative catchment management solutions where drinking water quality standards may affect your deployable output or lead to the use of alternative sources that may be more expensive, increase carbon emissions or have a greater environmental impact.	Included in Chapter 3

Topic	Recommendation	Action by Welsh Water
Demand options	Water efficiency/demand management measures should be targeted at a resource zone level and not just based on a company level assessment.	Included in Option Appraisal Chapter 6
SEA and HRA	Consult Natural Resources Wales at all relevant stages of your SEA and HRA.	Included in our SEA/HRA assessment
Water Framework Directive	The impact of potentially utilising a resource more than it is currently used (for yourselves or for trading) should also be investigated to ensure that the source remains sustainable and no deterioration of the water body occurs.	Included in our WFD assessment
National Environment Programme (NEP)	PR19 NEP schemes for water resources to be incorporated into deployable output or scenario modelling where appropriate.	Included in our DO modelling.
Invasive non-native species (INNS)	Discuss your obligations under the EU Regulation on INNS to understand your risks of spreading or introducing INNS in water courses through your operations.	Included in Sustainable Abstraction section, Chapter 3
	Environment Agency	
Resilience	When preparing your draft water resources management plan, you should ensure you have used appropriate methods and data and can provide a secure public water supply across the planning period. We support your proposals to prioritising the level of sophistication applied in supply assessments and assume you propose to follow Risk Composition 1, as per the UKWIR 2016 Risk Based Planning guidance, for your zones in England. However, given the short period of record supporting your deployable output assessment for your English zones, we would like to see evidence that you have considered a range of plausible droughts worse than the historical record.	Chapter 5 presents the results of our zonal extreme drought analysis.
Methodologies	Following the methodologies recommended in the Water Resources Planning Guideline. Please note to support the joint WRMP technical guideline, we have also produced a set of supplementary documents and templates that provide further information on specific topics. These include the supply demand and water company level tables to be used for capturing and presenting water resources planning data at a resource zone level to support your WRMP.	Requirement considered throughout the Plan
SEA and HRA	Demonstrating how your Strategic Environmental Assessment has informed development of your WRMP throughout the process.	Detailed in Option Appraisal Chapter 6 and included in our SEA/HRA assessment
Customer engagement	Clearly showing how your customers' views have influenced and shaped your final plan.	Detailed in Option Appraisal Chapter 6
Demand forecast	Updating your demand forecast with the latest planned housing development and population projections.	Detailed in Chapter 4

Topic	Recommendation	Action by Welsh Water
Resilience	We also expect you to review the outputs of the Water UK project 'Water Resources Long Term Planning Framework' and consider what it means for your company and the range of resilience solutions you have considered.	Set out in Chapter 7 'Our Plan'

Table 4 - NRW and EA expectations for WRMP19

We have worked closely with our key environmental regulators, Natural Resources Wales and the Environment Agency who will report back to Welsh Government and the Department for Environment, Food and Rural Affairs (DEFRA) on the efficacy of our Plan. This engagement has been through regular technical meetings and the use of method statements (Appendix 5) so that there are no surprises in either our approach in meeting guidance or in the results of analysis as the Plan has developed.

In addition to our environmental regulators we have also sought the views of environmental organisations across Wales through the Independent Environmental Advisory Panel (IEAP) which Welsh Water set up in 2012. We have consulted this Panel during the Plan preparation and have presented them with initial results for discussion and comment.

In developing our Plan we have paid particular attention to the proposals from our economic regulator, Ofwat[4], in their 2020 vision for regulation of water and wastewater services[5] but also its four key themes set out in the PR19 methodology[6] which are:

- Great customer service;
- Resilience;
- Affordable bills; and
- Innovation.

We met with representatives from Ofwat to explain our approach in these areas and in the potential magnitude of the investment needed to maintain resilient supplies to meet the forecast long term demand for water until 2050. Following our pre-consultation meeting we provided feedback to Ofwat on three minor points they raised:

1. Level of service decision – in particular the frequency of severe restrictions (standpipes, rota cuts)
2. Residual risk areas for our supply-demand balance
3. Supply and demand feasible options

Welsh Government has been very clear within its Guiding Principles document that our customers' views should be considered in the round in our approach to water resource planning and in particular our choice of schemes required to meet future needs. To this end, we have undertaken customer research to explore customers' attitudes and preferences towards various water supply demand initiatives. The findings of this customer research and how these have been used in developing our Plan are laid out in chapters 6 and 7.

2.8. Draft Plan Consultation

[4] The Water Services Regulation Authority
[5] OFWAT (2016) Our Regulatory Approach for Water and Wastewater Services in England & Wales - Overview
[6] OFWAT (2017) Delivering Water 2020 : Consulting on our methodology for the 2019 Price Review

We ran a full public consultation on our draft Plan for 12 weeks from the 16th March 2018 through to the 8th June 2018, receiving 11 responses. The main report, together with the planning tables, SEA/HRA reports and a bilingual non-technical summary were published on our website. During the consultation process we:

- Contacted over 120 organisations directly
- Contacted all relevant Members of Parliament and all Welsh Assembly Members
- Publicised the Plan via our Welsh Water Twitter, Facebook and Instagram feeds
- Attended the Welsh Water 2050 launch event at the Senedd in Cardiff Bay
- Utilised the Welsh Water 'Online Community' to explore the Plan in more detail with thirty of our customers

Full details of the consultation are presented in our Statement of Response report that accompanies this final Plan. A summary of the comments received are shown in Table 5 below.

Consultee	Section and Subject of change
Ofwat	Chapter 2 and 5 : Resilience Chapter 4: Demand Forecast Chapter 6: Water trading Chapter 6: Customer Engagement Chapter 7: Leakage strategy
Natural Resources Wales	Chapter 7: Leakage strategy Chapter 6: Pre-consultation feedback Chapter 3: Greenhouse gases
Environment Agency	Chapter 6: Water trading and transfer clarification Chapter 7: Leakage strategy Chapter 7: Vowchurch resilience Chapter 4: Demand Forecast - consumption model
Consumer Council for Water	Chapter 6: Water efficiency plans Chapter 7: Leakage strategy Chapter 7: Vowchurch and SEWCUS resilience
Canal and Rivers Trust	No change required
RSPB	Chapter 2 and 5 : Resilience Chapter 3: WFD Chapter 6: Water trading Chapter 6: Water efficiency plans Chapter 7: Leakage strategy
Conwy Borough Council	Chapter 6: Water efficiency plans
Pembrokeshire Coast National Park	Chapter 4: Demand Forecast
Waterwise	Chapter 6: Water efficiency plans
Business Customer	Chapter 7: Leakage
GARD	Chapter 6: Water trading

Table 5 – Summary of responses

2.9.An ecosystems approach

2.9.1. The principles of ecosystem services and the ecosystems approach

Another of the key themes within Government policy, guiding principles and stakeholder response is that we should take an ecosystems approach to our water resources planning. This approach looks at the way in which benefits are provided from the natural world to humans.

These categories of services affect human well-being in a range of ways but most importantly, ecosystem services identifies the principle that there is usually a need to understand and manage the ecosystem in an economic context. Any such ecosystem-management programme should:

- Reduce impact that adversely affects biological diversity;
- Promote biodiversity conservation and sustainable use; and,
- Fully account for the costs and benefits to the given ecosystem.

Adopting this approach will help us to meet the strengthened biodiversity duty placed on us by the Environment (Wales) Act 2016 and the commitment we gave in our statutory Biodiversity Plan, "Making Time for Nature", to consider biodiversity when reviewing our Water Resources Management Plan.

2.9.2. Water resources and the ecosystems approach

Water is fundamental to all life, as well as being essential to health and economic prosperity. Water is a renewable but finite resource and the links between our customers and environmental needs for water are recognised in the science, policy and regulation of water management.

The water industry in England and Wales aims to provide water services in an equitable, sustainable and affordable way, based on regulatory control and environmental laws to ensure that ecosystem services are preserved while at the same time ensuring customer wellbeing and economic development.

The water resource planning process reflects this through a range of measures, including:

- The protection of environmental flows, via our environmental regulators' Catchment Abstraction Management Strategies process;
- The aim of achieving Good Ecological Status (or potential) as required by the European Water Framework Directive;
- The protection of habitats and species of international importance via the enactment of EU Habitats and Birds Directives;
- The need to identify the least cost, most sustainable solution for maintaining a balance between supply and demand, taking account of carbon costs of schemes, and wider environmental issues via SEA and HRA; and subsequently to identify the best value option and,
- The statutory duty placed upon water companies to promote water efficiency.

These policies, legislation, regulations and guidance already accommodate principles of the ecosystems approach, to a large degree. We always endeavour to optimise the operational efficiency of our water supply system whilst remaining within control rules, ensuring that we achieve the appropriate levels of service. This contributes to achieving ecosystem goals by reducing operational costs and carbon emissions.

We align this ecosystems approach with internal processes that review the quantity and quality of our raw water sources, to ensure that our customers' health is protected as best as possible. As part of this, we assess the source areas from which our water originates and try to address any potential management issues which could pose a risk to customers' health.

Our Catchment Team is charged with identifying and understanding potential threats to raw water sources from contaminants, for example from pollution events or ongoing land management practices. If we identify any potential risks, we investigate the causes, and aim to address the situation through our work with land owners and third parties.

3. Forecasting Available Water Supply

3.1. Introduction

This chapter summarises the methods we use to generate our assessment of available supplies in our 24 Water Resource Zones over the planning period 2020 – 2050, together with the high level results of this process. The way in which we report our current supply capability and forecast this into the future follows the WRMP19 guidance and technical methodologies referenced within it. The regulatory measures of our supply forecast are defined as Deployable Output (DO) and Water Available for Use (WAFU).

DO is calculated for individual sources and for each water supply system. The factors which determine these are:

- The reliability of river flows and volumes of water captured by our reservoirs, particularly in a dry year. This is directly linked to the amount of rainfall that is received in these catchments.
- The reliable supply from our small but locally important boreholes
- The amount of water that we are legally licensed to take from our water sources.
- How our water supply systems are configured and the volume of water that can be pumped, treated and distributed from our sources to our customers tap.

The DO of a system will not remain static over time and we have looked at the future factors that could change our water resource position. Some examples of these are:

- Climate change, which is predicted to cause hotter drier summers and warmer wetter winters, potentially reducing the overall amount of water available within our catchments during dry years.
- Reductions in our abstraction licence volumes which are demonstrated to be ecologically damaging.
- Poor raw water quality which can reduce the amount of water that we able to supply from our treatment works without investment.

Under the current methodologies, the DO for each WRZ is calculated using simulation models and does not take account of some of the inefficiencies and water losses within the supply system. These need to be taken into account when we calculate the supply demand balance for each zone. Figure 7 shows how WAFU is calculated from the DO value for each WRZ. The sections of this chapter describe our approach in accounting for the elements of DO and WAFU. The WRMP19 tables accompanying this report provide the values for each WRZ that are used within the supply demand balances.

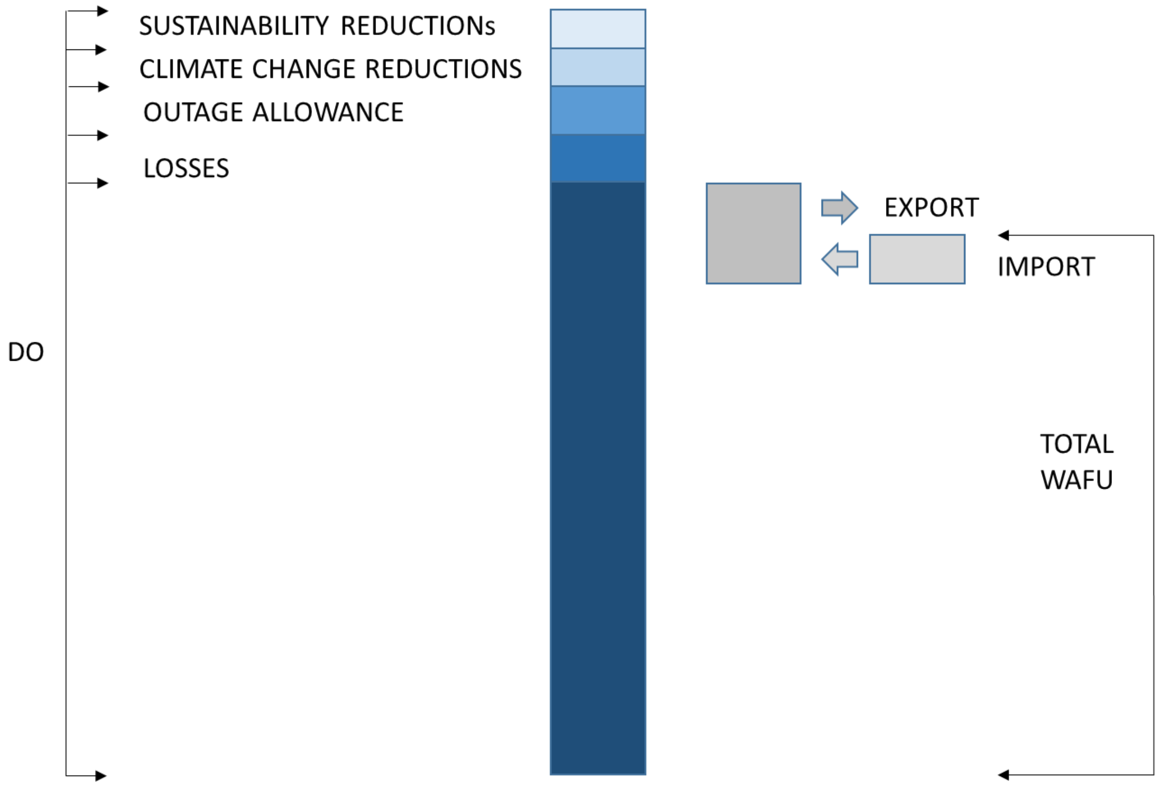


Figure 7 - Example WAFU calculation

3.2. Deployable Output

Our approach to the calculation of DO meets the requirements of the WRPG (2017) and the methods outlined in:

- UKWIR (2016a) WRMP19 Methods – Risk based planning; and
- UKWIR (2014) Handbook of source yield methodologies.

To assess DO we use computer simulation models of our water supply systems using the WRAPSim software. These are linear programming type models in which we describe the basic components of our supply system. For each component such as a reservoir, water treatment works or trunk main we define parameters and put limits on these in line with our actual supply system. For example, we need to specify the size of each reservoir and how much water we are able to take from it given any pipework constraints.

A key input to the model is the historic flow record for the rivers and reservoirs from which we abstract water. We also specify the variation in demand that we expect during a dry year, to represent the conditions that we will meet during the most challenging years. The models are run to simulate how our current systems would operate to meet demand if we had a repeat of our historic weather. The model runs on a daily time step.

Our calculation of DO is continually reviewed as our systems develop and we have undertaken extensive work in developing this Plan to ensure that our models reflect the constraints and the actual operation of our current water supply systems.

For all our WRZs we have undertaken a conventional DO assessment. The ‘explicit levels of service’ (UKWIR, 2014) approach has been followed whereby the WRAPSim models are run over the full period of historic record with the level of demand iteratively increased until the system reaches a point of failure. System failure can be caused for a number of reasons such as when the system cannot meet the modelled level of demand in the zone; when the permitted levels of service are exceeded; when abstraction licence conditions are breached, or when specified emergency storage within the reservoirs is not able to be met.

For each zone, the level of demand that can just be met without the supply system 'failing' is defined as the DO. Our policy LoS that are used to define DO are:

- Not to have a hosepipe ban (now called temporary water use ban) more than once in every 20 years (1-in-20), on average;
- Not to restrict water for commercial purposes such as car washers, building cleaning, dust suppression (called as non-essential use ban) more than once in every 40 years (1-in-40 on average).

We have consulted our customers to understand their views on our current LoS policy. The qualitative survey results from discussion groups & depth interviews with household and non-household customers can be summarised as;

In response to the current measure:

- Our customers have vague memories of the hosepipe bans during 1976 but do not see our current LoS on hose pipe bans as problematic;
- There was a unanimous response from our domestic customers that hosepipe bans on a 1:20 year basis is okay;
- That the inconvenience is reasonable given the type of problem;
- Customers are unsure of how this could be policed;
- 1 business customer stated that a commercial water use restriction could be catastrophic to his business.

In response to changing the measure

- A higher/lower LoS was not generally not supported;
- Responses to improving LoS on hosepipe bans to 1 in 40 years included, 'Why would you do this?', that this would be a misuse of Welsh Water funds and that money would be better spent elsewhere;
- Responses to decreasing this measure to 1 in 10 years were mentioned spontaneously with some support but concerns were expressed about giving anything back without knowing what Welsh Water would do with money saved. There was a general reluctance to support service decline.

Our quantitative survey results suggest that our customers are willing to pay £0.41 per household per year for an improvement in Temporary Use bans (TUB) from 1 in 20 years to 1 in 30 years, and £0.62 per household per year for an improvement in TUB chance from 1 in 20 years to 1 in 40 years. Given the number of households within our supply area our customers would be willing to pay around only £0.5m to move to an increased level of service. However, we are already above our policy level of service in all but the two zones, Pembrokeshire and Tywyn Aberdyfi (see Table 6 below) and this Plan describes how we will improve the LoS within these zones.

For each of our twenty four water resource zones, the following stages of work were undertaken to generate our 'Baseline' DO position:

- Stage 1: A detailed review of the current network model schematics to ensure it is an up to date representation of the water resources system;

- Stage 2: Incorporation of reviewed and updated base demands and demand profiles with data provided by Artesia (2017) ;

- Stage 3: Incorporation of reviewed and updated hydrological inflows provided by Amec Foster Wheeler (2017) and Atkins (2017b).

The details and outputs of this work for each specific water resource zone are summarised in Appendix 6 – Baseline Deployable Output assessment (AmecFW), Appendix 7 – Review and update of WRAPSim demand allocations (Artesia), and Appendix 8 – WRMP19 Inflows review and update (AmecFW), Appendix 9 – Best Value Analysis hydrology update (ATKINS).

3.2.1. Deployable Output Results

Table 6 below summarises the results of our baseline DO modelling. As a result of the improvements made to the models, we are reporting a number of WRZs with a different DO to that presented in WRMP14 and the subsequent Annual Reviews. We view these latest values as a more robust estimate of our water supply capability and gives us confidence that we can manage supplies in line with our modelled representation. The table also provides our LoS regarding Temporary Use bans and Non-Essential Use bans.

Zone	WRMP19 min AADO (Ml/d)	min CPDO (Ml/d)	Constraint	Level of Service TUB	NEUB
Alwen Dee	56.55	66.79	Bwlch tunnel capacity.	1 in 48	>1 in 96
Bala	1.77	2.26	Daily abstraction licence limit at Llyn Arenig Fawr	>1 in 89	>1 in 89
Barmouth	1.72	2.68	Eithinfynnydd WTW capacity.	>1 in 58	>1 in 58
Blaenau Ffestiniog	1.95	2.28	Garreglwyd WTW capacity.	>1 in 58	>1 in 58
Clwyd Coastal	26.06	32.76	Annual abstraction licence limit at Plas Uchaf and Dolwen	1 in 95	1 in 95
Dyffryn Conwy	35.76	41.58	Annual abstraction licence limit at Llyn Cowlyd.	1 in 29	1 in 58
Lleyn Harlech	17.44	23.22	Garndolbenmaen WTW capacity.	1 in 29	1 in 58
NEYM	52.04	61.69	Level of service (hosepipe bans).	1 in 58	>1 in 58
South Meirionnydd	2.41	2.99	Annual abstraction licence limit at Afon Gwril.	>1 in 58	>1 in 58
Tywyn Aberdyfi	1.25	1.92	Daily abstraction licence reached at Afon Fathew.	<1 in 20	>1 in 58
Mid and South Ceredigion	22.53	29.39	Llechryd and Strata WTW capacity.	>1 in 56	>1 in 56
North Ceredigion	12.44	16.03	Cefn Llan WTW capacity.	1 in 64	>1 in 64
Pembrokeshire	74.31	91.51	Bolton Hill WTW capacity.	<1 in 20	>1 in 58

Zone	WRMP19 min AADO (Ml/d)	min CPDO (Ml/d)	Constraint	Level of Service TUB	NEUB
Tywi Gower	221.68	268.05	Tycanol pumping station capacity.	>1 in 43	>1 in 43
Brecon Portis	4.48	5.25	Daily abstraction licence limit at Usk Reservoir.	>1 in 43	>1 in 43
Elan Builth	6.36	8.55	Daily abstraction licence limit at Elan Reservoir	>1 in 43	>1 in 43
Herefordshire	45.91	56.18	Daily abstraction licence limit at Broomy Hill intake.	>1 in 43	>1 in 43
Llyswen	4.39	5.00	Daily abstraction licence limit at Llyswen River Wye intake.	>1 in 43	>1 in 43
Monmouthshire	4.44	5.80	Mayhill WTW capacity.	>1 in 43	>1 in 43
Pilleth	2.31	2.96	Daily abstraction licence limit at Pilleth Boreholes	>1 in 43	>1 in 43
Ross on Wye	6.22	9.00	Daily abstraction licence limit at Ross on Wye intake.	>1 in 43	>1 in 43
SEWCUS	422.49	476.54	Minimum stocks of 24% at Llandegfedd reached.	>1 in 43	>1 in 43
Vowchurch	2.36	3.0	Daily abstraction licence limit at Vowchurch boreholes.	>1 in 43	>1 in 43
Whitbourne	5.15	7.00	Daily abstraction licence limit at Whitbourne intake.	>1 in 59	>1 in 59

Note * That "> 1 in 43" denotes a better level of service than 1 in 43, not a frequency that is greater than 1 in 43. Also, it should be pointed out that ">1 in 43" refers to those situations where we have records for the last 43 years, during which there have been no restrictions.

Table 6 - Summary Deployable Output values

3.3.Sustainable Abstraction

It is important that we fully meet our environmental obligations in the way that we take water from the environment, as an eco-system service, or transfer it from one catchment to another. This service is strictly controlled through environmental legislation to ensure that our activities are not environmentally damaging particularly during the driest years when the impact of abstraction can be at its greatest.

In meeting these obligations we are delivering against our strengthened biodiversity duty under Section 6(1) of the Environment (Wales) Act 2016. The sections below describe the how we plan to meet our environmental obligations and any impact that this might have on our water resource availability.

Our drinking water supplies are sourced mainly from surface waters – rivers and reservoirs – around Wales. These water bodies are generally of high quality which means they also support a healthy variety of flora and fauna. A significant proportion are designated under national and international law in recognition of their nature conservation importance. We work closely with our regulators, Natural Resources Wales and the Environment Agency, as they set the licences that allow us to abstract water from these water bodies.

Some of our licences allow us to take water from rivers and lakes that are Special Areas of Conservation, a designation made under the EU Habitats Directive. These Areas form part of a pan-European ecological network of "Natura 2000" sites to protect specific priority species and habitats. Under an exercise called the "Review of Consents", our regulators have previously reviewed our existing abstraction licences to make sure that our activities continue to have no significant adverse impact on the environment. For example, we have modified our abstractions on the Rivers Usk and Wye to ensure greater river flows during critical fish migration periods.

We also have a duty to have regard to the river basin management plan (RBMP) when carrying out our functions. The WRPG states that our Plan must support the achievement of Water Framework Directive (WFD) obligations and RBMP objectives and to ensure that our planned abstractions will:

- prevent deterioration in water body status compared to the baseline status reported in the 2015 RBMP;
- However, if deterioration has occurred in the water body during the first RBMP cycle there may be a need to restore sustainable abstraction;
- support the achievement of protected area objectives;
- support the achievement of the environmental objectives in the 2015 Plans and where relevant;
- ensure a new activity or new physical modification does not prevent the future achievement of good status for a water body.

3.3.1. "BREXIT" Position

Early indications from our regulators are that similar or equivalent environmental legislation will remain in place post the UK's withdrawal from the European Union, with only the governance changed. We have therefore assumed that the current environmental standards are still applicable.

3.4. Habitats Directive

The Habitats Directive was brought into UK law through regulations that

- provide for the designation of "European sites" (Natura 2000 sites);
- afford protection of "European protected species";
- provide for the adaptation of planning and other controls for the protection of such sites; and
- Impose a statutory requirement to deliver improvement schemes.

Under the Habitats Regulations, 'competent authorities' i.e. any Minister, government department, statutory authority, public body, or person holding public office, have a general duty, in the exercise of any of their functions, to have regard to the EU Habitats Directive. As the designated competent authority for Wales, Natural Resources Wales is required to ensure that its 'permissions', such as abstraction licences have no adverse effect on the 'integrity' of the Special Areas of Conservation (SAC) and Special Protection Areas (SPA) that form part of the pan-European network of Natura 2000 sites.

As a competent authority ourselves, we must have regard to the requirements of the Habitats Directive so far as they may be affected by the exercise of our functions.

NRW and the EA undertook a detailed review of a number of our abstraction licences and concluded there were twenty-one sites where potential adverse effects upon the protected species could not be discounted. Working closely with both the EA and NRW we have agreed all the required amendments to our abstraction licences in order to ensure they are sustainable now, and into the future. All amendments to our abstraction licences have been built into our baseline deployable output calculations. Table 7 below summarises the outcomes of this process.

Licence	Driver	Implementation Date
River Wye at Broomy Hill	Entrainment	November 2014
River Wye at Monmouth (Wye Transfer)	Flow	April 2018
	Entrainment	December 2017
River Wye at Monmouth (Mayhill)	Flow	April 2018
	Entrainment	December 2017
River Lugg at Byton	Flow	November 2014
Pilleth Boreholes	Flow	May 2015
Dunfield Boreholes	Flow	May 2015
Midsummer Meadow	Flow	May 2015
River Usk at Llantrisant	Flow and Entrainment	December 2018
River Usk at Brecon	Flow and Entrainment	July 2017
Brecon Boreholes	Flow	July 2017
River Usk at Rhadyr (Prioress Mill)	Flow and Entrainment	December 2018
Eastern Cleddau at Pont Hywel	Flow	March 2019
Western Cleddau at Crowhill	Flow	March 2019
	Entrainment	January 2019
Eastern Cleddau at Canaston	Flow	March 2019
	Entrainment	January 2018
Afon Teifi at Llechryd	Entrainment	January 2018
Afon Tywi at Nantgaredig	Flow and Entrainment	December 2018
Afon Tywi at Manorafon	Entrainment	January 2018
Llyn Cwellyn	Fish passage	May 2017
Llyn Eiddew Mawr	Water level	May 2017
Llyn Morwynion	Water level	May 2017
Llwyn Isaf borehole	Groundwater level	November 2010

Table 7 - Habitats Directive Environmental Outcomes

3.5.Water Framework Directive Heavily Modified Water Bodies

The European Water Framework Directive (WFD) (European Parliament 2000) came into force in December 2000 and became part of UK law in December 2003. Under the WFD, all inland water courses are divided into 'water bodies'. Some water bodies are designated as 'heavily modified'. A heavily modified water body (HMWB) is an existing body of water that has had its original character significantly changed to suit a specific purpose, such as water storage and flow regulation for water supply. Where a water body is classified as heavily modified, the UK should aim for that water body to reach Good Ecological Potential (GEP).

Where a waterbody is not at GEP then the required mitigation measures should not have a significant adverse impact upon the use of the water body; in this case on public water supply. All HMWBs should meet GEP by 2027. While the general objective of the WFD is to ensure Good Ecological Status (GES) is attained or retained for all possible water bodies, this may conflict with the specified use of a water body which provides social and economic benefits. Where a water body is designated as a HMWB, the environmental objective under the WFD is therefore to achieve GEP rather than GES.

A number of water bodies have been designated as HWMB due to the presence of our assets and their operation e.g. our impounding reservoirs that have dammed the river and disrupted the natural flow regime. For those sites identified as not being at GEP, NRW required us to investigate whether the main cause of this failure is the effects of our assets, and if so, what steps we should take to resolve this.

During the current five year AMP planning period we undertook the required National Environment Programme (NEP) investigations, working closely with NRW through a series of workshops, with the overall objective of appraising options that will achieve GEP for HMWBs where these are presently inadequate or do not exist. The investigations were undertaken in accordance with the UKWIR HMWB[7] appraisal guidance. Following completion of the investigations, which included the assessment of 'disproportionate cost' when comparing potential improvements against the ecological benefit, a number of schemes are required for us to deliver in order for these water bodies to achieve GEP. A summary of the outputs required for delivery in AMP7 is provided in Table 8 below.

WRZ	Water body	Welsh Water Asset	AMP7 Improvement required
NEYM	Llyn Cefni Afon Cefni - Ceint to Cefni Reservoir	Cefni reservoir	"No regrets" compensation flow
SEWCUS	Afon Taf Fawr - source to conf Taf Fechan	Llwynon reservoir Cantref reservoir Beacons reservoir Pontsticill reservoir	Sediment management "Flushing" flow
SEWCUS	Caerfanell - source to conf R Usk Talybont Reservoir	Talybont reservoir Nant Clydach intake	Ensure flow immediately below the dam Sediment management
SEWCUS	Bettws/Malpas Brook	Pant yr Eos reservoir Ynys y Fro reservoir Henllys intake	"No regrets" residual flow
SEWCUS	Shon-Sheffreys Reservoir Sirhowy R - source to Rock Villas	Shon Sheffrey	Increased compensation flow
SEWCUS	Grwyne Fawr - source to conf Grwyne-Fechan	Grwyne reservoir	Formalisation of compensation flow

[7] Heavily Modified Water Bodies: Guidance Document, UKWIR (2012), report ref: 12/WR/33/4

WRZ	Water body	Welsh Water Asset	AMP7 Improvement required
SEWCUS	Castell Nos Reservoir Lluest-wen Reservoir Afon Rhondda Fach - source to conf Rhondda R	Castell Nos reservoir Lluest wen reservoir	"No regrets" compensation flow Sediment management
SEWCUS	Unnamed tributary - source to conf Rhymney R	Nant Fawr intake	"No regrets" residual flow

Table 8 - HMWB summary of improvements

3.6.Eels regulations

We have undertaken extensive studies during AMP6 to understand our obligations under the Eels regulations[8]. The output from this work is a programme of measures designed to reduce or eliminate the impact that our assets have on Eel lifecycle. We are currently delivering these schemes which include intake screens and eel passes and alternative catchment measures where the hard engineering of schemes is not cost effective. Overall, this work does not impact upon our ability to abstract water or require the additional release of water from our reservoirs. There is, therefore, no impact from the regulations on the DO within any of our WRZs.

3.7.Abstraction Reform

In its 'Water Strategy for Wales' (2015) the Welsh Government confirmed its commitment to reforming the system of abstraction licensing in Wales. The aim is to "Create a better, fairer and more modern approach that will ensure that we make the best possible use of our water resources whilst protecting the environment." (WG, 2016)[9]

The WRPG (2017) states that for catchments managed by NRW, they will review all our abstraction licences at the point of transition and will make changes to licensed volumes where the unused amounts cannot be justified. The evidence NRW require us to provide is detailed in the following bullet points:

- licensed volumes that are part of your deployable output (dry year annual average and/or critical period);
- licensed volumes that are used operationally (e.g. to reduce costs by using low cost groundwater or to retain year to year flexibility) providing records of this use;
- licensed volumes that are retained for emergency purposes e.g. in a drought;
- licensed volumes that are set out in your (or another water company's) feasible options list ;
- adequate infrastructure is in place or will be provided within the life time of the Plan; and
- licensed volumes that are a direct abstraction from a reservoir.

Using the above criteria, we have an undertaken an initial risk assessment of all our abstraction licences to identify those unused licensed volumes that could potentially be removed without impact to our short term and long term water resource capability. The outputs are summarised below. We need to confirm that these

[8] The Eels (England and Wales) Regulations 2009
[9] Making the Most of Every Drop Consultation, Reforming the Water Abstraction Management System in Wales (Welsh Government 2016)

licences do not offer resilience under extreme droughts as part of our contingency plans. We will be undertaking this further review as we develop our Drought Plan in 2018.

Area	No. licences annual use 0%	No. licences annual use 0% - 50%	No. licences annual use 50-80%	No. licences annual use < 80-100%
North	10	11	12	18
South-East	2	5	11	12
South-West	17	21	24	20
Total	29	37	47	50

Table 9 - Current licence use

3.8.AMP7 Environmental Studies

3.8.1. Water Framework Directive 'No deterioration'

After discussions with NRW and EA, we have confirmed that for AMP7 there are currently no abstraction sites identified that, either due to growth or other reasons for increased use will cause an impact upon the waterbody status. This is principally a function of the work completed to date under the Habitats Directive and HMWB projects that have modified a number of our abstraction licences to ensure they are sustainable at their maximum volumes.

All potential new options that involve either increasing existing abstraction, re-instating currently disused abstraction or wholly new abstraction, have been assessed against WFD objectives for the particular water bodies of interest, to ensure no deterioration in their status.

3.8.2. National Environment Programme (Wales and England)

Within our Water Industry National Environment Programme (WINEP) from the Environment Agency, we have been asked to undertake an investigation into the potential effects of our borehole abstraction at Leintwardine upon flows in the River Teme. The River Teme in its upper reaches is known to dry up and it is felt that abstraction within the catchment, including ourselves, exacerbates this situation. Should any negative effects of our abstraction be confirmed then we will also undertake an options appraisal in AMP7 to determine the best course of action to address this.

The National Environment Programme (NEP) we have received from Natural Resources Wales requires us to deliver in AMP7 the HMWB outcomes from the AMP6 investigations. The NEP also asks us to consider any biosecurity risks from the potential transfer of invasive non-native species (INNS) between watercourses.

3.8.3. Invasive Non Native Species (INNS)

By transferring water from one area to another for storage prior to treatment, we risk enabling the spread of invasive non-native species (INNS). INNS are defined as any non-native animals or plants that have the ability to spread outside their native range causing damage to the environment, the economy, our health or the way we live. INNS pose a number of risks to the UK Water Industry (UKWIR 2016).

Recent legislative changes are likely to increase water companies' responsibilities for containing and managing INNS and force the implementation of wider biosecurity measures. Of particular importance are the EU Commission's Invasive Alien Species legislation (EU Invasive Alien Species Regulations (Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014) and The Infrastructure Act 2015 (February 2015). The EU Regulation became law in January 2015. It proposes interventions in the forms of: prevention; early warning and rapid response; and; management of the spread of INNS. It requires Member States to produce a list of INNS of concern, which is to be managed using risk assessments and scientific evidence. Table 10 shows a summary of the risk assessment of our raw water abstractions that we have undertaken as part of the 2019 Price Review (PR19). This will be used to inform our WINEP investigations required in AMP7.

Site	Does the water go straight to WTW? Y/N	If No, does the water stay in the same catchment Y/N	If yes does the water stay in the same water course Y/N	If No which water course does the water go to?
Nant Bodwigiad	N	N		Nant Bwllfa &/or Camnant
Nant y Bwllfa	N	N		Nant Bwllfa &/or Camnant
River Usk at Prioress Mill	N	N		Sor Brook via Llandegfedd
Henllys Brook	N	N		Malpas Brook via Ynys y Fro
Nantypridd Brook	N	N		Llanvaches Brook
Castroggy Brook	N	N		Llanvaches Brook
Lower lodge stream	N	N		Llanvaches Brook
Long meadow intake	N	N		Llanvaches Brook
Nant Carnfoesen	N	N		River Neath
Nant Garreg Lwyd	N	N		River Neath
Rhymney Bridge spring	N	N		River Sirhowy via Rhymney Br2
Nant Clydach (Talybont)	N	Y	N	Afon Caerfanell
Eastern Cleddau at Pont Hywel	N	N		Afon Syfynwy
River Towy at Nantgaredig	N	N		Afon Lliw/ Loughor to Taf
Tallin stream near Llandecwyn	N	N		Llyn Tecwyn Uchaf
Afon Gam - Llyn Morwynion refill	N	N		Llyn Morwynion
Afon Hesgin catchwater	N	N		Afon Tryweryn via Llyn Celyn
Bryn Aled intake	N	N		Afon Elwy via Plas Uchaf reservoir

Table 10 - INNS Risk Assessment of Raw Water Transfers

3.9. Climate change

3.9.1. Introduction

Climate change is expected to result in drier hotter summers and wetter winters across Wales and generally more extreme rainfall events. Welsh Government's Future Generations Act recognises that climate change is one of many challenges facing Wales now and into the future and that the case for action on climate change is clear and fundamental to the future prosperity and future resilience of our communities[10].

This change in the climate has the potential to reduce the amount of flow within our river and reservoir catchments into the future, meaning we will have a lower amount that can be relied upon. To ensure our customer supplies are secure and robust in the long term, our planning needs to account for climate change. We do this in two ways:

1. By estimating the most likely impact of climate change upon our supply capability (DO) into the future using our WRAPSim supply system models and making a direct allowance for this in our supply demand balances. The basic process is to adjust the simulated river and reservoir inflows to represent what they may look like under a changing climate. This is done for each of a number of potential future climate change scenarios. Our system simulation models are re-run as per the process described in Section 3.2. The most likely impact on DO is then calculated from this set of model runs.

2. By looking at the uncertainty around the climate change driven inflow projections used in our model runs. We include this uncertainty along with other uncertainty factors within our planning buffer assessment, 'Target Headroom' (see section 3.16).

The WRPG (2017) sets out the requirement for the assessment of climate change impact on WRZ DO utilising the following methodologies:

- Environment Agency (2017) WRMP19 supplementary information: Estimating impacts of climate change on water supply;
- Environment Agency (2013) Climate change approaches in water resources planning – Overview of new methods.

The approach set out in the estimating impacts of climate change report (EA, 2017), identifies four sections required for the climate change assessment:

- Vulnerability assessment;
- Calculation of river flows for a water resource zone in the 2080s;
- Calculation of DOs for the 2080s; and
- Scaling and uncertainty.

3.9.2. Basic vulnerability assessment

The basic vulnerability assessment has been applied to each WRZ using existing analysis from Water Resource Management Plans and Drought Plans together with currently known constraints and vulnerabilities in the systems. The assessment classifies a WRZ as either 'high', 'medium' or 'low' susceptibility to climate change, by considering the sensitivity and vulnerability of the water resources based on the following definitions:

---

[10] http://gov.wales/topics/environmentcountryside/climatechange/climate-change-future-generations-act/?lang=en

- Vulnerability: Climate vulnerability defines the extent to which a system is susceptible to, or unable to cope with, adverse effects of climate change including climate variability and extremes. It depends not only on a system's sensitivity but also on its adaptive capacity;

- Sensitivity: The degree to which a system is affected, either adversely or beneficially, by climate variability or change.

The final vulnerability classification for each of our twenty four WRZ is presented in Table 11. Although Lleyn Harlech is not classified as a high vulnerability WRZ, due to its connectivity with Barmouth this WRZ has been treated as a high vulnerability zone for the purpose of UKCP09 climate change projections.

High vulnerability	Medium Vulnerability	Low Vulnerability	Climate change resilient
Barmouth **NEYM** **Pembrokeshire** **SEWCUS** **Tywyn Aberdyfi**	Blaenau Ffestiniog Clwyd Coastal **Lleyn Harlech** N Ceredigion	Alwen Dee Bala Dyffryn Conwy M&S Ceredigion S Meirionydd Tywi Gower	Brecon Elan Hereford Monmouth Pilleth Ross on Wye Vowchurch Whitbourne Llyswen

Table 11 - Classification of WRZ

3.9.3. Approach to Climate Change Impact assessment

The Environment Agency (2016) published a guidance note for water companies in England that recommends the use of the 2080s planning horizon in assessing climate change impacts as part of WRMP 2019. This is due to concerns that natural variability in the 2030s can mask the impacts of climate change and potentially underestimate the climate change signal. However, it is recognised that an updated set of climate change projections is due for release in 2018 (UKCP18) and UKWIR has also recently commissioned a study to develop new approaches for considering climate change in the WRMP process to support the next round of plans (WRMP 2024).

Following discussions with NRW, the proposed approach for our high vulnerability WRZs for this Plan is to utilise the 2030s time horizon for baseline planning and use the 2080s as a sensitivity check. This provides a robust understanding of the sensitivity and longer-term challenges that might be faced in highly vulnerable zones and a view as to the potential time frames over which significant impacts might manifest and the projected urgency for any investment. The use of the 2030s and 2080s (both under a Medium Emission scenario) also provides a wide 'envelope' of scenarios that can be reviewed and reinterpreted following publication of UKCP18 and the new UKWIR guidance. The approach taken for the climate change impact assessment is in line with the WRPG. Table 12 provides a summary of the proposed methodology.

Vulnerability	Water Resource Zones	Methodology
Low	Alwen Dee, Bala, Dyffryn Conwy, M&S Ceredigion, South Meirionydd, Tywi Gower	Future Flows factors for the 2030s from the last assessment in 2012 are applied again for this assessment. DO impacts will be scaled to 2049/50.
Medium	Blaenau Ffestiniog, Clwyd Coastal, Lleyn Harlech, N Ceredigion	Future Flows factors for the 2030s from the last assessment in 2012 are applied again for this assessment. DO impacts will be scaled to 2049/50.

High	Barmouth, NEYM, Pembrokeshire, SEWCUS, Tywyn Aberdyfi	The impacts for both the 2030s and 2080s are considered for high vulnerability WRZs. UKCP09 Factors for the 2030s from the previous assessment will be used (and back scaled to 2049/50).The 2030s impacts will be modelled for Tywyn Aberdyfi and Barmouth, which were previously classified as medium vulnerability.

Table 12 - Summary of proposed methods according to vulnerability classification

3.9.4. DO modelling for climate change analysis

For this Plan, climate change projections for the 2030s have been generated using the 2009 United Kingdom Climate Projections (UKCP09) outputs so as to derive various river and reservoir inflow scenarios. The methodology to calculate river flows in low and medium vulnerability zones remains identical to WRMP14 and is based on using Flow Factors from the 2030 planning horizon scaled up to 2049-50.

High vulnerability zones have been assessed for both 2030s and 2080s planning horizons under a medium emission scenario. The methodology involves producing a range of perturbed weather scenarios. The temperature and rainfall data produced from these scenarios are then used to model their hydrological impact on water resources in each WRZ. This modelling has produced multiple river flow series for the 2030s and 2080s horizon, which have been subsampled into 20 representative climate change scenarios. The selection of the 20 scenarios focusses either on reservoir storage or on river flows depending on the primary water source of each WRZ. These scenarios have then been modelled in WRAPSim to understand the impact to DO.

The WRAPSim climate change assessment process is consistent with that applied for the baseline DO assessment. Monthly flow factors are applied to all sources within each WRZ to be assessed, for each climate scenario. Flow factors are grouped into 'catchments' within each zone, grouping sources by hydrological, meteorological and geomorphological similarities, and thus applying the same flow factors. Flow factors represent the monthly magnitude of change expected in the hydrological inflows for each source, and are applied to reservoir and river inflows in the zonal WRAPSim models to perturb the inflows accordingly. Full details of the WRAPSim climate change modelling are provided in Appendix 10 – Impact of Climate Change on DO (AmecFW), Appendix 11 – Climate Change Flow Factor (HRWallingford), and Appendix 12 – Basic Vulnerability Assessment (HRWallingford).

3.9.5. Best Estimate Impact on Deployable Output

The methodology for calculating the direct climate change impact to DO involves the generation of a 'Best Estimate' of the impact into the future. The process is to run the representative climate change scenarios to understand the impact on DO for each climate change projection. A suite of 11 Future Flows or 20 UKCP09 2030s projections have been run through the WRAPSim models. A summary of the climate change impacts on baseline DO in terms of minimum AADO for all the zones is presented in Table 13.

Water Resource Zone	WRMP19 Baseline minimum AADO	Most positive impact (Ml/d)	Most negative impact (Ml/d)
Alwen Dee	56.55	56.76	54.91
Bala	1.77	1.77	1.77
Barmouth	1.72	1.72	1.44
Blaenau Ffestiniog	1.95	1.95	1.95
Clwyd Coastal	26.06	26.11	25.81
Dyffryn Conwy	35.76	36.70	34.31
Lleyn Harlech	17.47	17.77	15.78
Mid &South Ceredigion	22.53	22.53	22.53

NEYM	52.04	52.04	41.11
North Ceredigion	12.44	12.59	11.97
Pembrokeshire	74.31	74.54	56.04
SEWCUS	422.49	437.17	374.38
South Meirionydd	2.41	2.41	2.34
Tywi Gower	221.68	221.68	221.68
Tywyn Aberdyfi	1.25	1.50	0.31

Table 13 - Predicted 2030s climate change impacts on min AADO in all Zones

The calculation of the 'Best Estimate' impacts of climate change on DO is as follows:

- The medium and low vulnerability WRZs which use Future Flows climate projections are equally weighted. Therefore, the best estimate of the impact of climate change on DO has been calculated by simply taking the mean of the WRAPSim modelled DOs.

- The high vulnerability WRZs use 20 weighted UKCP09 projections. In this case the 'best' estimate has been calculated by using a weighted mean of the WRAPSim modelled DOs

The 'best estimate' value for climate change impact in each year to 2030 is then interpolated from this result. We have also tested the impact of assessing the impact using data to 2080 for high vulnerability zones. The results of this testing are provided in chapter 7. Many of the climate change scenarios indicate a lower DO in the future, as shown in Figure 8, and so the impact to our supply systems will be a gradual reduction in the amount of water available to us during a dry year. The value for each year is applied within the supply demand balances as a direct reduction to DO in Ml/d.

3.9.6. Groundwater assessment

We have relatively short records of groundwater levels under dry weather conditions, which makes it difficult to forecast the potential effects of climate change upon their yield. Our records do show that we have not had any significant issues with borehole yield during known drought events such as 1976, 1984 and 1995 and so our assumption for this Plan is that they are climate change resilient. We are now collecting additional groundwater information in order that we can improve our hydrogeological analysis of source yields in AMP7.

3.9.7. Uncertainty due to Climate Change

Figure 8 provides an example of a distribution of climate change impacts on DO for the SEWCUS water resource zone. The distribution demonstrates that sixteen of the twenty, 2030s climate scenarios, have a negative impact, and of the negative impacting scenarios, two are more extreme, beyond -10% impact. A further three scenarios have a positive impact. One scenario, 5472, has a negligible impact, with minimum AADO remaining at the baseline level.

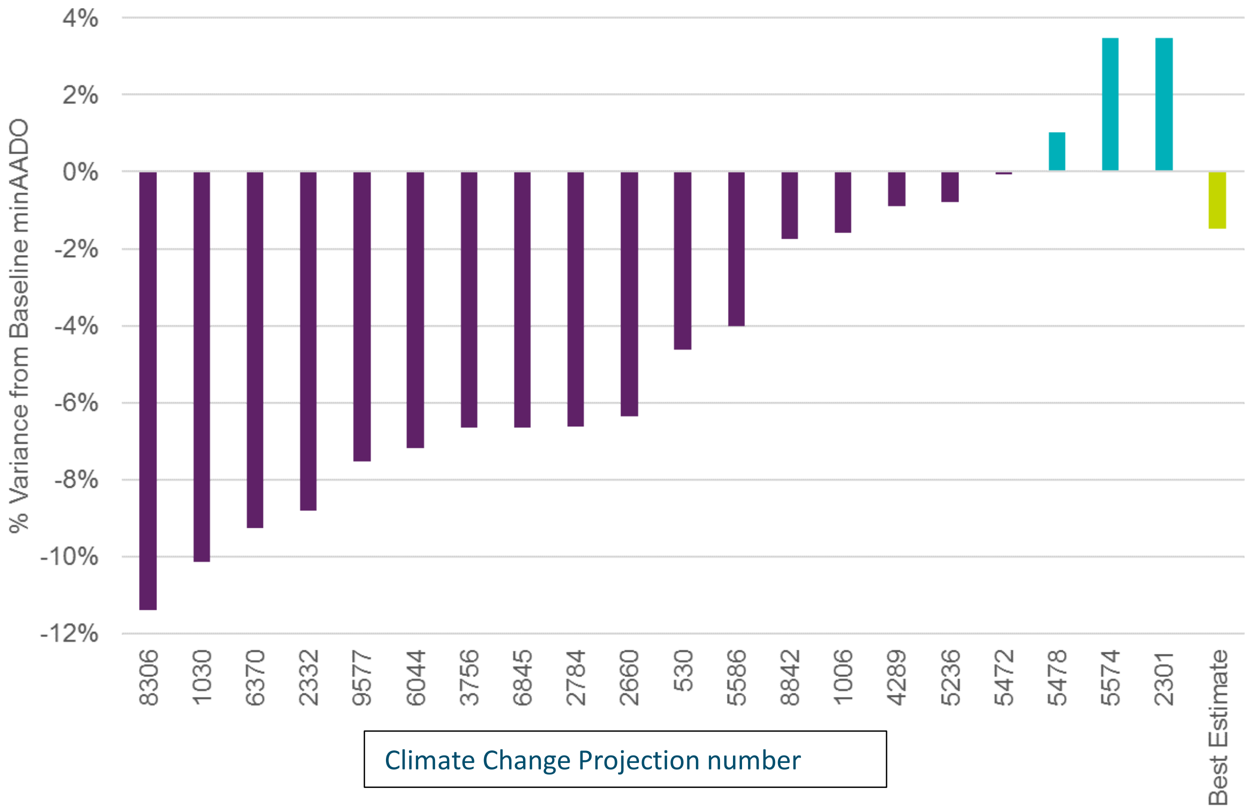


Figure 8 - Minimum AADO variance from Baseline in SEWCUS for all 20 UKCP09 2030s projections

Figure 8 also shows that whilst the 'Best Estimate' impact is calculated as an approximate 2% reduction in DO, the range of potential climate change is much wider, ranging from +3% to -11%. We therefore make an allowance within our 'Target Headroom' assessment for the potential risk that the true impact of climate change we see is much worse than our average 'Best Estimate'. The more extreme the climate change scenarios are in terms of range of impact to DO then the greater our uncertainty allowance will need to be. Conversely, for those WRZs where climate change is forecast to have little or no impact, then only a small headroom allowance is needed.

3.10. Operational use and losses

As described in the introduction to the chapter we need to account for a number of other factors in our supply demand balances to accurately account for the water that is actually available to meet zonal demands.

The deployable output of a source can be reduced by

- the raw water losses: water lost between the point of abstraction and the point of entry to the water treatment works;
- the treatment works operational use (TWOU): water lost during the treatment process.

3.10.1. Raw Water Losses

Raw water mains are the pipes that connect the source to either the first water treatment point or to raw water storage. For each main, one of two methods can be used to establish the raw losses:

- The actual difference between the raw water source meter and the WTW/raw storage inlet meter when these are present;

- If metering is not available, then losses are estimated using the average leakage rate per km of main multiplied by the known length of the main assessed. The average figure is derived from actual measured losses recorded across our raw water mains.

Occasionally raw water losses are included within the TWOU calculation (for example when the WTW inlet meter location is the raw water meter), in which case no raw losses are included for the purpose of the supply forecast. The calculated raw losses per WRZ for this Plan are presented in Table 14.

WRZ	Raw losses (Ml/d)	WRZ	Raw losses (Ml/d)
North Eryri Ynys Môn	0.46	**Hereford CUS**	0.035
Clwyd Coastal	0.192	**Llyswen**	0.001
Alwen Dee	0.222	**Monmouth**	0.029
Bala	0.004	**Pilleth**	0.015
Tywyn Aberdyfi	0.06	**Brecon Portis**	0.012
Blaenau Ffestiniog	0.028	**Vowchurch**	0.011
Barmouth	0.463	**Whitbourne**	0.002
Lleyn Harlech	0.454	**SEWCUS**	4.364
Dyffryn Conwy	1.898	**Tywi CUS**	1.635
South Meirionnydd	0.077	**Mid & South Ceredigion**	0.363
Ross on Wye	n/a	**North Ceredigion**	0.340
Elan Builth	0.06	**Pembrokeshire**	0.748

Table 14 - Summary raw losses across our WRZ

3.10.2. Treatment Works Operational Use (TWOU)

Our methodology for understanding TWOU is based on three separate calculations:

- The difference between raw water meter (flow entering a water treatment works (WTW)) and distribution input meter (flow leaving a WTW);
- The wastewater meter flow data;
- The theoretical process utilisation equivalent to the sum of the losses assigned for each specific treatment process that occurs at the WTW.

The three calculated values have been converted into a percentage of raw water inflow and averaged to give an overall value for each WTW. The WTW's values are combined and scaled accordingly to give an overall WRZ value. This methodology allows for a reduction in the impact of the potential inaccuracies associated with each method, for example:

- The meter accuracy in detecting low differences between measured volumes
- Some WTW do not have meters in place to measure all waste discharges
- Theoretical losses would not reflect unusual events such as maintenance

The TWOU percentage at each WRZ level is applied to the DO value for each zone to obtain the TWOU reduction volume. The same percentage TWOU value is applied across the whole planning period.

The calculated TWOU for our zones varies between 0% (WRZ reliant solely on groundwater sources or imports) to 10.5%. The TWOU can be relatively high where waste water cannot be recycled to be put back through the works, for example due to water quality concern. Figure 9 shows the scale of TWOU in each of our WRZs for this Plan under the Dry Year Annual average planning scenario expressed as a percentage of Deployable Output.

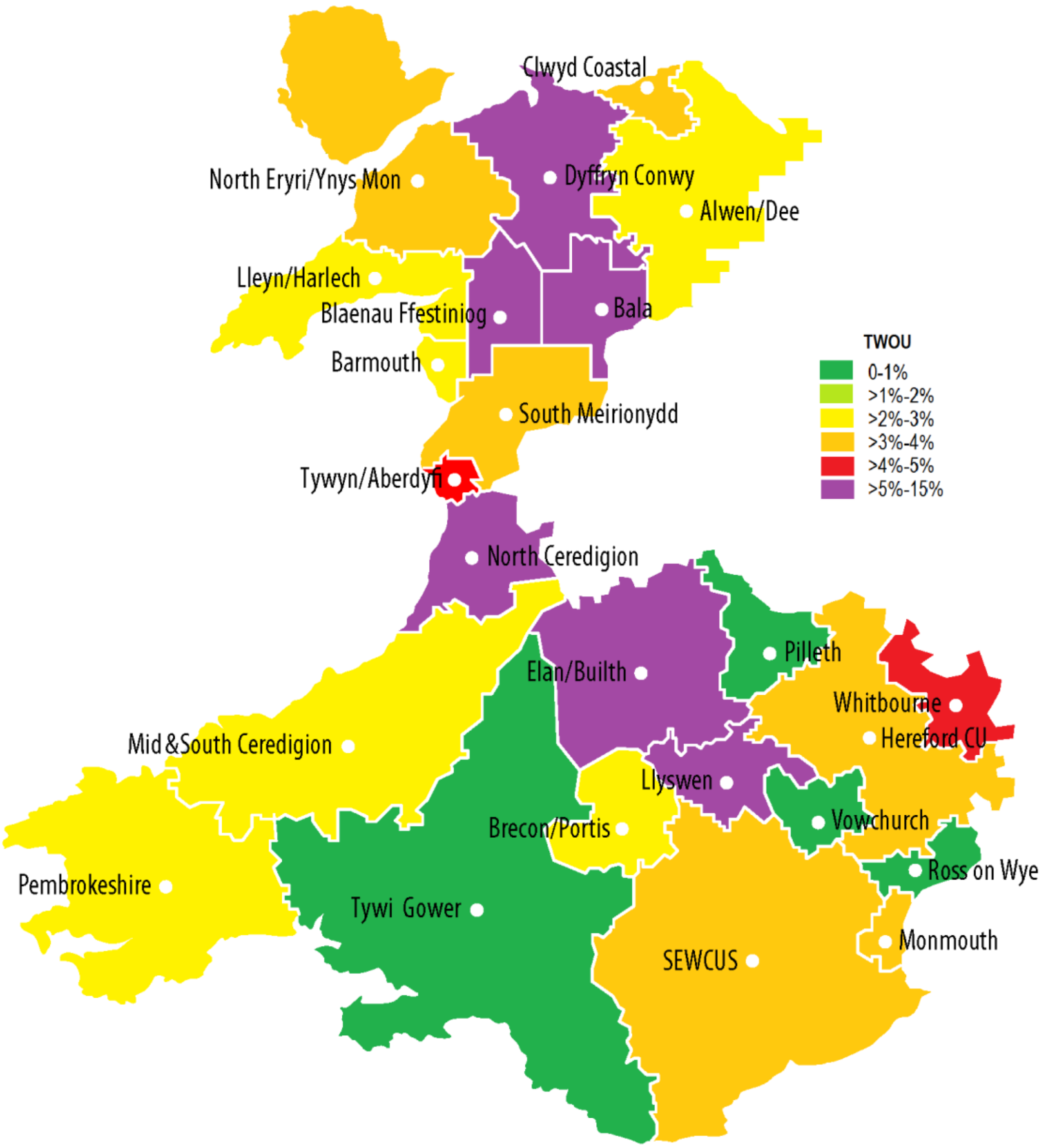


Figure 9 - Summary TWOU results across our WRZs

3.11. Outage allowance

Our modelled DO value assumes that all of our sources are available at all times. This is not always the case and any 'Outages' to water resource capability needs to be accounted for within the supply demand balance. Outage is defined as the temporary (less than 3 months) reduction or loss of DO at the source works. These reductions can be due to planned outage events such as maintenance, or unplanned outage circumstances such as high turbidity of a raw water source.

Our assessment follows the latest UKWIR guidance which includes a choice of several methods that can be used. The guidance was recently updated to allow risk based approaches to be utilised. We have already adopted a risk-based, probabilistic modelling methodology in previous Plans, which features as one of the methods in the current guidance. The same methodology has been applied for this Plan.

We have been collecting and analysing potential outages based on WTW metered data on a monthly basis since 2005. Consultation with our operational staff then allows us to screen the genuine outage events from those that would not reduce our output during a drought or high demand period. Discussion of what is driving the allowances, and comparison with the previous Plan is presented in Appendix 13.

Full details of our Outage methodology and calculations are provided in Appendix 13. Figure 10 shows the scale of outage allowance in each of our WRZs for this Plan under the Dry Year Annual average planning scenario expressed as a percentage of Deployable Output.

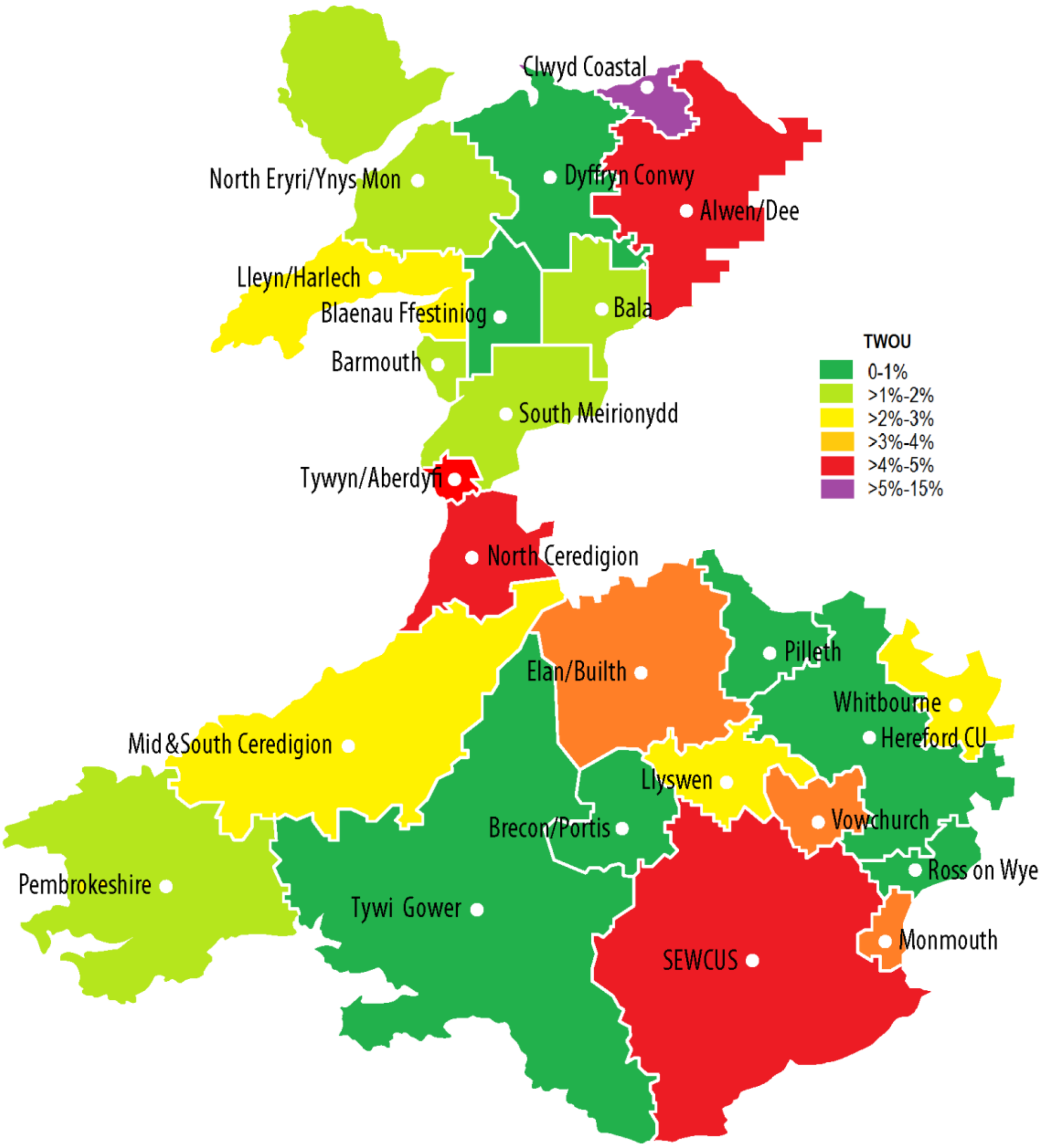


Figure 10 - 'Dry Year Annual Average' Outage allowances as a percentage of DO

3.12. Transfers of Water

To fully assess our supply capability we need to take account of the water that is moved internally between our WRZs and externally to neighbouring water companies. Within Welsh Water we have a number of transfers that help meet demands for water during peak periods. Through a series of operational actions on our potable network we are able to re-zone particular areas of demand onto alternative sources in a neighbouring area. This reduces the demand on the zone to a certain extent.

Our external transfers of water are principally to Severn Trent Water and Dee Valley Water. The transfers between ourselves and Severn Trent in the Mid Wales areas have arisen primarily as a function of the geography of the area where it is more economic to utilise supplies from outside of the company boundary than it is to extend our existing network. The Ross on Wye import from Severn Trent provides the whole of the supply for that WRZ.

A summary of all transfers expected in 2020 are shown in Table 15 below. These transfers are all potable water and so there are no risks from poor raw water quality. The maximum quantities identified are those that can be provided under drought conditions with agreements in place for the external transfers which guarantees these volumes. The quantities transferred are generally limited by infrastructure constraints and so new asset would be required to increase the maximum volumes. The transfers are all single direction with no ability to reverse the flow.

Export from	Import to	Maximum volume (Ml/d)	Description
Internal water transfers			
Hereford CUS WRZ	Vowchurch WRZ	0.46	The internal transfer figures are based upon the results of "WRAPSim" modelling and confirmation of network capacities.
Hereford CUS WRZ	Ross-on-Wye WRZ	1	
Hereford CUS WRZ	Whitbourne WRZ	1	
Llyswen	Vowchurch	0.13	
Lleyn Harlech WRZ	Barmouth WRZ	1	
Tywi CUS WRZ	SEWCUS WRZ	12.03	
External water transfers			
Alwen Dee WRZ	Dee Valley Water	0.16	DCWW export a small amount of water to Dee Valley Water in the lower part of the Dee system.
South Meirionnydd WRZ	Severn Trent Water	0.12	DCWW and Severn Trent exchange water across the boundary of South Meirionnydd due to the limited supplies in the area.
Severn Trent Water	South Meirionnydd WRZ	0.45	DCWW and Severn Trent exchange water across the boundary of South Meirionnydd due to the limited supplies in the area.
Severn Trent Water	Ross-on-Wye WRZ	9	DCWW imports all of the water for this WRZ

Note: Elan Builth WRZ exports water to Severn Trent Water (up to a maximum of 381 Ml/d). However since this is fully under the control of Severn Trent Water it is excluded from the DO for the zone.

Table 15 - Transfers of water

3.13. Non-potable water

As well as the transfer of potable water, we also have a number of supplies for non-potable water that need to be accounted for when assessing the overall supply capability within a zone. Full details of these sources are reported to Ofwat and NRW/EA as part of our Annual Reporting requirements. We supply non-potable water in the following areas:

- Pembrokeshire WRZ: raw water is supplied to the industrial area of Milford Haven. This is classified as an export within our supply forecast.
- SEWCUS WRZ: raw water is supplied to a steel manufacturer. This water is directly accounted for in the DO within our supply forecast.
- Alwen-Dee WRZ: raw water is provided directly from a single source to Albion Water. As it has no connectivity with other supplies in that area, this water is not included within our supply forecast.
- All WRZ: We have a small number of sources that supply water to single industrial customers. As this water has no connectivity with other supplies in these areas, this water is not included within our supply forecast as it is not available for use by our other customers.

3.14. Drinking Water Quality

Welsh Water abstracts water for supply from 120 catchments covering an area of almost 11,000km². Land within these catchments is subject to a variety of land use types and management practices. We have limited land holding across the catchments and consequently we have little control of land activities. Stock management, tree planting and harvesting, and the use of chemicals including pesticides, fertilisers or nutrients can present a risk to raw water quality and treatment challenges for our water treatment works.

Increased intensification of agriculture and tree felling, combined with more intense storms may lead to greater concentrations of pesticides, fertilisers, nutrients and pathogens in raw water and more turbid water reaching our water treatment works. We believe therefore that the 'catchments as a first line of defence' approach is crucial to the future safeguarding of drinking water quality.

For this Plan we have undertaken a review of the relationship between the raw water quality of our catchments and our treatment capability to understand the current position and whether there are any catchment constraints to DO. We have used our outage database described in section 3.11 to understand where water quality issues are leading to reductions in DO. We have then reviewed whether there are any options to increase DO in the zones where we have a supply demand deficit. This is not the case as detailed in the Catchment Options Appraisal report (Appendix 14 - Catchment Options Appraisal (AmecFW)).

Looking to the future, the company's strategy is to maintain or improve the water quality in the catchments we rely on for our water supply so that our DO is not impacted. We have instigated our WaterSource initiative, the name given to our Catchment Management approach. We are currently undertaking a number of schemes through co-creation partnering in line with Welsh Government's Well Being of Future Generations agenda. Existing schemes include:

- Building Resilience into Catchment (BRICS – Eastern and Western Cleddau rivers)
- Taclo'r Tywi – River Towy catchment improvement
- PestSmart – pesticide disposal scheme and the Weed-wiper Partnership
- Cantref – tree planting scheme to reduce landslip impact
- Pendine –Safeguard Zone
- Alwen – grip blocking scheme with RSPB looking at improvements to organics
- Cefni – wetlands LIFE project – NRW led on this, DCWW acting as partners
- Brecon Beacons Mega Catchment

Details of two of our key initiatives are given below.

3.14.1. Weed-wiper Partnership

In 2015/16 we successfully worked with Natural Resources Wales and the farming industry on an innovative campaign to tackle the rising levels of the grassland herbicide MCPA in water abstracted for supply in two catchment areas, River Teifi and River Wye. Working together, best practice advice was provided and land managers were offered free hire of a weed wiper; an alternative application method that reduces the risk of herbicide loss into watercourses.

Following the success of this trial, where we have seen 618 hectares weed wiped and a significant reduction in MCPA detection in 2015, lower than the previous 2 years, we are extending it further into the Afon Teifi catchment for the 2017 season.

3.14.2. Brecon Beacons Mega Catchment

Around half of the water we abstract for customers supply on a daily basis comes from the Brecon Beacons (Figure 11). There is a need to ensure that the raw water entering our treatment works is of a consistent and manageable quality. Without control of the raw water quality entering water treatment works, the treatment process will require upgrades and more robust processes to deal with the deteriorating and more variable raw water quality.

.

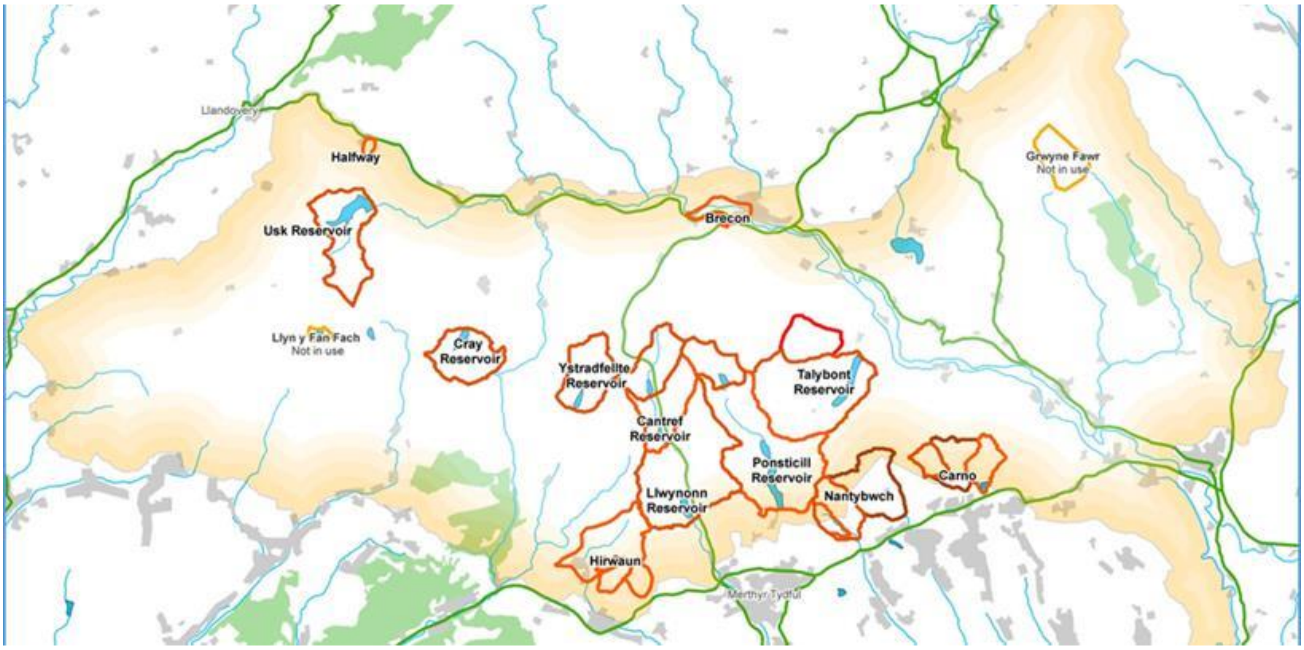


Figure 11 - Brecon Beacons "mega catchment"

We are working in partnership with the Brecon Beacons National Park and other key stakeholders to identify common areas of interest for future collaboration. We are developing new ways to work with land managers to promote their adoption of supporting activities and behaviours such as taking a “farming for water” approach. This work helps meet our 2050 vision and aligns with Welsh Government’s Environment Act as a good example of the Ecosystems Service approach in action.

Specifically for this Plan, in Chapter 6 we outline our approach to the assessment of catchment based options as potential solutions to Supply-Demand balance deficit zones including how for each Water Treatment Works we have identified the most likely option(s) from the short list that would address the problem. This is aligned and consistent with the company’s Drinking Water Safety Plans and Outage assessment.

3.15. Target Headroom

Long term supply demand assessment is a complex process involving the analysis of large amounts of data, with varying degrees of certainty around each of these data sources. We need to make an allowance for these risks so that we can be certain of always having a sufficient supply of water to our customers. We therefore make an allowance for ‘risk’ in our supply demand balance to account for the uncertainties. The key areas of inaccuracy are in our demand forecasts, the predicted effects of climate change, and our hydrological data that is critical in the calculation of Deployable Output. Figure 12 and Figure 13 show how the uncertainties associated with these three areas feed into the overall headroom allowance. The estimation of “Target headroom” is a key part of the supply demand balance for the baseline and final planning scenarios.

In our preparatory work for this Plan we have taken account of recent UKWIR methodologies and their incorporation into the WRPG 2017. There are two projects from the UKWIR WRMP 2019 Methods programme whose guidance is particularly important for assessing uncertainty and hence risk: UKWIR (2016) *WRMP19 Methods – Risk Based Planning* and UKWIR (2016) *WRMP19 Methods – Decision Making Process*. As required by the guidance we have undertaken a risk characterisation approach and produced a ‘Final Problem Characterisation Report’ which includes the recommended approach for assessing uncertainty within each of the WRZ’s. The report confirms that the conventional UKWIR method of Target Headroom ‘An Improved Methodology for Assessing Headroom (2002)’ is still appropriate for all our zones and should be maintained.

Hence for this Plan, the UKWIR 2002 headroom methodology has been applied using a Microsoft Excel spreadsheet based Monte Carlo simulation model with Crystal Ball add-in software. Application of the UKWIR 2002 methodology to calculate headroom uncertainty across our supply area provides consistency across all WRZs together with a clear audit path. During the process of updating the headroom model for this Plan, full account will has been made of all previous comments received on the headroom model outputs produced for WRMP14. Full details of our Headroom assessment are in Appendix 3.

In line with the recommended approaches set out in Section 5 of the WRPG (2017), a new headroom model was written in Microsoft Excel to undertake Monte Carlo simulations required for the UKWIR 2002 methodology utilising the Oracle Crystal Ball add-in. The model incorporates the same range of operations and functions as the model produced for WRMP14, but with improved usability.

The application calculates headroom uncertainty for the whole of the planning period from the base years (2016 - 2020) through to 2050 with outputs for each WRZ expressed as a probability distribution function (pdf); the absolute value of target headroom is then chosen according to the level of risk at each year in the planning period that we have decided to allow for. Within Welsh Water we are happy to accept a greater level of headroom uncertainty later into the thirty year planning period, as we are confident in having sufficient time to adapt our systems. We therefore reduce the percentile selected every five years until we are accepting a 25% chance from 2040 onwards that the actual performance of system will be outside of our forecasted performance. Table 16 outlines our chosen risk profile. Headroom uncertainty has been calculated for the Dry Year Annual Average (DYAA) and Dry Year Critical Period (DYCP) planning scenarios for each WRZ.

Year beginning	2020 – 2024	2025 – 2029	2030 – 2034	2035 – 2039	2040 – 2050
Percentile	95th	90th	85th	80th	75th

Table 16 - DCWW headroom risk profile

3.15.1. Supply-side headroom components

The supply-side headroom components (from UKWIR 2002) are listed in Table 17. Components S1 to S5 were not included in WRMP14 and are also not included in the dWRMP19 analysis.

Supply-side headroom component	Description
S1	Vulnerable surface water licences
S2	Vulnerable groundwater licences
S3	Time-limited licences
S4	Uncertainty surrounding bulk imports
S5	Gradual pollution of sources causing a reduction in abstraction
S6-1	Accuracy of supply-side data - Licence constrained sources (meter error)
S6-2	Accuracy of supply-side data - Infrastructure constrained sources (pump uncertainty etc.)
S6-3	Accuracy of supply-side data - Hydrology constrained (SW sources)
S6-4	Accuracy of supply-side data - Aquifer constrained (GW sources)
S8	Uncertainty of impact of climate change
S9	Uncertainty of a new scheme

Table 17 - Supply-side headroom components

3.15.2. Supply-side headroom components not used

At per WRMP14, we consider that uncertainties under components S1 to S3 should not be included in the analysis of target headroom. Abstraction licence uncertainty is associated with various regulatory processes such as implementation of the Water Framework Directive. However, government and regulators have indicated that measures to reduce, revoke or not renew existing abstraction licences would not be taken until alternative options had been secured to maintain the supply-demand balance and hence security of supply to customers. That view remains unchanged, so components S1 to S3 continue to be excluded from this analysis. The EA and NRW will formally notify water companies of confirmed and unconfirmed sustainability changes to abstraction licences and so in line with the WRPG, water companies are advised to not "…include any uncertainty about sustainability changes within your plan".

We receive bulk-supply imports from Severn Trent Water into the Ross-on-Wye and the South Meirionnydd WRZs. Discussions between our two companies have confirmed that these supplies would remain secure until the end of the planning period. The S4 component has therefore not been included in the analysis for any zones.

As for the previous analysis, we do not have any sources where gradual pollution is expected to have an impact on source output; component S5 has therefore been excluded from the analysis for this Plan.

3.15.3. Headroom Outputs

A baseline headroom analysis is run for each WRZ under the Dry Year Annual Average (DYAA) and Dry Year Critical Period (DYCP) scenarios. The outputs from the headroom analysis are the probability distribution of headroom uncertainty for each year of the planning period for each headroom component, which are then combined to give a Total headroom distribution for all components. The glidepath selected (i.e. the level of risk considered acceptable) is then used to extract the exact Target Headroom values (in Ml/d) to input into the final supply-demand planning tables. Table 18 presents the target headroom values outputted for each WRZ for the DYAA scenario in five year time-steps (actual model outputs provide a headroom value for each individual year in the planning horizon for use in the planning tables). We have set ourselves a challenging target for per capita consumption which has large positive effects for our zonal balances as demand is predicted to fall significantly by the end of the planning period. However, we are mindful that there are uncertainties, particularly in the long term, in achieving the PCC target of 100 l/hd/d by 2050. We have therefore taken account of this within our Headroom allowances in this Plan.

WRZ		**DYAA Target Headroom (Ml/d)**						
		Year	2020	2025	2030	2035	2040	2050
Ref	Name	Glidepath %	95%	90%	85%	80%	75%	75%
8001	North Eryri Ynys Môn		3.18	4.07	4.91	5.32	5.78	7.50
8012	Clwyd Coastal		1.15	0.95	0.82	1.01	1.19	1.94
8014	Alwen Dee		3.22	3.10	3.17	3.61	4.06	5.98
8020	Bala		0.08	0.07	0.06	0.07	0.08	0.13
8021	Tywyn Aberdyfi		0.39	0.81	1.19	1.28	1.37	1.60
8026	Blaenau Ffestiniog		0.08	0.07	0.06	0.08	0.10	0.17
8033	Barmouth		0.09	0.09	0.10	0.10	0.12	0.16
8034	Lleyn Harlech		0.90	1.02	1.18	1.26	1.35	1.78
8035	Dyffryn Conwy		1.58	1.31	1.21	1.38	1.58	2.56
8036	South Meirionnydd		0.12	0.10	0.09	0.11	0.13	0.21
8101	Ross-on-Wye		0.33	0.28	0.24	0.30	0.36	0.59
8102	Elan Builth		0.28	0.23	0.21	0.25	0.29	0.47
8103	Hereford		2.05	1.69	1.54	1.83	2.19	3.50
8105	Llyswen		0.16	0.14	0.12	0.13	0.15	0.24
8106	Monmouth		0.19	0.15	0.13	0.17	0.21	0.36
8107	Pilleth		0.12	0.11	0.10	0.12	0.14	0.23
8108	Brecon Portis		0.21	0.17	0.15	0.17	0.19	0.30
8110	Vowchurch		0.13	0.10	0.09	0.11	0.13	0.21
8111	Whitbourne		0.30	0.26	0.23	0.26	0.29	0.45
8121	SEWCUS		23.09	24.26	26.39	28.85	32.22	48.29
8201	Tywi CU		10.09	8.21	7.37	9.41	11.83	20.09
8202	MS Ceredigion		1.11	0.95	0.86	0.99	1.15	1.77
8203	N Ceredigion		0.61	0.57	0.57	0.61	0.66	0.93
8206	Pembrokeshire		6.68	9.22	11.81	12.18	12.68	15.46

Table 18 - DYAA Target Headroom values for 2020-2050 for all WRZ's

The headroom model also calculates indicative values for the contribution of each of the components to the total headroom uncertainty. This is achieved by calculating the probability distribution of each component's input into the total headroom uncertainty, and plotting their relative contribution on a bar chart (see examples in Figure 12 and Figure 13). These values can be used to sense-check the model inputs, i.e. that a component has a sensible magnitude of uncertainty, in the correct direction.

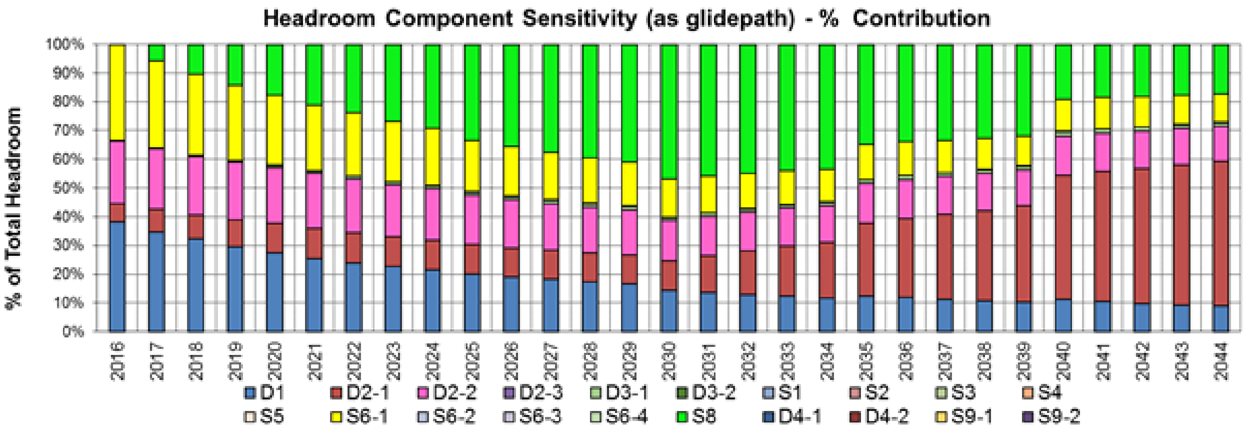


Figure 12 - SEWCUS DYAA – indicative percentage contribution of components to headroom uncertainty

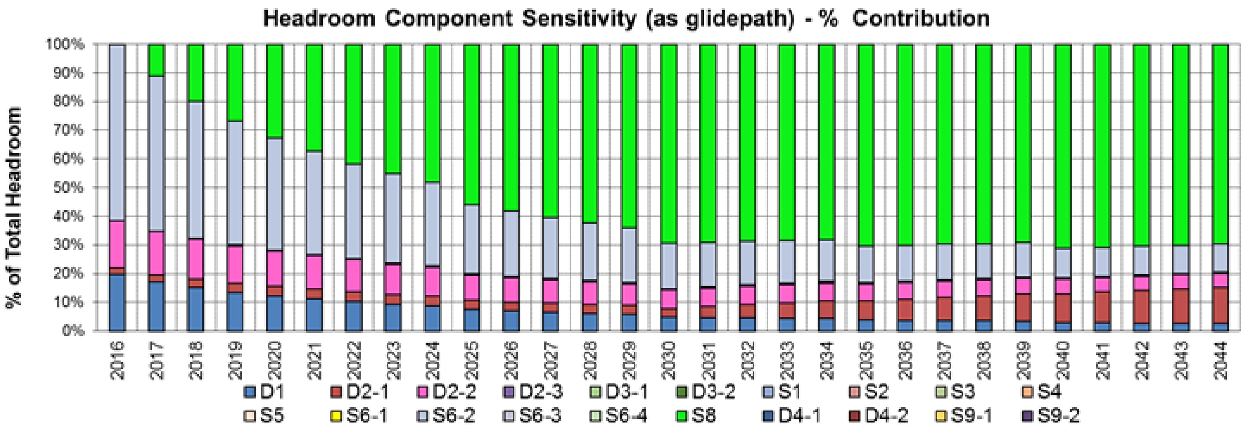


Figure 13 - Pembrokeshire DYAA – Percentage contribution of components to headroom

4. How we forecast demand

4.1. Introduction

This chapter describes the approach we follow to forecasting our customer's demand for water over the 30 year planning period. It is a key component of water resource planning as we are ultimately tasked with ensuring the long term, reliable supply of water to meet the demand from our customers. Our starting point must be an accurate estimate of the volume of water needed. In its simplest form this is an understanding of the number of people and businesses we have to supply and an estimate of how much water they will use alongside an understanding of how much water we will also lose through leakage on our supply system and other losses. Taken together, this is the demand for water that we must meet.

Although the processes used have been developed over many years variances remain in the way that some components of the demand forecast are built up and combined. Figure 14 provides a high level overview of our Demand Forecasting processes. This shows how convoluted some of these are in order to forecast the components of demand as accurately as we are able to, from available information. This section is generally more detailed than some of the others with a full technical detail provided in Appendix 15 – Demand Forecasting Technical Report.

We sought our customers and stakeholders views on our draft WRMP19. The comments received were supportive of our approach to demand forecasting, however they did challenge us to be more ambitious in our demand management strategy. We are currently improving our evidence base regarding leakage reduction and more specifically around the leakage that occurs on our customers properties and how this should be included within our economic analysis. Ofwat has challenged us to significantly reduce leakage and so we have committed to reducing leakage by 15% during AMP7 and are proposing much greater reductions in leakage levels throughout the planning period to 2050.

We have also taken note of the responses received to our draft plan consultation regarding the way we are able to influence our customers behaviour in encouraging the wise use of water, which over time can lead to lower impacts on the environment and lower water supply costs as less water is needed to be delivered. In this area, we are committing to a programme of schemes that will encourage our customers to take less water for their everyday use.

We have built the impact of these initiatives into our forecast of future water demand detailed within this section. Within this Plan we have defined our 'base year' i.e. the starting point for our forecasts as 2015/16 and from this point forward have estimated the demand out to 2050 for all 24 of our water resource zones. In line with our supply side planning scenarios we produce a Dry Year Annual Average and Dry Year Critical Period demand forecast.

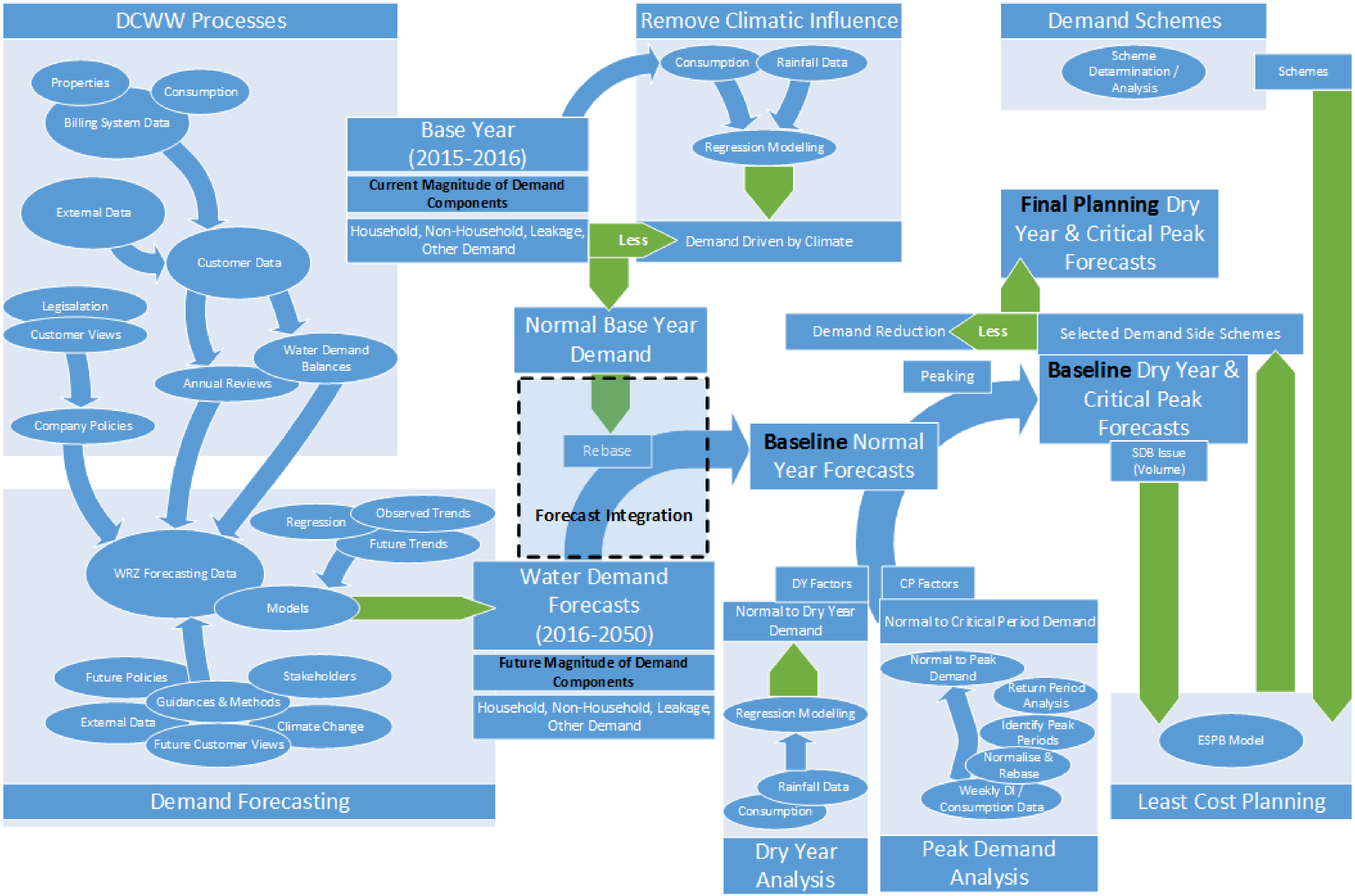


Figure 14 - Overview of the demand forecasting process

4.2. Understanding 'Base' Year

For the purposes of demand forecasting, water consumption is disaggregated into the following 'macro' components:

- Unmeasured Household (Population x Per Capita Consumption)
- Measured Household (Population x Per Capita Consumption)
- Unmeasured Non-household
- Measured Non-household
- Minor Components - Water Taken Unbilled (Legally & Illegally) & Distribution System Operational Use

For each component a WRZ level forecast is produced, representative of the Annual Average demand for each year of the planning period. These represent central forecasts for each of the demand components. The sum of these components, with the addition of *'Total Leakage'* (which is not considered as consumption) equates to total demand or Distribution Input (DI). These demand components are forecast from a base year where we have a good understanding of these.

The 'Base Year' for the current demand forecasts is 2015/16 and the starting values for the demand component forecasts are those reported in *Table 10bi* of the 2016 Annual Regulatory return (AR16).

4.2.1.1. Assessing the Influence of weather on Base Year Consumption

Consumption levels in the base year relate in part to the observed weather patterns. The assessment and understanding of the influence of weather on consumption is important to forecasting and is an enabler for two further processes:

1. 'Normalisation' of the Base Year.
2. 'Dry Year' Peaking from a 'Normalised' Base Year.

Assessment of the influence of weather on consumption has been undertaken using Multiple Linear Regression (MLR) to establish the relationship between recorded historical consumption (Distribution Input minus Leakage) and total summer rainfall (April to September) across a 24 year time series (1992 to 2015 inclusive). This has been conducted at the regional level.

Normalising Base Year

The regional 'normalisation' process involves assessing and removing the effect of weather on the recorded base year consumption by applying the MLR model to a theoretical normal year where the rainfall level is assumed to be the same as the long term average. The result for 2015/16 was a normalisation factor of 0.998 indicating this year was close too, but slightly drier than, the theoretical norm. Consequently base year consumption has to be reduced slightly to represent a Normal Year (NY) positon. NY factors are produced at the regional level and therefore the same factor is applied across all WRZs.

Producing Normal Year to Dry Year uplift

To produce a Dry Year (DY) forecast, we use similar analysis of weather to the normalisation process to produce a peaking factor that is applied to the NY forecast. The year that has the lowest rainfall (as a percentage of LTA) across the full record is taken as the Dry Year. In our record, 1995 was identified as having the lowest rainfall in the April to September period. The result is a regional 'Dry' factor of 1.018. Normal Year consumption is therefore increased by 1.018 (1.8%) to represent a 'dry year' scenario. NY to DY factors are initially produced at the regional level and converted to a WRZ equivalent.

4.2.1.2. Base Year Components

The following section details how each of the 'macro' demand components are assessed and understood in the base year (prior to normalisation and generation of the dry year scenario).

Understanding our Customers in Base Year

Forecasts are built upon the 'macro' demand level with customer data underpinning the household demand forecasting and regression modelling. We have recently developed a comprehensive Customer Water Use Survey and are in the process of setting up the means to regularly capture customer data through ongoing water efficiency and customer engagement strategies.

We use our own customer information and Customer Water Use Survey results to calculate occupancy. These suggest occupancy levels are higher in measured properties and lower in unmeasured properties compared to current base year levels.

For this Plan we have used an estimate of Per Capita Consumption (PCC) in developing our forecast rather than a more refined approach of using unmeasured Per Household Consumption (uPHC) information. Doing this with our current data would likely reduce our overall demand forecast across all WRZs by restating base year household demand.

To make such a large step change to base year assumptions (including the annual water balance and Annual Review process) is difficult and has wider implications for other company targets. Thus, the changes have not been incorporated into the demand forecast at this time. We recognise the importance of incorporating the changes above but this will need to be undertaken in a phased approach in AMP7 along with restatement of prior years to align with any new methodology.

Population, Properties and Occupancy

Figure 15 below overlays our WRZ and Local Planning Authority (LPA) areas, including National Park Authorities whilst Table 19 shows the proportion of LPA Population in each of our WRZ. It is clear that supply and planning authorities are not continuous with one another and when using official LPA statistics there is an element of distribution across supply areas required.

'Base Year' property counts are those reported within the 2015/16 Annual Regulatory return. Property records are sourced from 'Rapidxtra' at year end but are reported as Annual Average for the reporting year (April to March) where:

(Year End counts Yr 1 + Year End counts Yr 2) / 2 = Annual Average or mid-year point

Property counts are placed geospatially into respective WRZs using a combination of QAS batch (an address matching software) and our GIS data. A range of data quality checks are undertaken to ensure these allocations are as accurate as possible. Properties are categorised by metering status (Meter / Unmetered), type (Household / Non-household) and billing status (Billed/ Unbilled). Unbilled properties are assumed as voids and are not used in the allocation of household population. A range of data quality checks are undertaken to ensure property categorisations are as accurate as possible.

The sub-categories of Meter Household Properties reflects our metering policy i.e. "New", "Optant" and "Other". The data to allocate metered household properties to the respective sub-categories is also sourced from the company billing system 'Rapidxtra'. We hold and maintain an extensive & increasing dataset of 'meter installation reasons / categorisations' built from the longstanding practice (since 2000) to categorise any meter installations (excluding replacements) on an annual basis. The 'meter categorisation' dataset underpins the determination of the household meter sub-categories in the 'base year' and for forecasting. The WRZ level installations are also reconciled to the regional new connections and option meter installations that are reported as part of the company annual returns.

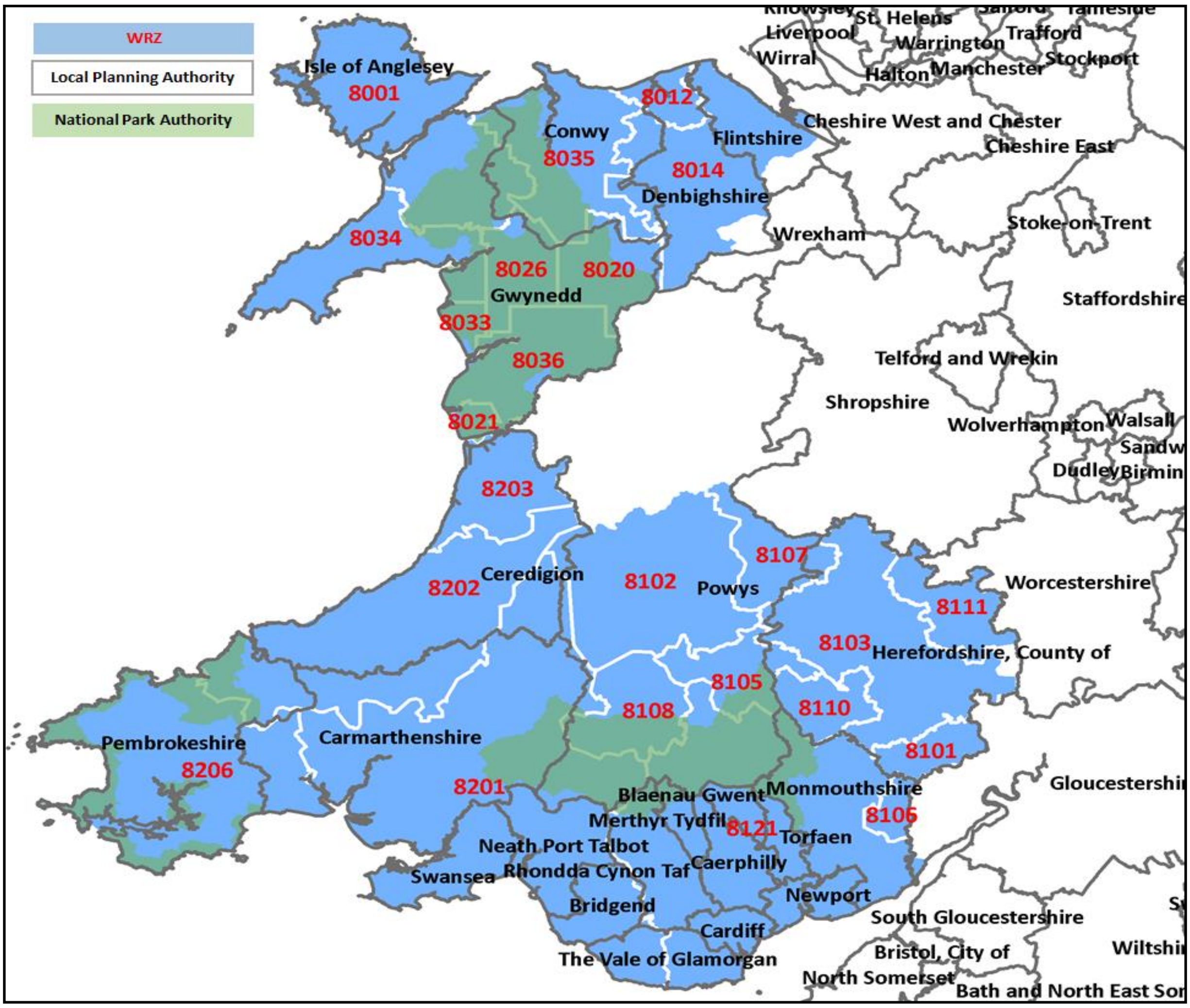


Figure 15 – Overlay of the Dwr Cymru Supply area & LPA Geography

WRZ	Country	Local Authority Name	% of LAUA MYE Pop. within WRZ	% of WRZ MYE Pop. within LAUA	WRZ	Country	Local Authority Name	% of LAUA MYE Pop. within WRZ	% of WRZ MYE Pop. within LAUA	WRZ	Country	Local Authority Name	% of LAUA MYE Pop. within WRZ	% of WRZ MYE Pop. within LAUA
8101	England	Forest of Dean District Council	0.60	2.26	8026	Wales	Gwynedd Council	5.37	99.97	8116	Wales	Torfaen County Borough Council	43.87	37.44
8101	England	Herefordshire, County of	11.66	97.73	8033	Wales	Gwynedd Council	3.69	100.00	8119	Wales	Blaenau Gwent County Borough Council	76.61	41.26
8103	England	Forest of Dean District Council	0.08	0.05	8034	Wales	Gwynedd Council	28.45	100.00	8119	Wales	Caerphilly County Borough Council	24.65	34.29
8103	England	Herefordshire, County of	73.19	99.59	8035	Wales	Conwy County Borough Council	81.20	99.63	8119	Wales	Merthyr Tydfil County Borough Council	50.29	22.96
8103	England	Malvern Hills District Council	0.05	0.03	8035	Wales	Denbighshire County Council	0.01	0.01	8119	Wales	Monmouthshire County Council	2.02	1.45
8103	England	Shropshire Council	0.06	0.13	8035	Wales	Gwynedd Council	0.27	0.35	8119	Wales	Powys County Council	0.02	0.02
8105	England	Herefordshire, County of	0.76	14.47	8036	Wales	Gwynedd Council	6.59	99.20	8119	Wales	Rhondda Cynon Taff County Borough Council	0.01	0.01
8106	England	Forest of Dean District Council	0.08	0.48	8036	Wales	Powys County Council	0.05	0.80	8120	Wales	Bridgend County Borough Council	0.70	0.50
8106	England	Herefordshire, County of	0.03	0.32	8101	Wales	Monmouthshire County Council	0.00	0.01	8120	Wales	Caerphilly County Borough Council	45.67	41.82
8107	England	Herefordshire, County of	0.35	7.20	8102	Wales	Powys County Council	15.67	100.00	8120	Wales	Cardiff Council	1.35	2.44
8107	England	Shropshire Council	0.05	1.88	8103	Wales	Powys County Council	0.21	0.21	8120	Wales	Merthyr Tydfil County Borough Council	49.68	14.93
8109	England	Forest of Dean District Council	6.36	0.71	8105	Wales	Powys County Council	6.34	85.53	8120	Wales	Newport City Council	0.01	0.00
8110	England	Herefordshire, County of	4.17	99.90	8106	Wales	Monmouthshire County Council	15.57	99.19	8120	Wales	Powys County Council	0.02	0.01
8111	England	Herefordshire, County of	8.38	96.40	8107	Wales	Powys County Council	6.18	90.92	8120	Wales	Rhondda Cynon Taff County Borough Council	33.33	40.18
8111	England	Malvern Hills District Council	0.71	3.30	8108	Wales	Powys County Council	9.39	100.00	8120	Wales	Vale of Glamorgan Council	0.18	0.11
8111	England	Shropshire Council	0.02	0.30	8109	Wales	Blaenau Gwent County Borough Council	0.00	0.00	8201	Wales	Bridgend County Borough Council	99.30	19.35
8116	England	Herefordshire, County of	0.00	0.00	8109	Wales	Caerphilly County Borough Council	26.22	6.34	8201	Wales	Carmarthenshire County Council	88.09	22.48
8001	Wales	Conwy County Borough Council	0.18	0.16	8109	Wales	Cardiff Council	98.65	46.93	8201	Wales	Ceredigion County Council	0.12	0.01
8001	Wales	Gwynedd Council	48.12	45.53	8109	Wales	Monmouthshire County Council	43.56	5.40	8201	Wales	City and County of Swansea	100.00	33.30
8001	Wales	Isle of Anglesey County Council	100.00	54.31	8109	Wales	Newport City Council	99.99	19.72	8201	Wales	Neath and Port Talbot County Borough Council	100.00	19.39
8012	Wales	Conwy County Borough Council	16.69	24.63	8109	Wales	Rhondda Cynon Taff County Borough Council	1.63	0.52	8201	Wales	Powys County Council	7.77	1.42
8012	Wales	Denbighshire County Council	62.64	75.35	8109	Wales	Torfaen County Borough Council	56.13	6.90	8201	Wales	Rhondda Cynon Taff County Borough Council	0.93	0.30
8012	Wales	Flintshire County Council	0.01	0.02	8109	Wales	Vale of Glamorgan Council	78.65	13.48	8201	Wales	Vale of Glamorgan Council	21.18	3.73
8014	Wales	Conwy County Borough Council	1.87	1.36	8110	Wales	Monmouthshire County Council	0.01	0.07	8202	Wales	Carmarthenshire County Council	6.89	19.86
8014	Wales	Denbighshire County Council	33.02	19.56	8110	Wales	Powys County Council	0.00	0.02	8202	Wales	Ceredigion County Council	56.84	66.86
8014	Wales	Flintshire County Council	82.21	79.01	8112	Wales	Rhondda Cynon Taff County Borough Council	38.58	100.00	8202	Wales	Pembrokeshire County Council	6.89	13.28
8014	Wales	Gwynedd Council	0.09	0.07	8113	Wales	Merthyr Tydfil County Borough Council	0.02	0.02	8203	Wales	Ceredigion County Council	43.04	99.90
8014	Wales	Wrexham County Borough Council	0.01	0.00	8113	Wales	Neath and Port Talbot County Borough Council	0.00	0.01	8203	Wales	Gwynedd Council	0.00	0.00
8020	Wales	Conwy County Borough Council	0.06	1.61	8113	Wales	Rhondda Cynon Taff County Borough Council	25.53	99.97	8203	Wales	Powys County Council	0.02	0.09
8020	Wales	Denbighshire County Council	0.02	0.50	8116	Wales	Blaenau Gwent County Borough Council	23.39	15.18	8206	Wales	Carmarthenshire County Council	5.02	7.46
8020	Wales	Gwynedd Council	3.53	97.89	8116	Wales	Caerphilly County Borough Council	3.46	5.80	8206	Wales	Pembrokeshire County Council	93.11	92.54
8021	Wales	Gwynedd Council	3.90	100.00	8116	Wales	Monmouthshire County Council	38.83	33.40					
8026	Wales	Conwy County Borough Council	0.00	0.03	8116	Wales	Powys County Council	6.62	8.18					

Table 19 – LPA Intersects based on Population Assessment

Base Year Population

'Base Year' population is consistent with that reported within the 2015/16 Annual Regulatory return. Residential population is based on the 2014 mid-year estimate (MYE). As the MYE population is mid-calendar year 2014 (June) this must be inflated to represent mid-reporting year 2015 (September). Reported Population represents **Annual Average** (or mid-reporting year) covering the April to March period.

Postcode level population is allocated spatially to WRZs using our geographical mapping system and the distribution of address points from the Ordnance Survey Address Layer 2 dataset. Postcode boundary population is allocated to each supply area based on its intersect with the supply boundary.

In terms of the connected population, 'Resident' population is defined as the total people residing within the water supply area. This is different to the population that is connected to and receiving services from or which is being billed by the water company, sometimes termed 'connected or billed' population.

The total billed population is derived from multiplying the WRZ resident population (adjusted for inset agreements) by a connection rate estimated from our GIS. This provides a simple connected percentage which is used to downwardly adjust the resident population to give an equivalent 'connected / billed' estimate. Connection rates vary between WRZ and range between 84.4% and 99.9% in the base year with an overall company connection rate of 98.7%.

Our 'Base Year' estimates make provision for population associated with inset agreements present within the company supply area and is also netted from the resident population estimate. At present only the Valley Wood inset agreement is residential in nature and includes household properties. The site itself is solely supplied from the Tywi CUS WRZ. It is estimated that the total population at this site is 253.

Base year Non-Household Population

Estimated WRZ level non-household population consists of three components and is entirely allocated to the measured category; unmeasured non-household is reported as zero. These categories are:

- People counted in the 2011 Census as resident in communal establishments (prisons, hospitals, etc.) allowing for some continuing, consistent with annual growth forecasts used in our 2014 Plan.
- People living in multiple domestic properties metered as single supplies (flats & apartments). The practice of metering blocks of flats as single supplies has now been largely stopped, although some retirement developments are emerging on bulk supplies.
- People living in individual non-household properties (e.g. farms and public houses).

Billed Household population is a function of the following:

Total Billed Hh Population = Residential Population *less* Insets Population *less* Non-Connected *less* Non-Hh Population

Measured occupancy rates define the distribution of household population between the measured and unmeasured household categories where:

Measured Hh Occupancy Rate x Billed Measured Hh Properties = Billed Measured Hh Population

Total Billed Hh Population *less* Billed Measured Hh Population = Billed Unmeasured Hh Populations

Billed Unmeasured Hh Populations / Unmeasured Billed Hh Properties = Unmeasured Hh Occupancy Rate

Measured Hh occupancy rates have been the starting point in this process for more than 15 years. The introduction of the meter option programme within Welsh Water during 2000 provided an opportunity to collect customer data, including occupancy rates.

Measured occupancy rates have been assessed using a combination of occupancy data determined from Meter Optants (pre and Post 2000) and New Connections.

Base Year Household Demand

Base Year Household Demand is further categorised into Measured and Unmeasured and both are consistent with that reported in the 2015/16 Annual Regulatory Return. Total Household Demand (excluding supply pipe leakage) is variable across the WRZs with a range of 0.12 Ml/d to 42.91 Ml/d for measured and 0.35 Ml/d and 147.66 Ml/d for unmeasured. Regional Measured and Unmeasured Demand accounts for 12.8% and 36.9% of Distribution Input respectively.

Unmeasured Household Demand

Unmeasured Household (UH) Demand is derived from the company domestic consumption monitor (DCM) and the unmeasured per capita consumption (uPCC) figure that the monitor produces. The regional uPCC figure is actually converted to an equivalent WRZ estimate using a scaling method where the regional uPCC figure is scaled or distributed to each WRZ based upon demand 'driver' characteristics. The WRZ level uPCC figures are multiplied by each WRZ estimate of unmeasured household population to produce the initial UH demand estimate, where:

UH Demand = uPCC X unmeasured Hh Pop

The initial estimate of UH demand is subject to further volume adjustments accounting for Meter under Registration (MUR) at a rate of 2.75%, Maximum Likelihood Estimation (MLE) and Provision for 'Transient consumption'. Base Year UH demand or consumption does not include supply pipe leakage, as this is considered within the total leakage estimate in terms of water balance.

Base Data Statistics

Table 20 below provides a WRZ level summary of the key Base data statistics in the 'base year' with SEWCUS subzones highlighted in green

WRZ	WRZ Name	Resident Pop.	Connected Pop.	NHh Pop.		Hh Pop.		NHh Props.		Hh Props.		% Billed Hh	Hh Occupancy		Hh Meter Penetration	
				M	Um	M	Um	M	Um	M	Um		M	Um	Inc Voids	Exc Voids
8001	North Eryri / Ynys Mon	129,564	127,747	4,578	0	35,826	87,343	5,758	587	21,206	33,931	95.28	1.76	2.72	38.46	38.85
8012	Clwyd Coastal	79,468	79,345	1,984	0	34,861	42,500	2,705	228	19,441	16,040	95.77	1.85	2.80	54.79	55.33
8014	Alwen / Dee	160,348	158,516	3,707	0	52,884	101,926	6,261	463	27,921	37,610	96.92	1.95	2.81	42.61	42.81
8020	Bala	4,425	3,780	96	0	1,099	2,585	274	32	690	916	92.93	1.71	3.05	42.94	43.17
8021	Tywyn / Aberdyfi	4,768	4,689	204	0	2,284	2,201	317	35	1,632	1,092	96.09	1.45	2.12	59.92	60.32
8026	Blaenau Ffestiniog	6,585	6,313	92	0	1,338	4,883	222	39	994	2,166	92.12	1.44	2.47	31.45	31.96
8033	Barmouth	4,509	4,357	141	0	1,631	2,585	314	74	1,081	1,152	93.75	1.58	2.43	48.40	49.18
8034	Lleyn / Harlech	34,865	34,116	705	0	10,455	22,956	2,597	405	7,264	9,684	94.96	1.50	2.52	42.86	43.38
8035	Dyffryn Conwy	95,012	93,925	3,876	0	36,860	53,190	4,437	364	21,481	20,585	95.20	1.79	2.74	51.07	51.56
8036	South Meirionnydd	8,141	6,872	215	0	2,335	4,322	457	62	1,683	2,089	94.42	1.44	2.23	44.63	45.60
8101	Ross-on-Wye	22,373	22,006	1,207	0	8,498	12,300	1,127	90	4,452	4,399	97.18	1.97	2.87	50.30	50.19
8102	Elan / Builth	20,906	18,401	1,343	0	6,615	10,444	1,243	108	3,810	4,285	93.54	1.82	2.65	47.07	47.86
8103	Hereford C.U. Area	138,342	134,259	7,200	0	55,734	71,324	5,549	335	28,950	24,668	97.28	1.98	2.98	53.99	54.06
8105	Llyswen	9,888	8,626	949	0	3,114	4,563	641	45	1,723	1,884	95.85	1.87	2.55	47.76	48.19
8106	Monmouth	14,567	14,335	768	0	4,923	8,645	614	50	2,444	3,239	97.16	2.08	2.74	43.00	42.86
8107	Pilleth	9,059	8,102	179	0	2,366	5,557	488	47	1,288	2,203	95.56	1.89	2.67	36.89	37.54
8108	Brecon / Portis	12,532	11,608	1,116	0	3,642	6,850	721	210	2,065	2,800	96.27	1.81	2.56	42.45	42.91
8109	Sluvad / Court Farm / Llwynon	752,484	750,852	33,435	0	254,680	462,738	17,153	1,343	135,200	169,022	96.39	1.94	2.85	44.44	44.71
8110	Vowchurch	7,818	6,744	528	0	2,255	3,961	481	29	1,133	1,279	97.63	2.04	3.18	46.97	47.04
8111	Whitbourne	16,386	15,478	2,155	0	5,388	7,936	1,097	104	2,756	2,879	97.09	2.01	2.84	48.90	48.95
8112	Rhondda	91,540	91,465	1,256	0	11,584	78,626	1,942	325	7,360	34,801	92.58	1.66	2.45	17.46	17.84
8113	Cynon	60,647	60,540	818	0	11,075	48,647	1,247	212	6,321	21,352	93.12	1.83	2.47	22.84	23.49
8116	Talybont	107,538	104,928	2,291	0	22,663	79,974	3,440	343	12,236	32,832	95.92	1.92	2.55	27.15	27.33
8119	Pontsticill High Level / Heads of Valleys	129,706	129,504	2,216	0	21,853	105,435	2,348	340	11,979	43,908	95.24	1.90	2.53	21.43	21.64
8120	Pontsticill Low Level	197,787	197,062	2,899	0	49,189	144,973	4,268	689	25,641	58,126	96.36	1.98	2.59	30.61	30.78
8201	Tywi C.U. Area	730,022	721,822	17,078	0	198,868	506,126	19,810	2,167	109,656	204,999	95.45	1.88	2.60	34.85	35.25
8202	Mid - South Ceredigion	64,395	60,158	6,859	0	17,772	35,527	4,772	278	9,967	15,201	95.26	1.86	2.47	39.60	39.93
8203	North Ceredigion	32,705	31,605	7,041	0	8,622	15,943	1,405	143	4,753	6,508	95.03	1.90	2.59	42.21	42.49
8206	Pembrokeshire	125,130	123,213	3,769	0	37,814	81,631	8,007	463	21,080	33,660	95.71	1.87	2.53	38.51	38.53
8999	Dwr Cymru Welsh Water Region	3,071,511	3,030,368	108,700	0	906,226	2,015,692	99,694	9,608	496,207	793,311	95.74	1.89	2.67	38.48	38.84

Table 20 - WRZ level 'base' year data

Base Year Measured Household Demand

Measured Household (MH) demand is derived from the recorded consumption of 489,095 meters held within Rapidxtra and forms part of the water demand dataset that we hold. There continues to be a significant number of unmeasured customers taking up, as per metering policy, the free meter option programme offered by the company. Approximately 13,000 customers switched to a measured supply during 2015-16, contributing to the gradual increase in the volume of water delivered to our measured households. In addition, 2015-16 observed an additional 7,400 new household connections added to the metered household stock.

The initial estimate of MH demand is subject to further volume adjustments accounting for income reconciliation, Meter under Registration at a rate of 4.15% and Maximum Likelihood Estimation.

Base Year MH demand or consumption does not include supply pipe leakage, as this is considered within the total leakage estimate in terms of water balance. Measured Household PCC (mPCC) is a calculated figure obtained by dividing MH Consumption by MH Population, where:

mPCC = MH Consumption / Measured Hh Pop

Base Year Non-Household Consumption

Base Year Non-Household Demand is further categorised into Measured and Unmeasured and both are consistent with that reported within the 2015/16 Annual Regulatory return. Total Non-Household Demand (excluding SPL) is variable with a range of 0.16 Ml/d to 63.02 Ml/d for measured and 0.01 Ml/d and 1.41Ml/d for unmeasured. Regionally Measured and Unmeasured NHh Demand accounts for 21.2% and 0.6% of Distribution Input respectively.

Base Year Unmeasured Non-Household Demand

Unmeasured Non-Household (UMNH) Demand is based upon the consumption records of measured non-household properties that have been compulsorily metered over the last 10+ years. The initial estimate of UMNH demand is subject to further volume adjustments accounting for Meter under Registration at a rate of 4.55%, Maximum Likelihood Estimation and provision for ‘Transient consumption’. Base Year UMNH demand or consumption does not include supply pipe leakage, as this is considered within the total leakage estimate in terms of water balance.

Base Year Measured Non-Household Demand

Measured Non-Household (MNH) Demand is derived from the recorded consumption of 85,493 meters held within Rapidxtra and forms part of the water demand dataset that the company holds. The initial estimate of MNH demand is subject to further volume adjustments accounting for Income Reconciliation, Meter under Registration at a rate of 4.55% and Maximum Likelihood Estimation. Base Year MNH demand or consumption does not include supply pipe leakage, as this is considered within the total leakage estimate in terms of water balance.

Other / Minor Demand Components

A small proportion of WRZ level Distribution Input is made up of ‘other’ or ‘minor’ demand components constituting; Water Taken Unbilled Illegally and Water Taken Billed Legally and Distribution System Operational Use. Base Year ‘minor’ demand components are consistent with those reported in our 2015/16 Annual Regulatory Return. ‘Minor demand’ components are variable with a range of 0.03 Ml/d to 14.29 Ml/d. Regionally, this accounts for c3.5% of Distribution Input. The initial estimates are subject to further volume adjustment accounting for the application of Maximum Likelihood Estimation.

Total Leakage

Base Year Total Leakage is consistent with that reported in our 2015/16 Annual Regulatory Return. Total Leakage is variable with a range of 0.09 Ml/d and 87.26 Ml/d. Regionally, Total Leakage accounts for 22.6% of Distribution Input in the base year.

Total leakage is considered to be the sum of losses from distribution mains, service reservoirs, trunk mains and customer supply pipes. The techniques and methods to report, monitor and manage leakage is consistent with '*Managing Leakage 2011* (UKWIR)'.

District Meter Area (DMA) Leakage comprises of 1153 discrete monitored areas measuring flows into this area of the network and are monitored and reported using our Leakage Monitoring and Reporting Software (LMARS). Leakage is assessed between 12.00am and 06:00am and an estimate of night time consumption (household and non-household) is made and deducted from the direct flow measurement. This direct measurement of leakage is sometimes referred to as 'bottom up' leakage and is used as a component in the annual water balance calculation. At this stage, the approach to determining and reporting DMA leakage remains unchanged and is based upon a minimum rolling hour and the 20th Percentile, 7 day rolling average of the daily leakage figures.

Customer supply pipe leakage is considered as part of the assessment of DMA Leakage, given that customer supply leakage would also pass through the district meters. Customer supply pipe leakage is assessed by means of a measured sample of identified leaks but this is for the purpose of separating out leakage into its respective components i.e. distribution / network leakage.

Trunk Main & Service Reservoir (TM & SR) Leakage is that occurring outside of the DMA estate and is derived differently to DMA leakage due to bulk transfer of water. TM & SRV leakage is a static, estimated volume.

The initial estimate of total Leakage is subject to further volume adjustments accounting for the application of Maximum Likelihood Estimation a technique used to redistribute the Water Balance Gap back across balance components as part of the reconciliation process.

Table 21 below provides a summary of the WRZ Total Leakage components within the base year.

WRZ	WRZ Name	Total Leakage		DMA Leakage	TM & SRV Leakage		Distribution Mains Leakage	Supply Pipe Leakage
8001	North Eryri / Ynys Mon	6.44		5.65	0.79		4.48	1.97
8012	Clwyd Coastal	3.42		2.89	0.53		2.28	1.14
8014	Alwen / Dee	7.00		4.98	2.01		4.72	2.27
8020	Bala	0.51		0.40	0.11		0.45	0.06
8021	Tywyn / Aberdyfi	0.09		0.04	0.05		0.00	0.09
8026	Blaenau Ffestiniog	0.33		0.32	0.01		0.23	0.11
8033	Barmouth	0.27		0.25	0.02		0.19	0.08
8034	Lleyn / Harlech	2.95		2.28	0.67		2.33	0.62
8035	Dyffryn Conwy	9.40		4.09	5.31		7.95	1.45
8036	South Meirionnydd	0.56		0.34	0.22		0.43	0.13
8101	Ross-on-Wye	1.46		1.38	0.07		1.14	0.31
8102	Elan / Builth	1.18		1.12	0.06		0.90	0.28
8103	Hereford C.U. Area	4.34		3.79	0.55		2.59	1.75
8105	Llyswen	0.63		0.60	0.03		0.51	0.12
8106	Monmouth	0.75		0.72	0.03		0.56	0.19
8107	Pilleth	0.59		0.53	0.06		0.48	0.12
8108	Brecon / Portis	1.03		0.89	0.14		0.85	0.18
8110	Vowchurch	0.63		0.60	0.02		0.54	0.09
8111	Whitbourne	1.11		1.06	0.05		0.91	0.20
8121	SEWCUS	87.26		66.24	21.02		67.16	20.10
8201	Tywi C.U. Area	32.03		29.42	2.61		21.21	10.82
8202	Mid - South Ceredigion	5.88		5.59	0.30		4.98	0.91
8203	North Ceredigion	2.27		2.26	0.01		1.86	0.40
8206	Pembrokeshire	9.73		9.43	0.31		7.83	1.90
8999	DCWW Region	179.86		144.88	34.98		134.57	45.29

Table 21 - WRZ total leakage components (Ml/d) within the base year

4.3. Forecasting Demand Components

The following provides a very high level approach to the 'macro' component forecasting methods employed for this Plan:

- Property & Population Forecasting – Observed Trends, Official statistics and Local Planning datasets
- Unmeasured Household (Population x Per Capita Consumption) – *Regression Modelling*
- Measured Household (Population x Per Capita Consumption) – *Regression Modelling*
- Unmeasured Non-household – Projection of observed historical Trends
- Measured Non-household – Econometric Regression Modelling
- Minor Components - Water Taken Unbilled (Legally & Illegally) & Distribution System Operational Use *– Per property rate in base year x forecast props*
- Total Leakage – short run Sustainable Economic Level of Leakage (srSELL)
- Overall Forecasts – Bespoke Excel Model to collate forecasts, provide reporting consistency (MUR, MLE adjustments), and to generate scenario years and Micro-component apportionment.

Component forecasts are initially produced in separate models and the outputs in most cases are raw and exclude other adjustment such as MUR and MLE. The raw component forecasts are then brought together in the overall demand forecasting model, termed the 'collation tool' which makes adjustments to the forecasts to ensure base year consistency and applies various scenario year (DY, CP) adjustments.

4.3.1.1. Baseline Forecasting and Company Policies & Strategies

Baseline forecasts are influenced by and reflect the company's current and future polices around Leakage Management, Metering and Water Efficiency.

The Total Leakage and Household Demand components of our demand forecast have been updated since the draft WRMP19. The underlying methodologies and techniques to produce these forecast components are fundamentally the same but they have now been aligned to the performance commitments set within our PR19 Business Plan.

All other forecasting components are the same as the Draft Plan submission with the 'base year' remaining as 2015/16 despite having two additional years of annual data available for this Plan. The added benefit in terms of forecast accuracy of including two extra data points into the various models is negligible in terms of impact and change. For example, both the household and non-household demand forecasts are two of the largest components in the process and are already based on 15 years of observed data, therefore updating this to 17 years of observed data is unlikely to significantly affect the outputs.

4.3.1.2. Company Leakage Policy

The AMP6 Leakage Management policy / stagey focused around Economic Leakage Levels primarily managed through Active Leakage Control (ALC), network optimisation and some asset renewal.

We are proposing a step change in our approach in AMP7 in working towards our 2050 Vision of Total Leakage at 10% of 2015/16 Distribution Input. ALC will continue to feature to overcome NRR and provide some further reduction based on SELL to achieve part of the AMP7 reduction commitment but new innovative approaches will be required to meet the ambitious reductions across AMP7. Our leakage targets will continue to align with SELL which is estimated to reduce given our improved understanding of customer side leakage including lead replacement programmes, technological improvements (e.g. acoustic Loggers), increased trunk mains detection and repair. Changes to allowance models through evidence gathering and better understanding and use of customer base data will also play a part.

Application of the new leakage consistency of reporting methodology should have no impact to either the Total Leakage or DI forecasts. The impacts of leakage consistency has been considered and will result in no change to the leakage reduction profiles across the horizon. These will remain as the SELL glide path used as the baseline position. Any impacts will be offset by Yr1 AMP7 and the SELL glide path resumed.

The commitment to achieving both a 15% AMP7 reduction and a 10% of DI Total Leakage by 2050 are now built into our baseline demand forecasts.

4.3.1.3. Company Meter Policy

The current policy for increased metering relates to new connections and through the long standing meter option programme. We do not engage in compulsory metering or metering on change of occupier. Company metering policy is reflected and considered through the property and population forecasts as well as the household demand forecasts.

4.3.1.4. Smart Metering

Smart metering is not widely used within the company and is currently being trialled in two pilot areas, the most significant area being Tywyn Aberdyfi WRZ with rollout scheduled before the end of AMP6. Baseline household demand forecasts for this WRZ consider the demand impacts of this trial.

4.3.1.5. Water Efficiency

Water efficiency activity will increase over the remainder of AMP6 and into AMP7. This is in line with the views of our customers through our customer engagement work where a proactive stance to water efficiency is welcomed. Baseline household and non-household demand forecasts also make provision for water efficiency activity over the planning period, reflecting changes in our policies and strategies as well as changing technology and the behaviours of our customers in respect of water consumption into the future.

Household Demand forecasts reflect our commitment to year on year reductions in overall household demand and our longer term 2050 vision / aspiration of a more challenging average PCC reductions. Average PCC is forecast to reduce from 145 l/hd/day to 138 l/hd/day by the end of AMP7, with the longer term aspiration of a reduction to 100 l/hd/day by 2050.

4.3.1.6. Population, Properties and Occupancy Forecasting

The forecasting principles follow those developed in the 2014 Plan. Forecasts use a combination of Official datasets (Office for National Statistics, Welsh Government) and our own billing / customer datasets, GIS and summaries of the information underpinning the June Returns / Annual Reviews between 2000/01 to 2015/16.

Our approach follows the guidance set out in the 'WRMP19 Methods – Populations, Household Property and occupancy Forecasting – Guidance Manual, (UKWIR, 2016)' as well as bespoke methodologies / analysis where required.

Three forecast scenarios are produced termed 'Central' (most likely), 'Upper' and 'Lower'. The 'Central' Forecast (most likely) is the baseline forecasting scenario presented within the planning tables. The 'Central' Forecast is based on property forecasts developed from observed billing data trends and new connection levels from each Local Authority mapped to our supply areas. Population forecasts are based on the Trend-based 'Principle Projections'.

‘Upper’ and ‘Lower’ scenarios are based on variants (e.g. High Fertility, Low Fertility, etc.) of Household and Total population projections produced by the Welsh Government for each Welsh Local Authority. Property forecasts are the same under all three scenarios.

Population Forecasting

Population forecasts project from the respective population categories reported in the 2016 Annual Return. Forecasts utilise the Trend-based LPA projections for Total and Household Population at both the national and subnational (local authority) level covering all Welsh (including NPAs) and intersecting English LPAs.

To ensure consistency across the process we have sourced and based our forecasts on projections produced by the official statistical bodies. All population forecasts are therefore based on the LPA projections produced by, and available from, the ONS and Welsh Government.

Any population forecasts submitted from the LPA during engagement have not been used. In most cases the population forecasts quoted by LPAs are those produced by the official statistical bodies.

Non-household or commercial population is taken as the difference between the total and household population projections.

All LPA forecasts are 2014-based (2014 to 2039) whereas NPA forecasts are 2013-based (2013 to 2038) – projections are extrapolated beyond the last year taking the average change over the last 5 years of the forecasts. Trend based projections provide a robust and consistent set of figures across the country of the future demographic demand given a clear set of assumptions. On this basis and the fact they are the “official” projections in the UK it was felt they would be the most reliable and consistent source of population projection data to use.

We have engaged with all LPAs to obtain their latest plan based data (development and population forecasts). On the whole, data received was to varying degrees of quality and completeness, and not all LPAs provided data.

Furthermore, in some cases the plan based population projections provided were the trend based projections. To this end, plan based population projections were not used for forecasting for reasons of quality and inconsistency. Furthermore any ‘uncertainty’ with the projections would be dealt within the range of ‘variant’ trend forecasts used to generate the upper and lower bounds.

The trend based LPA projections have undergone a number of consistency ‘adjustments’. These include:

- Rebasing to the latest available LPA Mid-Year Estimate;
- Ensuing consistency between the Welsh National and sum of the Sub-national Projections;
- Accounting for National Park Authorities forecasts;
- Converting to average (mid reporting year).

LPA Projections have been apportioned to supply areas based on distribution of Address counts between postcode and WRZ intersects as determined from GIS. Each postcode is also mapped back to its LPA. This is the same technique used during the Annual Review and water balance process.

A number of adjustment are made to the Supply Area populations to account for (a) the scale of housing development; (b) the company forecasts of household occupancy and (c) other forecast changes not in projections; for ‘baseline’ forecasts no adjustments have been made. The impacts of population due to the Wylfa Newydd development have been considered as a ‘scenario’ for resilience testing and is not considered in baseline forecasting.

Forecasts of supply area (WRZ) resident population are then converted to a 'Connected' or 'Billed' equivalent using the base year (2015/16) WRZ connection rates. These are applied to each forecast year held fixed at base year levels.

Allocating Total Connected Population to the population sub-categories

'Connected' Supply area (WRZ) resident population is already disaggregated to the 'household' and 'non-household' components from the ONS and other official sources. WRZ non-household population forecasts are allocated entirely to the Measured Non-household component.

The disaggregation of household population to the subcomponents of Measured and Unmeasured is a function of the household occupancy and household property forecasts. Initially, WRZ level forecasts of measured and unmeasured occupancy rates, billed measured and unmeasured household properties and total household population, are undertaken as independent analysis / forecasts. When combining these forecasts together, inconsistencies are inevitable and it is important to ensure they reconcile with one another. In-line with the UKWIR (2016) methodology, adjustments are made to ensure consistency between the separate forecast datasets.

Population Forecast Summary

Figure 16 below shows the regional population component forecasts.

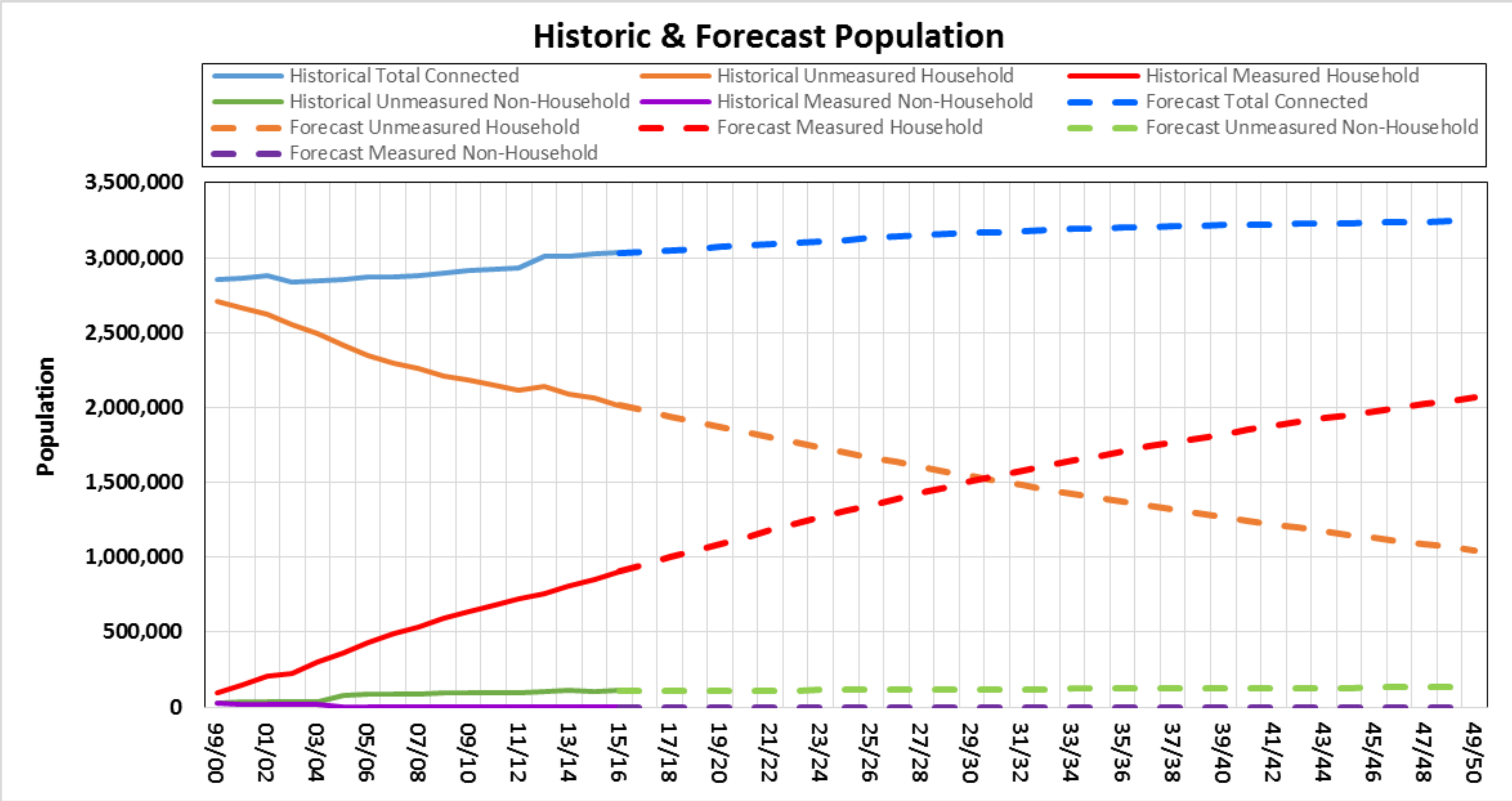


Figure 16 - Component population forecasts

Table 22 below shows the regional population component forecasts.

Component	00/01	05/06	10/11	15/16	19/20	24/25	29/30	34/35	39/40	44/45	49/50
Unmeasured Household	2,661,268	2,351,064	2,149,033	2,015,692	1,870,247	1,698,656	1,541,573	1,397,058	1,266,922	1,150,860	1,047,611
Measured Household	145,791	434,706	681,452	906,226	1,089,676	1,308,084	1,505,923	1,675,910	1,822,656	1,951,285	2,064,896
Non-Household	51,820	85,465	95,086	108,700	109,988	113,274	117,202	122,730	126,554	129,614	132,710
Total	2,858,879	2,871,235	2,925,571	3,030,619	3,069,910	3,120,015	3,164,697	3,195,699	3,216,131	3,231,758	3,245,217

Table 22 - Historical and forecast population components

Table 23 below shows the WRZ level projections of household population components.

Name	2019/2020				2029/30				2039/40				2049/50			
	Total Connected	UmHh	mHh	Total NonHh	Total Connected	UmHh	mHh	Total NonHh	Total Connected	UmHh	mHh	Total NonHh	Total Connected	UmHh	mHh	Total NonHh
North Eryri / Ynys Mon	128.57	81.32	42.57	4.68	130.96	67.59	58.29	5.08	133.19	55.96	71.72	5.51	134.93	46.43	82.77	5.72
Clwyd Coastal	79.81	37.38	40.40	2.03	81.58	26.63	52.73	2.21	82.08	18.88	60.85	2.36	82.00	13.41	66.17	2.43
Alwen / Dee	161.03	92.99	64.24	3.80	166.54	73.37	88.93	4.24	169.24	57.51	106.90	4.83	170.14	45.33	119.66	5.15
Bala	3.84	2.43	1.32	0.09	4.03	2.08	1.87	0.07	4.17	1.78	2.33	0.07	4.30	1.52	2.71	0.06
Tywyn / Aberdyfi	4.73	1.88	2.64	0.21	4.81	1.21	3.38	0.22	4.88	0.78	3.87	0.23	4.92	0.51	4.18	0.24
Blaenau Ffestiniog	6.39	4.61	1.68	0.10	6.68	3.93	2.64	0.11	6.78	3.28	3.36	0.13	6.73	2.74	3.83	0.15
Barmouth	4.38	2.33	1.91	0.14	4.48	1.75	2.57	0.15	4.52	1.30	3.06	0.16	4.54	0.97	3.40	0.17
Lleyn / Harlech	34.42	21.47	12.22	0.73	35.17	17.91	16.44	0.82	35.97	14.91	20.15	0.91	36.77	12.44	23.37	0.96
Dyffryn Conwy	94.83	47.97	42.93	3.93	97.40	36.75	56.48	4.17	99.41	28.02	66.89	4.50	100.92	21.42	74.86	4.65
South Meirionnydd	6.95	3.96	2.79	0.21	7.20	3.15	3.88	0.18	7.35	2.48	4.69	0.17	7.48	1.96	5.36	0.16
Ross-on-Wye	22.17	11.36	9.59	1.22	22.43	9.39	11.77	1.27	22.68	7.76	13.59	1.33	22.90	6.43	15.10	1.37
Elan / Builth	18.70	9.40	7.97	1.33	19.18	7.18	10.66	1.34	19.60	5.45	12.78	1.36	19.92	4.14	14.43	1.35
Hereford C.U. Area	135.47	65.21	63.01	7.25	139.37	52.23	79.59	7.56	140.90	41.81	91.13	7.96	141.41	33.56	99.61	8.23
Llyswen	8.89	4.11	3.85	0.93	9.41	3.13	5.39	0.90	9.73	2.39	6.45	0.89	10.05	1.83	7.35	0.86
Monmouth	14.53	8.11	5.64	0.77	14.86	7.08	6.99	0.79	15.12	6.21	8.10	0.82	15.36	5.47	9.06	0.83
Pilleth	8.19	5.33	2.69	0.18	8.49	4.82	3.48	0.19	8.69	4.38	4.10	0.20	8.84	4.02	4.63	0.20
Brecon / Portis	11.87	6.28	4.48	1.11	12.17	4.92	6.12	1.13	12.48	3.84	7.49	1.14	12.79	2.99	8.66	1.14
Vowchurch	6.84	3.74	2.58	0.52	6.92	3.29	3.10	0.53	7.02	2.84	3.64	0.54	7.06	2.47	4.02	0.57
Whitbourne	15.63	7.43	6.04	2.16	15.76	6.46	7.11	2.19	16.07	5.57	8.26	2.23	16.32	4.82	9.24	2.27
SEWCUS	1349.75	858.08	448.06	43.61	1386.29	717.69	621.82	46.79	1404.11	598.08	754.89	51.15	1412.10	501.08	856.48	54.54
Tywi C.U. Area	734.68	471.89	245.54	17.24	764.29	392.75	352.44	19.10	778.95	325.70	431.81	21.44	786.89	271.88	492.15	22.86
Mid - South Ceredigion	60.80	32.71	21.21	6.89	62.75	25.60	30.11	7.04	65.06	19.70	38.11	7.25	67.28	15.08	44.85	7.35
North Ceredigion	31.94	14.54	10.33	7.08	32.80	11.22	14.35	7.22	33.32	8.56	17.35	7.41	33.60	6.53	19.51	7.56
Pembrokeshire	125.51	75.72	45.99	3.79	131.10	61.44	65.76	3.90	134.80	49.73	81.13	3.94	137.97	40.57	93.50	3.89
DCWW Region	3069.91	1870.25	1089.68	109.99	3164.70	1541.57	1505.92	117.20	3216.13	1266.92	1822.66	126.55	3245.22	1047.61	2064.90	132.71

Table 23 - WRZ level population forecast components (000's)

Property Forecasting

Our approach to forecasting Household properties follows the UKWIR (2016) Population, Household Property & Occupancy Forecasting methodology.

Property Forecasts project from the respective property categories reported in the 2016 Annual Return and are aligned to the requirements of the planning tables. The forecasts are primarily based upon the property data collected and categorised at the WRZ level during each Annual Return giving a time series of property base data spanning some 15 years.

We have also drawn on Local Planning Authority development datasets and national / subnational household projections to help forecast the magnitude of new housing development over the planning period. This does not cover non-household new connections. Our metering policy also plays a large role in defining property forecasting.

Forecasting Household New Connections / New Builds

Figure 17 below shows the observed, 'Trend', WRMP14 and the WRMP19 regional new Household projections. The observed level of new connections is something the company tracks on an annual basis using analysis of billing system data. Between 2000/01 and 2007/08, new connections to our supply network averaged around 9,000 per annum. From 2008/09 the rate dropped to around 5,500 to 6,500 per annum, reflecting the economic climate and pressures on the construction sector during that period. Since 2012/13 new connection levels have been recovering with 7,166 new household connections observed in 2015/16.

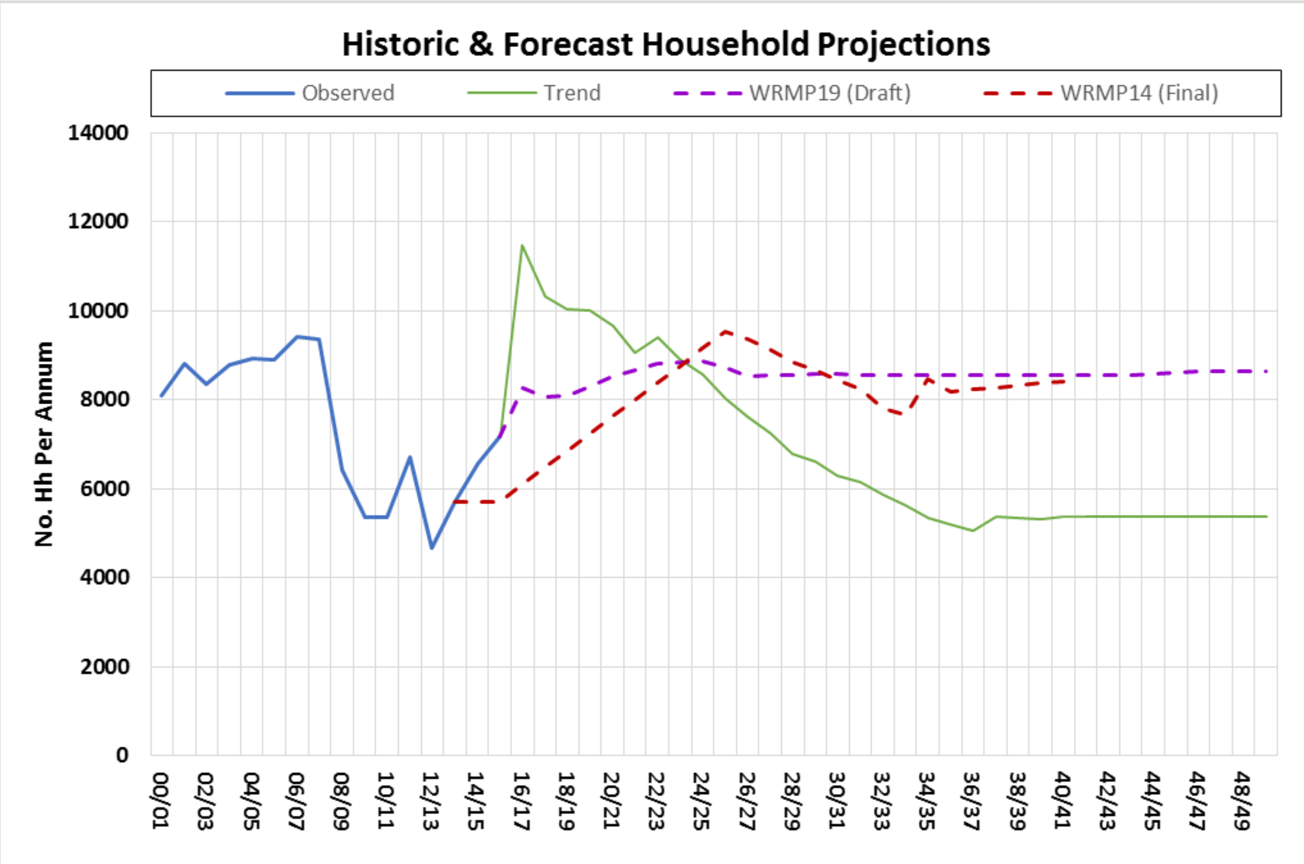


Figure 17 - Observed and Forecast household projections

The supply area trend based levels have not been observed historically, the new connection rates for 2016/17 as determined in the Annual Return suggest a household new connection rate of c.7,700, well below the trend based projection of c11,000.

In light of the above the approach to forecasting new household connections is aligned to 'Plan' based projections. These also align well with the UKWIR guidance embedding LPA engagement and development data within the household forecasting process. The approach to new household property forecasting uses the same level of detail, data and approach for all water resource zones, regardless of risk.

Housing Development data was gathered from a range of sources including data gathered from Direct LPA Engagement, reviewing all LDPs, Joint Housing Land Availability Studies (JHLAS – Wales) and Strategic Household Land Availability Studies (SHLAS - England) and some extrapolation beyond 5 years (i.e. the LPA data timeframe). Housing development data is the basis to allocate the high level LPA housing trajectories (trend or plan) to specific areas of the supply network.

This level of data gathering presented an opportunity to review the approach taken in the 2014 Plan and improve data collection and forecasting robustness across all WRZ, regardless of risk, and embed LPA development data and engagement into the process going forward.

All LPA's intersecting the supply area were engaged throughout the process. As per the 2014 Plan a data collection pro-forma was sent to each planning department to gather plan based development data and projections for consideration in the process. This included collecting the LPA housing development trajectories.

All LDP's were reviewed and relevant development data extracted. Individual planning departments were also contacted directly to gain the latest development data where necessary and to confirm any returned data and information.

Contact was also made with our Developer Services department who provided GIS polygons of some of the specific LPA developments referenced in the LDPs, JHLASs and SHLASs. Additional GIS polygons were obtained from direct LPA engagement. The availability of GIS polygons allowed the development to be allocated to a supply area more accurately based on the portion of development occurring in each supply area boundary. Where GIS polygons were absent the developments were manually assigned to a supply boundary.

4.3.1.7. Producing Supply Area Forecasts

Once the high level LPA profile has been set the process then considers the year that the specific development is set to take place, the physical capacity of each development site and how long (in years) it would take for the site to fill to capacity assuming a given build rate. Build rates are based upon the data for build numbers per annum and site capacity from the JHLAS / SHLAS five year supply and estimated from other development datasets collected.

The high level LPA household trajectory is then apportioned to each development site based on the magnitude of the units being built per year in each LPA's specific development site. As each development site has been allocated to a supply area in GIS this then allows supply area new household development to be determined.

One limitation is that the same development sites and apportionment cannot be used across the whole planning period. The sites have a finite capacity and its logical to account for the fact that as sites fill to capacity over the planning period they then become unavailable (i.e. when at capacity). At this point they can no longer be used to apportion the LPA trajectory to the supply area and other means are necessary.

To ensure that a LPA profile and household development can be represented at the supply area across the whole planning period, as sites drop out due to capacity, 'fixed share' gets increasingly used to apportion the development to the supply areas.

An allowance is also made for magnitude of 'windfall and small site' development in each LPA. A proportion of the high level LPA trajectory will therefore include provision for this. 'Small site' development depends on the LPA but it is small scale developments of anything between 1 and 10 properties and is not allocated to specific development sites in the LDPs, JHLAS or SHLAS.

Setting High Level LPA Housing Trajectories

The high level LPA profiles are based on the data gathered and available from the LPA. Direct engagement with the LPA (i.e. the expected profiles the LPA is planning to deliver) take precedence when available, with the JHLAS / SHLAS or the LDP high level trajectories being used in that order of preference.

The LPA profiles are then assessed against the LPA new build completion statistics (available from the ONS and WG) and are then set or limited to 'reasonable' limits of these statistics. This step prevents unrealistic and overall aspirational development profiles being produced and apportioned in light of actual observed performance. Table 24 below indicates the plan based LPA trajectories underpinning the supply area apportionment.

LPA Name	2016	2020	2025	2030	2035	2040	2045	2050
Brecon Beacons NPA (W18000001)	136.33	136.33	136.33	136.33	136.33	136.33	136.33	136.33
Herefordshire, County of	327.00	395.78	415.50	415.50	415.50	415.50	415.50	415.50
Cheshire East Council	8.00	5.00	6.00	3.00	2.00	4.40	4.40	4.40
Cheshire West and Chester Council	1310.00	1286.06	1286.06	1286.06	1286.06	1286.06	1286.06	1286.06
Shropshire Council	1231.09	1231.32	1417.77	1483.59	1483.59	1483.59	1483.59	1483.59
Cheltenham Borough Council	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cotswold District Council	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest of Dean District Council	330.00	310.00	331.91	361.06	367.59	367.59	367.59	367.59
Gloucester Borough Council	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Stroud District Council	3.00	0.00	0.00	2.00	0.00	1.00	1.00	1.00
Tewkesbury Borough Council	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bromsgrove District Council	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Malvern Hills District Council	149.00	225.00	226.00	231.00	205.00	212.80	212.80	212.80
Redditch Borough Council	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worcester Borough Council	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wychavon District Council	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wyre Forest District Council	1.00	1.00	0.00	0.00	0.00	0.80	0.80	0.80
Wirral Borough Council	203.20	274.83	293.86	307.48	318.23	327.17	334.86	334.86
Gloucestershire County Council	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worcestershire County Council	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pembrokeshire Coast NPA (W18000002)	85.00	133.00	99.00	65.00	65.00	65.00	65.00	65.00
Snowdonia NPA (W18000003)	27.00	54.00	76.00	76.00	76.00	76.00	76.00	76.00
Isle of Anglesey County Council	91.61	76.36	76.36	76.36	76.36	76.36	76.36	76.36
Gwynedd Council	183.03	195.06	194.79	194.62	194.48	194.38	194.29	194.29
Conwy County Borough Council	285.44	317.65	341.96	359.53	373.49	385.16	395.24	395.24
Denbighshire County Council	176.00	192.41	201.43	207.82	212.82	216.95	220.49	220.49
Flintshire County Council	511.00	540.63	540.63	540.63	540.63	540.63	540.63	540.63
Wrexham County Borough Council	341.43	353.31	346.91	342.74	339.66	337.23	335.23	335.23
Ceredigion County Council	125.00	156.75	159.32	161.07	162.42	163.51	164.43	164.43
Pembrokeshire County Council	358.85	441.12	487.76	488.60	488.60	488.60	488.60	488.60
Carmarthenshire County Council	591.31	592.49	567.97	552.31	540.91	532.00	524.71	524.71
City and County of Swansea	621.95	505.44	475.96	457.64	444.55	434.48	426.34	426.34
Neath and Port Talbot County Borough Council	404.41	481.61	544.19	584.00	584.00	584.00	584.00	584.00
Bridgend County Borough Council	646.00	683.91	761.54	761.54	761.54	761.54	761.54	761.54
Vale of Glamorgan Council	694.00	921.59	928.00	676.00	676.00	676.00	676.00	676.00
Cardiff Council	733.00	733.00	733.00	733.00	733.00	733.00	733.00	733.00
Rhondda Cynon Taff County Borough Council	468.62	508.38	503.48	500.23	497.80	495.87	494.26	494.26
Caerphilly County Borough Council	414.00	229.00	302.00	302.00	302.00	302.00	302.00	302.00
Blaenau Gwent County Borough Council	147.00	127.74	164.10	164.10	164.10	164.10	164.10	164.10
Torfaen County Borough Council	194.38	189.77	178.94	172.15	167.26	163.48	160.41	160.41
Monmouthshire County Council	240.00	326.90	312.14	302.83	296.12	290.91	286.67	286.67
Newport City Council	908.00	811.00	881.49	881.49	881.49	881.49	881.49	881.49
Powys County Council	297.94	281.11	262.44	262.44	262.44	262.44	262.44	262.44
Merthyr Tydfil County Borough Council	156.00	156.00	156.00	156.00	156.00	156.00	156.00	156.00

Table 24 - LPA plan based household trajectories used for supply area apportionment

Forecasts of Household Meter Optant Levels

We describe customers who change the way that they pay for their water from a rateable value to a metered basis as 'optants'. Household meter optants are determined at the WRZ level using an average optant rate which is applied to the prior year's unmeasured base; the optant rate is currently set to the 3 year average zonal optant rates.

The average optant rate has been determined from examining the number of optant meters installed each year between 2000 to 2016 expressed as a percentage of the prior year unmeasured Hh base. As the rate is applied to an eroding unmeasured property base per annum, the actual level of optants gradually reduces each year, although the % of the prior base is constant across the planning period. The number of optants are presented as the number per annum, initially rebased to the observed optants in the base year and projecting forward from that point.

Annual Optant installations are added to the annual new connections and 'other meter' installation numbers and the existing measured property base each year to give the new measured property counts for each forecast year.

Forecasts of Other Household Metering

There is an element of household metering that is not categorised as new or optant metering. This is categorised as 'other'. This is assessed in the exact same way as the optant i.e. using the 3 year average rate applied to prior unmeasured base.

The 'other' meter installations are presented as numbers per annum, initially rebased to the observed other installations in the base year. Annual 'other' installation connections are added to the annual new Hh connections and optant numbers and the existing measured property base each year to give the new measured property counts for each forecast year.

As per meter policy, there are no meters assigned to the Compulsory, Occupier change or selective metering categories as the company does not currently exercise these meter policies.

Assignment to the Billed (Occupied) / Unbilled (Void) Categories

For the purpose of forecasting, billed and unbilled categories are those properties that are occupied and those that are void respectively. To disaggregate forecasts into the billed and unbilled categories a simple application of the long term average 'billed to void' % split has been used. This is applied to the billed property forecasts (measured or unmeasured) in each year to split forecasts into the respective categories to provide a subsequent split.

Long term average '% Billed to Unbilled' has been determined from the observed annual average property counts and the billed vs unbilled counts between 2000/01 and base year (2015/16).

Non-Household Property Forecasting

As with other property forecast components, Non-Household Property Forecasts project from the respective categories reported in the 2015/16 Annual Returns outturn (base year). Non-Household Properties are forecast based upon non-linear trends developed from the observed annual average Non-Household properties in each WRZ over the past 17 years (2000 to base year). There has been a step change in the average number of non-household properties reported in the annual returns between 2014/15 and 2015/16.

Forecasts of NHh Property subcomponents associated with the property churn are therefore encompassed within this trend forecasting process. There is no planning requirement to report annual NHh new connections, optants or 'other metering' as is the case for households. Although this data is determined or estimated for other purposes.

The split between 'Billed and Void' properties is based on the ratio of 'Billed to Void' properties in the base year. A base year ratio is determined at each WRZ and applied to the forecasts of billed NHh properties in each year to determine an equivalent void (unbilled) number.

Summary of Property Forecasts

Figure 18 and Table 25 below shows the regional property component forecasts.

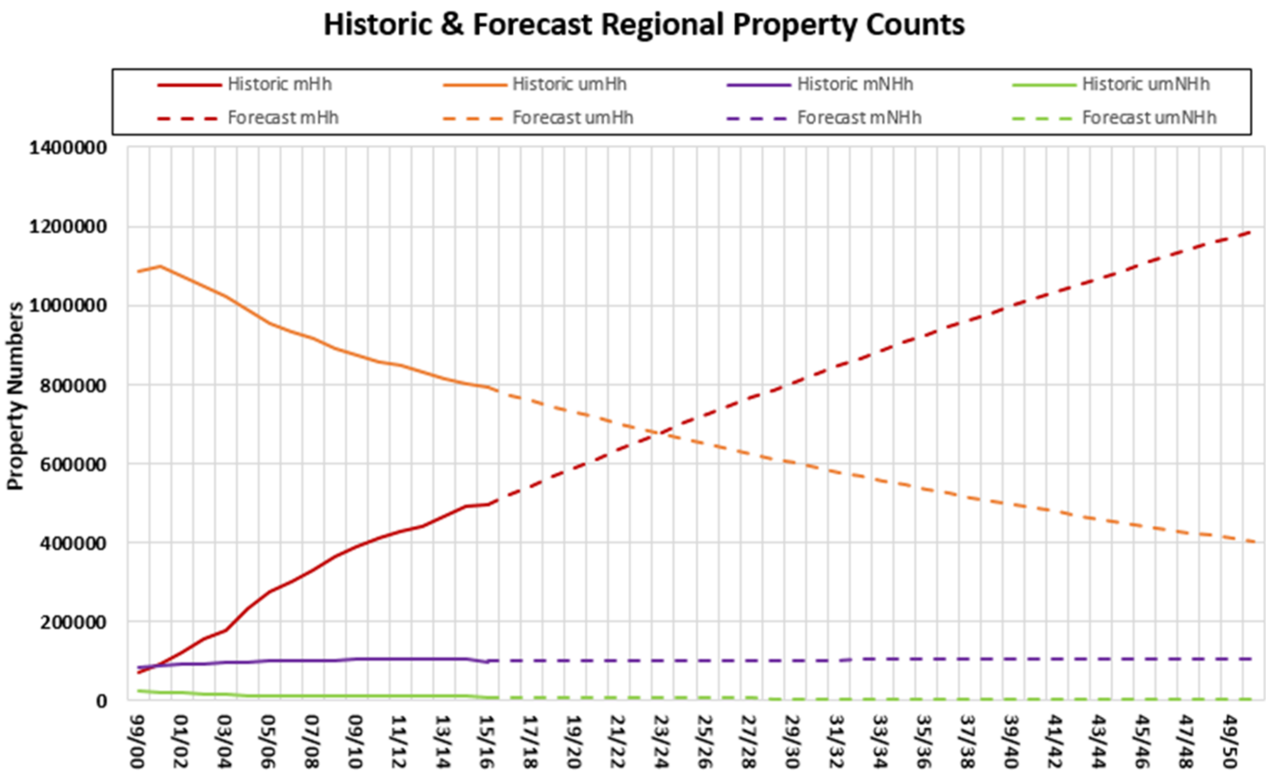


Figure 18 - Historical and forecast regional property components

Component	00/01	05/06	09/10	15/16	19/20	24/25	29/30	34/35	39/40	44/45	49/50
Unmeasured Household	1,097,324	953,647	873,905	793,311	729,781	661,927	600,796	545,683	495,962	451,074	410,521
Measured Household	92,143	274,255	390,830	496,207	589,705	702,057	806,964	905,778	999,205	1,087,893	1,172,636
Non-Household	110,149	113,614	116,332	109,302	109,487	109,616	109,707	109,795	109,898	110,021	110,168
Total	1,299,615	1,341,516	1,381,068	1,398,820	1,428,972	1,473,600	1,517,467	1,561,256	1,605,064	1,648,988	1,693,325

Table 25 - Historical and forecast regional property components

Name	2019/2010					2029/30					2039/40					2049/50				
	Total	UmHh	mHh	Tot NonHh	Met Pen	Total	UmHh	mHh	Tot NonHh	Met Pen	Total	UmHh	mHh	Tot NonHh	Met Pen	Total	UmHh	mHh	Tot NonHh	Met Pen
North Eryri / Ynys Mon	62.18	31.20	24.63	6.34	44.12	64.03	25.38	32.31	6.34	56.01	66.15	20.65	39.17	6.33	65.48	68.16	16.80	45.03	6.33	72.84
Clwyd Coastal	38.69	13.89	21.89	2.91	61.17	40.19	9.78	27.55	2.86	73.79	41.02	6.89	31.32	2.82	81.97	41.73	4.85	34.09	2.79	87.55
Alwen / Dee	74.20	33.96	33.55	6.69	49.69	79.25	26.56	46.07	6.62	63.43	84.89	20.77	57.55	6.57	73.48	90.72	16.25	67.94	6.54	80.70
Bala	1.95	0.82	0.83	0.30	50.20	2.16	0.65	1.21	0.30	65.02	2.41	0.52	1.60	0.29	75.64	2.76	0.41	2.06	0.29	83.41
Tywyn / Aberdyfi	3.10	0.93	1.82	0.35	66.06	3.18	0.63	2.20	0.35	77.59	3.26	0.43	2.48	0.35	85.18	3.34	0.29	2.70	0.35	90.21
Blaenau Ffestiniog	3.48	2.02	1.20	0.26	37.30	3.76	1.67	1.83	0.27	52.20	4.11	1.39	2.46	0.27	63.93	4.51	1.15	3.09	0.27	72.92
Barmouth	2.63	1.03	1.20	0.39	53.80	2.71	0.82	1.50	0.39	64.72	2.80	0.65	1.75	0.39	73.02	2.88	0.51	1.97	0.39	79.33
Lleyn / Harlech	20.15	8.96	8.20	2.99	47.77	20.77	7.34	10.47	2.96	58.79	21.39	6.01	12.44	2.94	67.44	21.93	4.92	14.08	2.93	74.12
Dyffryn Conwy	47.55	18.20	24.58	4.77	57.46	49.81	13.59	31.52	4.70	69.88	52.44	10.15	37.65	4.64	78.77	55.35	7.58	43.17	4.61	85.07
South Meirionnydd	4.32	1.85	1.95	0.52	51.27	4.60	1.42	2.65	0.53	65.06	4.85	1.09	3.23	0.53	74.71	5.24	0.84	3.87	0.54	82.19
Ross-on-Wye	10.22	4.04	4.96	1.22	55.09	10.44	3.25	5.97	1.22	64.75	10.71	2.61	6.87	1.22	72.45	11.03	2.10	7.71	1.22	78.58
Elan / Builth	9.66	3.77	4.54	1.35	54.66	10.15	2.83	5.97	1.35	67.86	10.66	2.12	7.19	1.35	77.21	11.30	1.59	8.35	1.35	83.99
Hereford C.U. Area	60.46	22.09	32.44	5.93	59.49	64.15	16.89	41.25	6.01	70.96	67.21	12.91	48.23	6.07	78.89	69.98	9.87	53.99	6.12	84.55
Llyswen	4.52	1.69	2.13	0.70	55.68	5.10	1.34	3.05	0.72	69.50	5.44	1.06	3.66	0.73	77.58	5.78	0.83	4.21	0.74	83.44
Monmouth	6.51	2.98	2.86	0.68	48.94	6.88	2.42	3.75	0.71	60.71	7.28	1.97	4.57	0.73	69.86	7.66	1.60	5.30	0.75	76.76
Pilleth	4.06	2.05	1.48	0.54	41.89	4.36	1.75	2.06	0.54	54.06	4.66	1.50	2.62	0.54	63.57	4.93	1.29	3.11	0.54	70.71
Brecon / Portis	5.98	2.57	2.49	0.92	49.20	6.25	2.10	3.27	0.89	60.89	6.53	1.72	3.95	0.86	69.72	6.94	1.40	4.69	0.85	77.00
Vowchurch	3.00	1.19	1.30	0.51	52.28	3.08	0.99	1.58	0.51	61.44	3.42	0.82	2.08	0.51	71.68	3.83	0.68	2.64	0.51	79.39
Whitbourne	7.00	2.66	3.13	1.21	54.14	7.10	2.19	3.70	1.21	62.77	7.58	1.81	4.55	1.22	71.53	8.16	1.50	5.44	1.23	78.45
SEWCUS	605.04	333.25	238.00	33.79	32.67	638.81	278.00	326.79	34.02	44.26	672.19	232.67	405.32	34.19	53.81	705.92	195.38	476.17	34.38	61.59
Tywi C.U. Area	345.62	189.17	134.46	21.99	41.55	373.73	157.73	194.02	21.99	55.16	400.77	131.51	247.28	21.98	65.28	427.38	109.65	295.72	22.01	72.95
Mid - South Ceredigion	30.85	14.18	11.48	5.19	44.72	32.96	12.09	15.40	5.47	56.03	35.41	10.30	19.43	5.68	65.35	38.12	8.78	23.48	5.86	72.78
North Ceredigion	12.92	5.89	5.49	1.55	48.23	13.63	4.76	7.32	1.54	60.59	14.23	3.85	8.84	1.54	69.64	14.80	3.12	10.14	1.53	76.49
Pembrokeshire	64.87	31.37	25.11	8.39	44.46	70.37	26.61	35.54	8.23	57.19	75.65	22.56	44.97	8.12	66.59	80.86	19.14	53.69	8.03	73.72
DCWW Region	1428.97	729.78	589.70	109.49	44.69	1517.47	600.80	806.96	109.71	57.32	1605.06	495.96	999.20	109.90	66.83	1693.32	410.52	1172.64	110.17	74.07

Table 26 - WRZ level property forecast components (000's) & meter penetration (%)

Household Occupancy Forecasting

The approach to forecasting Household Occupancy follows the methods within the UKWIR (2016) 'Population, Household Property & Occupancy Forecasting'.

An Occupancy Rate model is initially developed from observed WRZ level mHh & umHh occupancy rate data collated during annual returns and considers future forecasts of meter penetration across the planning period. The OR forecasts are then adjusted to ensure consistency with the overall 'trend' based household population and property forecasts and combined / average Hh occupancy rates.

The principle of the OR model is that the trend in both Unmeasured and Measured Hh occupancy rate increases over time representing the impact of the meter optant programme and occupancy tending towards 'norm' (i.e. average / combined OR) as meter penetration increases.

4.3.1.8. Household Demand Forecasting

Changes between WRMP14 & WRMP19

The previous approach forecast individual micro-components based on the Ownership Volume Frequency (OVF) approach. During 2016, UKWIR released new guidance / methods around forecasting Household Consumption and this is now an integral part of the WRMP guidelines *(NRW & EA, 2017).*

Our approach to forecasting follows the framework set out in the 'WRMP19 Methods – household Consumption forecasting, UKWIR (2016)'. Household forecasts were developed and produced by Artesia Consulting (Appendix 16 – WRMP19 Household Consumption Forecast (Artesia)) who were, for WRMP19, commissioned to produce the forecasts.

The fundamental changes for WRMP19 are as follows:

- Household forecasts are produced at the 'macro' demand level (i.e. Measured and Unmeasured household Demand) not the micro-component level using the OVF approach.
- They utilise multiple linear regression (MLR) models to understand the variables contributing to demand variability over time.
- They are based on company specific datasets.
- Micro-component forecasts are still produced based on apportioning the macro demand forecasts into the MC's.

The use of the MLR approach is a major improvement given that it's primarily based on Welsh Water specific data and importantly it has enabled the development of an in-depth understanding of customer use / demand at a WRZ and company level on which forecasts are then based.

The Approach

The process of producing the household demand forecasts is summarised below and fully explained in the Technical Appendix to this report (Appendix 15 – Demand Forecasting Technical Report).

The multiple linear regression (MLR) approach has been applied to all 24 WRZs. Although an MLR model surpasses the requirements for some of the zones, a fundamental principle of the MLR development is spatial validation; which means that applying the model to all WRZs improves the performance analysis of the model. For this reason, as well as work efficiency, MLR modelling is the preferred method in all zones.

The output of the model was a set of base model parameters and coefficients that are applied to the forecast variables (e.g. Adults / child split, ACORN Clusters, Property Types and optant numbers) for the measured and unmeasured categories for each WRZ.

The modelling process also considers:

- Climate Change impacts consistent with the UKWIR report 13/CL/04/12 “Impact of Climate Change on Water Demand”. The forecast currently applies a 1.40% increase in Hh demand between 2012 and 2040 extrapolated forward for the plan horizon;
- Trends which are imposed onto the forecast to account for policy and strategic changes to water efficiency, behavioural and technological changes that the MLR model can’t fully forecast (i.e. Residual analysis);
- Optant Metering attrition whereby the impacts of meter optants in terms of demand savings will erode over time as the ‘optant’ effect wears off;
- The benefits of smart metering have been included in two WRZ’s: SEWCUS (250 meters) (WISDOM Project) and also a wider scale project within Tywyn Aberdyfi c. 2,500 meters.

As noted previously, forecasts of household demand and PCC have been updated to align with the Company’s commitment to year on year reductions in overall household demand. Average PCC is forecast to reduce from 145 l/hd/day to 138 l/hd/day by the end of AMP7, similar to the draft forecasts. However our longer range forecast has been updated to achieve an average PCC of 100 l/hd/day by 2050 compared to the 135 l/hd/day we were forecasting in our Draft Plan.

It is important to note that the principle of the forecasting methodology is fundamentally unchanged from the Draft Plan and is based on the same MLR model and processes as referenced in the technical appendices. The alignment of the forecasts to the average PCC glide path has been achieved by imposing a ‘trend’ over the forecasts in the same manner as undertaken for the Draft Plan.

The trends imposed onto and used in the Draft Plan forecasts were in themselves subjective and based on engineering judgement / expert opinion provided by consultants during development of the household forecasting model. They represented an average of a range of the various trends that were developed for the Draft Plan. The purpose of using these additional trends / adjustments is to try and account for future changes that the modelling process, based on the observed data, could not forecast but which could conceivably occur.

This is either because the observed data has never expressed such changes (e.g. future policy / strategic changes) or because the casual relationships between data variables used in the modelling process are not fully realised; the so called ‘residuals / modelling’ error. Imposing additional trends onto the forecasts is therefore a sensible technique to improve their robustness.

The trend term imposed onto the forecasts for this Plan represents the company’s aspiration to continually reduce overall Household Demand and Average PCC year on year by increasing and implementing water efficiency activities and strategies. In the early stages of this Plan up until 2030, the trends are broadly similar to the Draft Plan forecasts in terms of reductions. Post 2030, the trend term is much more aggressive, driving reductions in both measured and unmeasured PCC to achieve an average PCC of 100 l/hd/day by 2050.

Summary of Household Demand Forecasts

Figure 19 below shows the baseline regional Total Hh Demand for each scenario year including the observed / out turn demands up to and including base year.

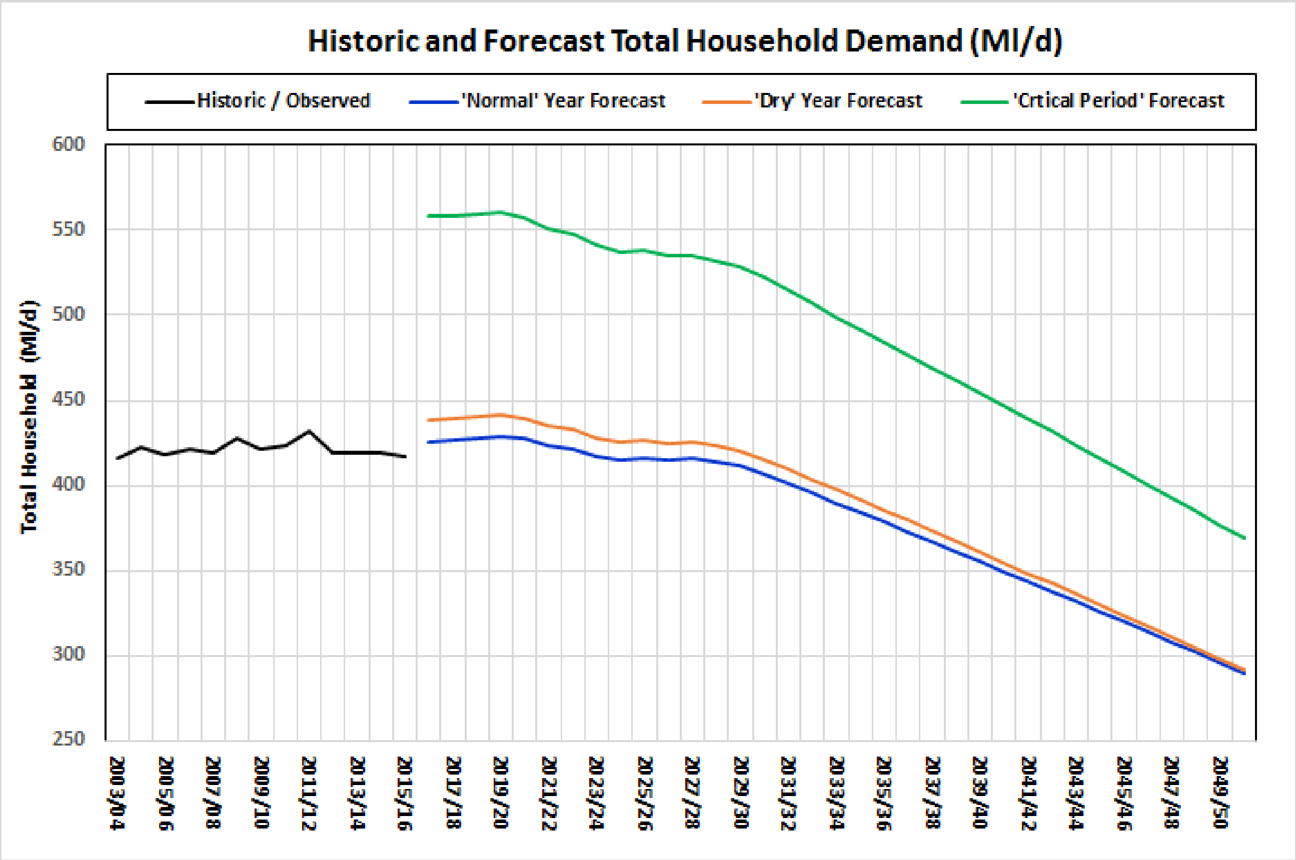


Figure 19 - Regional historical and baseline scenario year forecasts of total Hh demand

4.3.1.9. Non-household Demand Forecasting

Unmeasured Non-Hh Demand Forecasts

There is a relatively small number of unmeasured non-household (umNHh) connections and therefore demand that remains within the company supply area. For the base year, average umNHh property counts were reported at 9,608.

In terms of forecasting, umNHh demand makes up 0.56% of the overall Demand Forecast in the first year of the Plan and reduces every year after as the number of properties reduces. The approach to forecasting is first to develop a volume per property forecast. A power trend is then fitted through the observed volume per property data points. This trend is then forecast across the planning horizon, offset to start from the base year position.

The umNHh demand forecasts are produced by multiplying the per property forecasts by the forecasts of billed umNHh properties. Whilst observed umNHh demand is variable, the trend shows that average umNHh demand per property will continue to decline over time. This reflects continued low level metering of the low level consumers that now remain.

Measured Non-Hh Demand Forecasts

Non-household Demand is the second largest component of our water balance. As of base year 2015/16 it constituted 21.2% of regional Distribution Input, varying between 11.28% and 34.97% of DI across the 24 WRZ.

Forecasting baseline non-household demand is problematic. Unlike household demand, it is much more heterogeneous and is difficult to separate and understand causal relationships required for forecasting. Past trends may also have no bearing on future forecasts of demand due to its complex and varied nature.

Following the 2014 Plan we came to the consensus that a different approach was needed and commissioned CACI Ltd to construct an econometric regression model. The sole aim was to help improve the way in which we forecast non-household demand beyond extrapolation of past trends and make better use of the historical demand data the company holds and freely available econometric datasets.

To this end the mNHh demand forecasts are generated in MS Excel based on Multivariate regression modelling using a combination of Welsh Water non-household demand data and external econometric and climatic variables. An econometric based model, at present, is deemed as the best practice approach to forecasting mNHh demand.

For this Plan our approach to forecasting builds upon the Econometric regression model framework developed by CACI Ltd, developing functionality, scenarios, uncertainty (Monte Carlo) and sensitivity analysis. To support model delivery CACI Ltd also produced a comprehensive technical method**.**

In terms of 'Economic' Indicators used by the model, Table 27 summarises the latest forecast parameters values in the short term period (5 to 10 years) on which forecasts are based. It is worth noting that we have not considered any potential economic impacts of 'Brexit' within our demand forecast.

Component	Units	2016	2017	2018	2019	2020	2021	2022	2023	2024
		2017	2018	2019	2020	2021	2022	2023	2024	2025
Unemp	%	4.61	5.20	5.53	5.87	6.20	6.20	6.20	6.20	6.20
Employ	%	72.46	73.20	73.55	73.89	74.24	74.24	74.24	74.24	74.24
Oil	$/Barrel	43.55	54.10	56.60	58.00	59.20	60.30	60.30	60.30	60.30
GDP	% Gr	2.11	2.00	1.60	1.70	1.90	2.00	2.00	2.00	2.00
GVA	% Gr	3.34	3.17	2.53	2.69	3.01	3.17	3.17	3.17	3.17
IOP: B-E:	% Gr	1.34	1.57	1.55	1.52	1.50	1.50	1.50	1.50	1.50
CPI	% Gr	0.96	2.40	2.30	2.00	2.00	2.00	2.00	2.00	2.00
RPI	% Gr	2.02	3.70	3.60	3.10	3.10	3.20	3.20	3.20	3.20
IR	%	0.34	0.30	0.50	0.60	0.80	1.00	1.00	1.00	1.00

Table 27 - Summary of forecasting parameters used by the regression model

We have not specifically engaged with our larger users to understand short / medium projections of consumption changes going forward. This assessment is in itself is difficult to determine with any level of certainty and would introduce greater risk into the modelling process and forecasts than basing a model on actual observed data. We have dedicated "Large Business Customer" and "Developer Services" teams who were consulted through the WRMP process with regards to this aspect. Specific, well known developments / changes have been considered e.g. Wylfa Newydd in Anglesey is included as a scenario demand forecast, rather than in our baseline demand forecast, due to the uncertainty in the potential volumes of water required. Furthermore, as econometric regression modelling has been used, by definition demand changes are considered when regressing observed historical demand against the modelling parameters.

Summary of Non-Household Demand Forecasts

Figure 20 below shows the baseline regional Total Measured Non-Hh Demand for each scenario year including the observed / out turn demands up to and including base year.

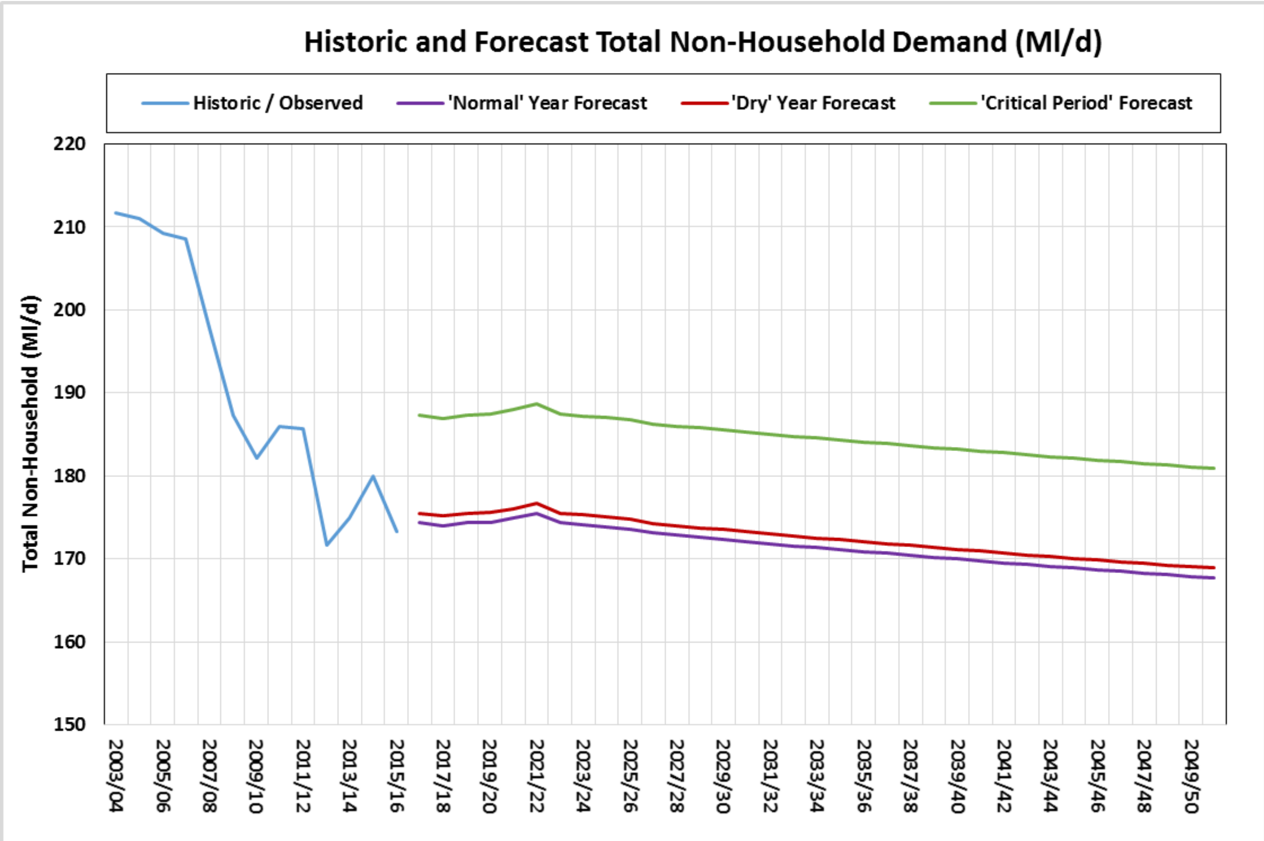


Figure 20 - Regional historical and baseline scenario year forecasts of total mNHh demand

Figure 21 below provides a sector by sector comparison of the raw Measured Non-Household Forecasts (pre-adjustments for MLE, MUR, etc.) for the WRMP19 and WRMP14 Measured Non-Household Forecasts.

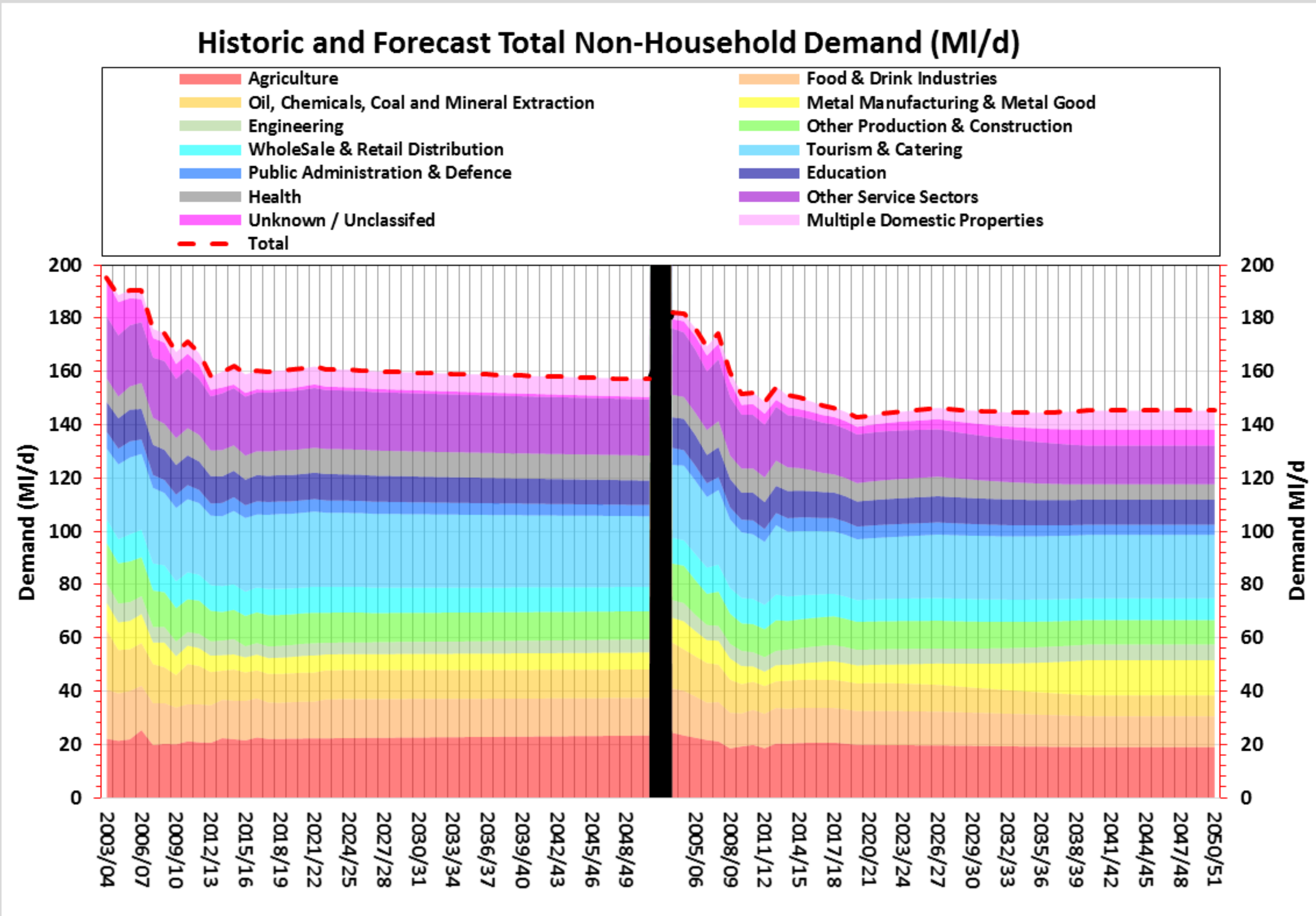


Figure 21 - Measured non-household sector forecasts comparison of WRMP19 and WRMP14

Figure 22 below provides a comparison of the raw Total Measured Non-Household Forecasts (pre-adjustments for MLE, MUR, etc.) for the current and previous forecast methods (trend based). It also shows the impact of including 'fuzzy logic' to provide an estimate of Water Efficiency measured on demand.

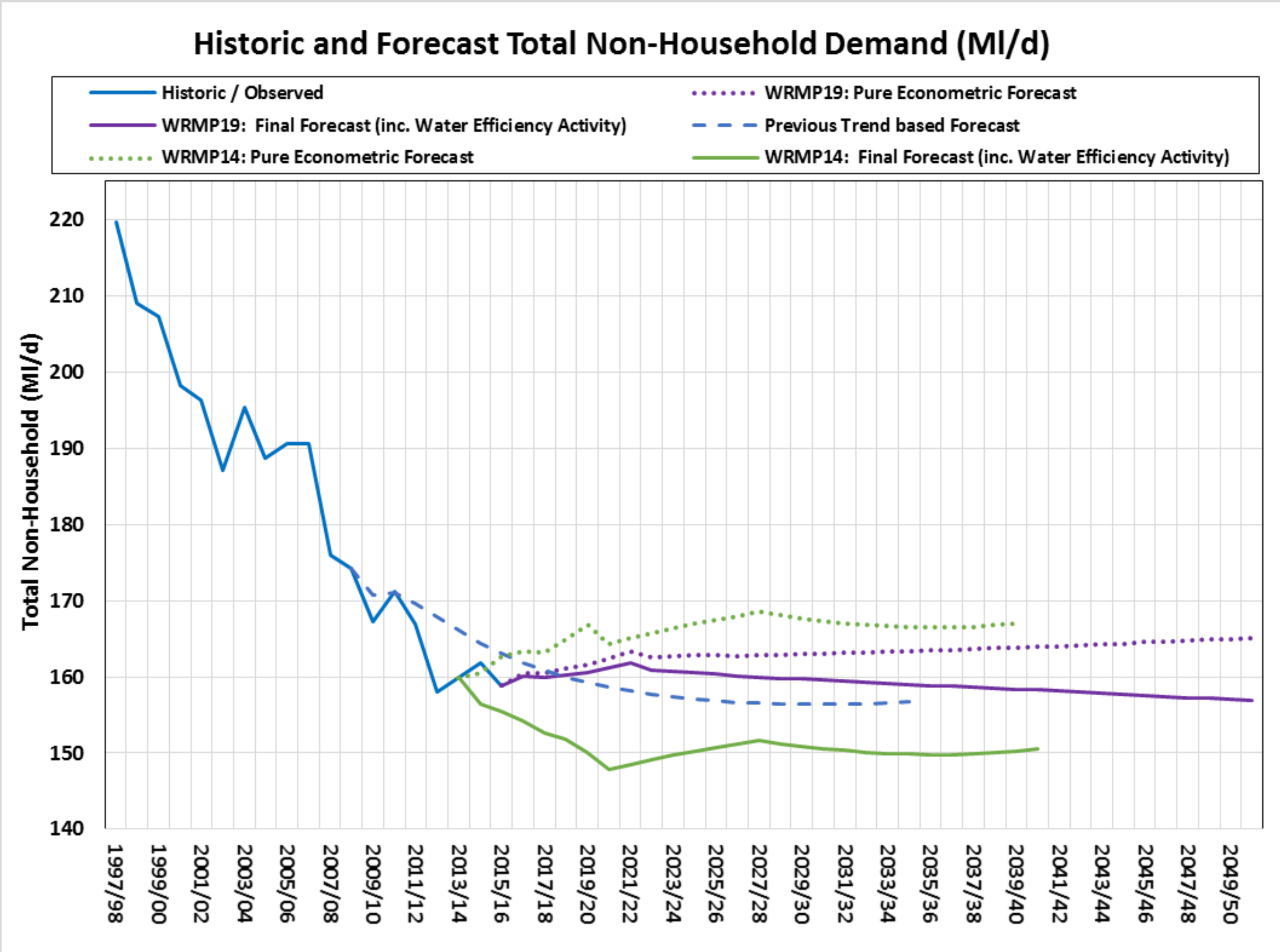


Figure 22 - Regional historical and baseline scenario year forecasts of total mNHh demand

Table 28 below provides the WRZ level baseline 'Normal Year' Total Non-household forecasts by component.

Name	2015/16			2019/20			2029/30			2039/40			2049/50		
	Total (Ml/d)	UmHh (Ml/d)	mHh (Ml/d)	Total (Ml/d)	UmHh (Ml/d)	mHh (Ml/d)	Total (Ml/d)	UmHh (Ml/d)	mHh (Ml/d)	Total (Ml/d)	UmHh (Ml/d)	mHh (Ml/d)	Total (Ml/d)	UmHh (Ml/d)	mHh (Ml/d)
North Eryri / Ynys Mon	10.96	0.42	10.54	10.65	0.39	10.26	10.35	0.33	10.02	10.18	0.28	9.89	10.03	0.25	9.78
Clwyd Coastal	4.61	0.08	4.53	4.68	0.07	4.61	4.61	0.05	4.56	4.54	0.04	4.51	4.48	0.03	4.45
Alwen / Dee	15.72	0.24	15.48	15.78	0.21	15.57	15.57	0.15	15.41	15.32	0.12	15.20	15.11	0.09	15.02
Bala	0.29	0.03	0.26	0.29	0.02	0.26	0.28	0.02	0.26	0.28	0.02	0.26	0.27	0.02	0.26
Tywyn / Aberdyfi	0.43	0.05	0.39	0.43	0.05	0.39	0.43	0.04	0.38	0.42	0.04	0.38	0.41	0.04	0.37
Blaenau Ffestiniog	0.19	0.04	0.16	0.19	0.03	0.16	0.19	0.03	0.16	0.19	0.03	0.16	0.18	0.03	0.16
Barmouth	0.53	0.04	0.49	0.54	0.04	0.50	0.53	0.04	0.49	0.52	0.03	0.48	0.51	0.03	0.48
Lleyn / Harlech	3.65	0.42	3.23	3.66	0.39	3.27	3.60	0.35	3.25	3.54	0.32	3.22	3.49	0.30	3.19
Dyffryn Conwy	5.09	0.17	4.91	5.11	0.15	4.96	5.00	0.11	4.89	4.90	0.08	4.81	4.81	0.07	4.74
South Meirionnydd	0.51	0.07	0.43	0.51	0.07	0.44	0.50	0.07	0.43	0.49	0.06	0.43	0.48	0.06	0.42
Ross-on-Wye	1.22	0.06	1.17	1.22	0.05	1.17	1.20	0.04	1.16	1.18	0.03	1.15	1.16	0.03	1.14
Elan / Builth	1.18	0.04	1.14	1.19	0.04	1.15	1.17	0.03	1.14	1.16	0.03	1.13	1.15	0.02	1.12
Hereford C.U. Area	10.27	0.20	10.07	10.04	0.19	9.86	10.20	0.16	10.05	10.08	0.12	9.96	9.98	0.10	9.89
Llyswen	0.49	0.02	0.47	0.50	0.02	0.48	0.49	0.01	0.48	0.49	0.01	0.48	0.48	0.01	0.47
Monmouth	0.64	0.02	0.62	0.65	0.02	0.64	0.65	0.01	0.64	0.64	0.01	0.64	0.64	0.01	0.63
Pilleth	0.37	0.01	0.36	0.38	0.01	0.37	0.37	0.01	0.36	0.37	0.01	0.36	0.36	0.00	0.36
Brecon / Portis	0.96	0.02	0.94	0.96	0.02	0.93	0.93	0.01	0.92	0.92	0.01	0.91	0.90	0.01	0.89
Vowchurch	0.65	0.01	0.64	0.66	0.01	0.65	0.65	0.01	0.65	0.65	0.01	0.64	0.64	0.00	0.64
Whitbourne	1.51	0.06	1.45	1.52	0.06	1.46	1.54	0.06	1.48	1.53	0.05	1.48	1.52	0.04	1.48
SEWCUS	64.41	1.41	63.00	64.97	1.21	63.76	64.13	0.84	63.28	63.31	0.60	62.71	62.60	0.44	62.16
Tywi C.U. Area	32.29	0.86	31.44	32.98	0.75	32.23	32.45	0.55	31.90	31.98	0.41	31.57	31.56	0.31	31.25
Mid - South Ceredigion	4.30	0.27	4.03	4.44	0.26	4.18	4.51	0.24	4.28	4.51	0.22	4.29	4.50	0.21	4.29
North Ceredigion	2.50	0.06	2.45	2.57	0.05	2.51	2.53	0.04	2.49	2.48	0.03	2.45	2.44	0.02	2.42
Pembrokeshire	10.53	0.14	10.39	10.55	0.12	10.43	10.47	0.08	10.39	10.33	0.06	10.27	10.20	0.04	10.17
DCWW Region	173.30	4.72	168.58	174.46	4.22	170.24	172.35	3.28	169.07	169.99	2.61	167.37	167.92	2.14	165.78

Table 28 - WRZ baseline Normal Year component forecasts of total NHh demand

4.3.1.10. Other / Minor Components

Forecast volumes of Distribution System Operational Use, Water Taken Legally Unbilled and Water Taken Illegally Unbilled are produced using a component volume per property multiplied by the total property counts in each forecast year. The component volume per property is derived from the base year and is fixed at this rate across the forecast horizon.

4.3.1.11. Leakage Forecasting

One of the key comments we received from Welsh Government and our Regulators and stakeholders on our draft Plan was that our baseline demand forecast should reflect our Company's commitment to Ofwat's challenge of a minimum 15% reduction in Total Leakage by the end of AMP7. Our Draft Plan examined the impact of committing to this target as a scenario but in response to the consultation, for this Plan we have:

a. Committed to meet Ofwat's challenge of a minimum 15% Total Leakage reduction by the end of AMP7.

b. Included the longer term aspiration, in line with our 2050 vision, to meet a 10% of Total Leakage level of base year (2015-16) Distribution Input (c.79.5 Ml/d) by 2050. As a result, our Total Leakage profile is no longer 'flat' beyond AMP7 but continues to show a year on year reduction across the horizon.

c. The impacts of leakage consistency have been considered within this assessment and will result in no change to the leakage reduction profiles across the planning period. This will therefore remain as the glide path presented in our baseline position. Any impacts of 'Convergence' will be offset by the end of 2020/21.

There is a regulatory requirement for every water company to provide an assessment of its sustainable economic level of leakage (SELL) and we will continue to assess our leakage targets on this basis.

We prepared an initial SELL assessment for the draft WRMP19. However recent regulatory guidance includes both changes in leakage reporting procedures and a challenge for water companies to aim for more ambitious reductions in leakage. The approach used in 2017 to generate our initial SELL assessment for the draft WRMP19 is consistent with the methodology developed and utilised at PR14. The regulatory review of our approach at PR14 found it to be compliant with available technical guidance, industry best practice, and PR14 regulatory guidance, and there were indications that the methodology was at the leading edge of UK Water Companies' SELL assessment approaches.

Using existing techniques and technology we consider that we are operating close to the economic level of leakage. Meeting new targets will require a step-change in our approach. During AMP6 we have undertaken a number of projects aimed at improving the water balance and our understanding of the current leakage position.

We have embarked on a project to coordinate water efficiency and customer side leakage operations on an area by area basis. Utilising new technology that can detect very low flows, even in unmetered properties, we have established that the volume of water 'lost' through in home leakage, such as through dripping taps and faulty toilet cisterns, is much higher than previously thought. This is both a challenge and an opportunity. If we can work with customers to tackle these 'plumbing losses', then we can reduce water usage and overall leakage, at a lower cost than seeking further leakage reductions from our mains and distribution networks, where we face diminishing returns.

Project Cartref (meaning 'home' in Welsh) is our customer-side leakage reduction strategy for AMP7. It responds to the innovation, trials, and research we have conducted during AMP6 to better understand losses on the part of the network that is owned and controlled by customers.

We have piloted Project Cartref during AMP6 with trials in 20 areas. When a home has been identified as potentially having significant plumbing losses, a dedicated trained plumber follows up with the customer and offers to carry out a domestic water efficiency audit to understand the source of leakage and provide other water efficiency advice. We then offer repairs and water efficiency devices at our cost. The trials have been successful, in that they have been welcomed by customers and have reduced leakage and consumption in those areas. They have also provided useful learnings on how to make the approach successful when rolled out at scale.

In conjunction with Project Cartref we will continue with our policy of repairing leaking or damaged supply pipes for free and replacing lead supply pipes when they are found.

Project Cartref means providing a different kind of service to customers and will rely on our customers to trust us to work in their homes for mutual benefit. We believe that our high trust scores and our ‘not for profit’ model will help us to do so successfully. Project Cartref marks an important innovation in our approach to leakage; one that is based on active customer participation and behavioural change. Our existing ‘find and fix’ and ‘upstream’ leakage detection and prevention activities will also need to continue in order to deliver the significant overall leakage reduction target to which we are committing in AMP7.

Our three-pronged strategy for Leakage reduction will involve tackling upstream losses on trunk mains, reducing losses on the distribution system, and a new focus on customer side losses (both from external underground supply pipes, and internal plumbing) – see the below sections for further details.

4.3.1.12. DMA Distribution Leakage

We propose to improve the efficiency of our leakage detection activity in DMAs in order to free up staff to focus on upstream and customer side leakage. A key part of our strategy is to utilise fixed monitoring systems in areas with high natural rate of rise (NRR), including acoustic logging, but also other emerging technologies. We also propose to systemise leak detection surveys by using new hand-held devices that make use of noise and vibration analysis algorithms rather than relying on the human ear.

4.3.1.13. Customer side leakage and losses

A key element of our AMP7 leakage plan is to increase focus on customer side losses, both external underground supply pipe losses to meet our leakage target, and internal plumbing losses through our water efficiency programme. Our pilots have shown that the level of leakage beyond the customer boundary box may be higher than previously reported. Our Cartref project will determine the costs and practicality of identifying those properties with leaks, and then engaging with the customer to make the repairs.

Detection will be aided by the use of new technology such as Stop Watch, and repairs by the use of new no dig techniques such as Aquapea. The forecast savings are based on the results from our pilot projects in 20 of our per capita consumption (PCC) areas, and the Cartref project, using a projected cost curve for detection and repair.

4.3.1.14. Trunk Main Leakage

Building on our work to estimate the level of real loss in zones and “tiles” in the upstream network, we have identified sections where there appears to be leakage to find. Utilising new technology such as trunk main leak noise correlators, satellites, drones, mobile survey systems and fixed monitoring systems we will put greater emphasis into locating leaks, and we will increase staff resources accordingly.

As part of our customer minutes lost programme we will be installing additional monitors on trunk mains, which will support in identifying leaks. We have also commenced a programme of monitoring service reservoirs for overflows and losses through the structure and on-site pipework. Our pilots have shown that it is possible to locate leaks in this way, as well as unaccounted for consumption. The forecast saving over the AMP is based on our experience to date from our trunk mains team, which was established in 2015.

The configuration of our trunk main network makes isolating some sections of main difficult in order to effect repairs. We are planning to develop enabling measures for repairs alongside our increased detection focus.

4.3.2. Total Leakage Forecast

Our baseline approach to total leakage forecasting is currently in line with the short run Sustainable Economic Level of Leakage (SELL) methodology and is generated from the SALT model. Total Leakage Forecasts include Supply Pipe Leakage (SPL) and as such other demand forecast components therefore exclude SPL. The SELL profiles are also considered post-MLE and undergo no further adjustment as part of collating component forecasts and producing an overall DI forecast.

As noted previously, for this Plan the Total Leakage glide path has been updated to reflect:

a. The commitment to meet Ofwat's Challenge of a minimum 15% Total Leakage reduction by the end of AMP7.

b. The longer term aspiration, in line with our 2050 vision, to meet a 10% Total Leakage level of base year (2015-16) Distribution Input (c.79.5 Ml/d) by 2050.

c. The impacts of leakage consistency.

This is now considered as the Company baseline scenario. The processes and methodologies employed in producing this revised leakage profile are unchanged from draft and are based on the same SELL methodology. This is summarised below and fully detailed in Appendix 17 – AMP7 SELL Assessment (RPS).

All data and elements required for the SELL assessment have been updated for WMRP19 and used to produce a set of WRZ specific total leakage profiles incorporating an estimate of Trunk Mains and Service Reservoir losses.

At a regional level the base line leakage as a result of the modelling activity produces a glide path for District Meter Area (DMA) leakage across AMP7 of -26 Ml/d reducing from 169 to 143 Ml/d between 2019/20 and 2025/26 (Figure 23). Beyond AMP7, the leakage glide path is set to reduce year on year reaching c79.5 Ml/d by 2050.

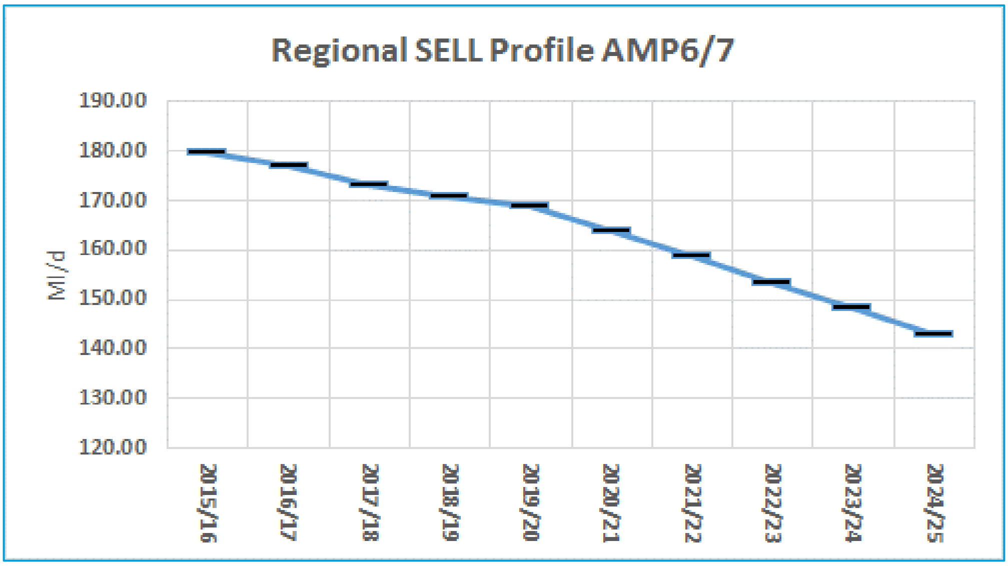


Figure 23 - AMP6/7 baseline total leakage glidepath (based on srSELL Assessment)

The above incorporates the estimate of Trunk Mains and Service Reservoir losses which is held static over the same period. For the remainder of AMP6 the WRMP14 SELL assessment applies with the AMP7 reductions continuing from the last year of AMP6. Table 29 below shows the current AMP6 and AMP7 WRZ reductions

WRZ	WRZ Name	Total Leakage Volume (Ml/d)										Reduction Volume (Ml/d)									
		BY	AMP6				AMP7						AMP6				AMP7				
		2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25
8001	North Eryri / Ynys Mon	6.44	6.97	6.59	6.30	6.07	5.85	5.63	5.41	5.19	4.96		0.53	-0.39	-0.28	-0.23	-0.22	-0.22	-0.22	-0.22	-0.22
8012	Clwyd Coastal	3.42	3.98	3.98	3.98	3.98	3.83	3.69	3.54	3.39	3.25		0.56	0.00	0.00	-0.01	-0.15	-0.15	-0.15	-0.15	-0.15
8014	Alwen / Dee	7.00	6.56	6.55	6.54	6.52	6.26	6.00	5.74	5.48	5.22		-0.44	-0.01	-0.01	-0.02	-0.26	-0.26	-0.26	-0.26	-0.26
8020	Bala	0.51	0.44	0.42	0.40	0.39	0.38	0.37	0.37	0.36	0.35		-0.08	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
8021	Tywyn / Aberdyfi	0.09	0.23	0.23	0.23	0.23	0.22	0.21	0.20	0.19	0.18		0.14	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01
8026	Blaenau Ffestiniog	0.33	0.49	0.46	0.44	0.42	0.41	0.39	0.38	0.36	0.35		0.15	-0.03	-0.02	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01
8033	Barmouth	0.27	0.29	0.29	0.29	0.29	0.28	0.27	0.26	0.25	0.24		0.02	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01
8034	Lleyn / Harlech	2.95	3.07	3.07	3.07	3.05	2.93	2.81	2.70	2.58	2.46		0.13	-0.01	0.00	-0.02	-0.12	-0.12	-0.12	-0.12	-0.12
8035	Dyffryn Conwy	9.40	9.65	9.58	9.49	9.45	9.02	8.60	8.17	7.75	7.32		0.25	-0.07	-0.09	-0.04	-0.43	-0.43	-0.43	-0.43	-0.43
8036	South Meirionnydd	0.56	0.49	0.49	0.49	0.49	0.47	0.45	0.43	0.41	0.38		-0.07	0.00	0.00	0.00	-0.02	-0.02	-0.02	-0.02	-0.02
8101	Ross-on-Wye	1.46	1.38	1.21	1.09	1.00	0.97	0.93	0.90	0.86	0.83		-0.08	-0.17	-0.12	-0.08	-0.04	-0.04	-0.04	-0.04	-0.04
8102	Elan / Builth	1.18	1.01	0.95	0.90	0.86	0.83	0.80	0.77	0.74	0.71		-0.17	-0.06	-0.06	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
8103	Hereford C.U. Area	4.34	4.86	4.86	4.86	4.85	4.67	4.50	4.32	4.14	3.97		0.52	0.00	0.00	-0.01	-0.18	-0.18	-0.18	-0.18	-0.18
8105	Llyswen	0.63	0.51	0.51	0.51	0.51	0.49	0.47	0.46	0.44	0.42		-0.12	0.00	0.00	0.00	-0.02	-0.02	-0.02	-0.02	-0.02
8106	Monmouth	0.75	0.80	0.79	0.79	0.79	0.76	0.73	0.71	0.68	0.65		0.05	-0.01	0.00	0.00	-0.03	-0.03	-0.03	-0.03	-0.03
8107	Pilleth	0.59	0.38	0.38	0.38	0.38	0.36	0.35	0.34	0.32	0.31		-0.21	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01
8108	Brecon / Portis	1.03	1.06	1.06	1.06	1.06	1.02	0.98	0.94	0.90	0.87		0.04	0.00	0.00	-0.01	-0.04	-0.04	-0.04	-0.04	-0.04
8110	Vowchurch	0.63	0.68	0.67	0.67	0.67	0.65	0.62	0.60	0.58	0.55		0.05	0.00	0.00	0.00	-0.02	-0.02	-0.02	-0.02	-0.02
8111	Whitbourne	1.11	1.00	0.99	0.99	0.98	0.95	0.91	0.88	0.84	0.81		-0.11	-0.01	-0.01	-0.01	-0.03	-0.03	-0.03	-0.03	-0.03
8121	SEWCUS	87.26	84.59	82.30	81.08	80.09	77.77	75.45	73.14	70.82	68.51		-2.66	-2.29	-1.22	-1.00	-2.32	-2.32	-2.32	-2.32	-2.32
8201	Tywi C.U. Area	5.88	33.37	33.37	33.37	33.32	32.54	31.76	30.98	30.20	29.42		27.48	0.00	0.00	-0.05	-0.78	-0.78	-0.78	-0.78	-0.78
8202	Mid - South Ceredigion	2.27	4.75	4.66	4.66	4.65	4.49	4.32	4.16	3.99	3.83		2.49	-0.09	0.00	-0.01	-0.16	-0.16	-0.16	-0.16	-0.16
8203	North Ceredigion	9.73	2.12	2.10	2.10	2.08	2.01	1.94	1.87	1.80	1.73		-7.61	-0.02	-0.01	-0.01	-0.07	-0.07	-0.07	-0.07	-0.07
8206	Pembrokeshire	87.26	8.33	7.70	7.19	6.87	6.63	6.38	6.14	5.90	5.66		-78.93	-0.63	-0.50	-0.33	-0.24	-0.24	-0.24	-0.24	-0.24
8999	**DCWW Region**	**179.86**	**177.03**	**173.22**	**170.88**	**169.00**	**163.80**	**158.60**	**153.40**	**148.20**	**143.00**		**-2.83**	**-3.80**	**-2.34**	**-1.88**	**-5.20**	**-5.20**	**-5.20**	**-5.20**	**-5.20**
												Remainder AMP6 Reduction				-10.86	AMP7 Reduction				-26.00

Table 29 - WRZ total leakage glidepath and volume reductions AMP6/7 (based on srSELL)

4.3.2.1. Leakage estimation and targeting

We will retain our current process which is followed for each of the 24 water resource zones to give a forecast for leakage over the 30-year planning period, with the SELL for each zone being aggregated into a total for the Company. The current model does not distinguish between the types of leaks found in DMAs and for the forthcoming review of SELL, on which work has started. Changes are being made to the methodology to better understand the options available to us to meet the Ofwat challenge. We will improve the SELL model such that:

- An estimate will be made for the cost – benefit relationship for all available options for reducing leakage on the three sections of the network referred to above, especially in light of the recent findings related to customer supply pipe leakage and night use;
- Consideration will be given to reducing the level of ALC on mains and communication pipes in DMAs in order to free up resources for other more cost effective activities;
- At a company level, the model will show transparently the high level relationship between investment in leakage reduction measures and the resulting level of leakage;
- Leakage reduction scenarios will be better integrated with other strategic aims and investment cases such as zonal studies, water quality, supply interruption and pressure transient impact of more mains repairs. The wider benefits of an increased customer side leakage focus will be explored.
- Rather than a single SALT model for each zone, there will be separate models for the three specific sections of the network – 1) trunk mains and service reservoir leakage, 2) DMA leakage on mains and communication pipes and 3) customer side leakage comprising underground supply pipe leakage and internal plumbing leaks;

Alternative Total Leakage Forecasts

Alternative leakage profiles have been developed for scenario planning and to test the overall plan. They do not reflect the company's baseline position, which is currently based on the economic level of leakage from srSELL. Further to this, none of the alternative leakage profiles have been run through the SELL methodology to determine the economics and forecast profiles of these alternative scenarios.

4.3.2.2. Consistency of leakage reporting

Water companies, in conjunction with Water UK, have been working to improve the consistency of reporting definitions for key performance measures so that comparisons between companies can be made more easily. This work is supported by Ofwat, the Environment Agency, Natural Resources Wales and the Consumer Council for Water. The requirement is to report leakage in compliance with the 2017 UK Water Industry Research (UKWIR) report on Consistency of Reporting Measures (herein referred to as Consistency) which requires a series of operational and data improvements to meet minimum compliance with the new standards.

Initial shadow reporting alongside existing methodologies is expected, with adoption of the new standard by April 2020. We need to make changes to our 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. The effect is purely a change in the reporting of leakage; it should not affect the actual amount of water lost through leakage. We have assessed the impact of adhering to these new requirements using our current data sets and they will result in a significant increase to our reported leakage levels. We will have completed a programme of water balance improvement projects by the start of AMP7 to deliver compliance and we anticipate that this will resolve the reported leakage increases to at least a neutral position by the end of AMP6. Some additional projects are planned as mitigation to ensure that our reported leakage does not increase and to potentially make gains from the opportunities presented by the new standards. The change in reporting of leakage is purely a change in reporting; it does not affect the actual amount of water lost through leakage

4.2.2 Changes to Household Demand

Another clear response to the consultation on our draft WRMP19 from Regulators and stakeholders was the agreement that we should move forward with proposed additional investment used to better engage with our customers on lowering per capita consumption (PCC) through behavioural change. In addition, respondents to our consultation also asked that we include further information in our plan on our approach.

As laid out in our PR19 Business Plan, Table 30 below shows a summary of our estimated spend on water efficiency (excluding metering) in AMP7 in comparison to our previous spend (AMP5) and current spend (AMP6). A significant increase in spend is forecast as a direct result of much greater water efficiency activity we will undertake over the five years from 2020 – 2025.

Water Efficiency Spend	AMP5	AMP6	AMP7
	£2,200,000	£2,718,500	£4,548,000
		+ £518,500	+ £1,829,500

Table 30 - Comparison of our Water Efficiency budget AMP 5 to AMP7

In line with this, investment, we have set ourselves challenging PCC targets as we believe that this will drive innovation and our own awareness that water efficiency should be brought into conversations with our customers wherever these arise. Our target is to reduce average PCC from 145 l/hd/day to 138 l/hd/day by the end of AMP7, with the longer term aspiration of a reduction to 100 l/hd/day by 2050.

We have built a framework of initiatives which we are able to bring together where there are synergies geographically and or where we need to target effort in our least water resource resilient zones. A current example of this is our Rhondda Fach Resilient community's project where our zonal studies programme is driving significant water supply projects in a local area. We are engaging with the local community to raise awareness of the water supply projects and are also using this opportunity to engage on water efficiency.

The key initiatives are:

- To build water efficiency messaging and education into our Cartref leakage initiative. Through the Cartref project an estimated 18,000 customer properties will receive a home water efficiency audit which will include the targeted installation of water saving devices and information encouraging conscientious and efficient use. The results from this work stream will inform and assist in delivery of our AMP7 performance commitment for PCC.

- To Increase our Domestic Audit Programme – supporting c.30,000 customers across AMP7 compared to c.5,500 across AMP6;

- To continue to deliver, and improve upon, our award winning schools outreach programme. Working in collaboration with our education team, Welsh Government and Local Authorities we will aim to introduce water efficiency to children between the ages of 5-10 (c.210,000 individuals) over the AMP7 period, promoting water saving behaviours and encouraging the use of water efficient devices and practices through links to the educational curriculum.

- To work collaboratively with developers and planners and ensure that water efficient fixtures and fittings are installed in an effort to limit maximum use to 125 litres per person, per day in line with the Building Regulations 2010, (with consideration given to the amendments due in November 2018). We also plan to investigate ways of incentivising water efficiency measures into new builds.

- We will ensure our own premises are water efficient through the implementation of the Waterwise Checkmark at all key sites.

- Provide a targeted approach to Water Efficiency within our deficit zones utilising data and information from related work streams (Cartref, Community Support, SELL etc.) to implement solutions which achieve quantified demand saving results. This includes assessment of demand savings achievable from implementation of SMART metering solutions.

- To engage with and support our most vulnerable communities as part of our current 'Zonal Studies' programme of work. This is again exemplified by our support c.10,000 customers within the Rhondda Fach Valley, an area of considerable water debt and vulnerable customer groups. This will set the basis for further 'community' support programmes going forward;

4.4.Producing Overall Baseline Demand Forecasts

4.4.1.1. Bringing the forecast components together

For this Plan we have produced an overall demand forecasting tool termed the 'collation tool' building on many of the same principles as the Demand Forecasting Model developed for previous Plans.

The collation tool deals with consistency to the Annual Return values, making adjustments for MUR, MLE and ensuring forecasts project from this point. It also normalises demand and produces scenario years (i.e. Dry Year and Critical Peak) and produces scenarios (sourced from the component forecasts themselves) to underpin resilience testing and allocates the overall household demands to respective micro-components.

Changes to Household Meter Under Registration (MUR) affecting forecasts

Initially Base Year (2015/16) Hh MUR has been set to 4.15%, however, during 2016-17 we committed to conducting a company specific study into Household MUR, updating the MUR rate applied to measured household water delivered within the water balance.

As such the forecasts of measured household demand have a MUR applied at 4.15% for 2015/16 which is then increased to 7.8% for 2016/17 (consistent with that used in AR17) and the remainder of the Plan period.

Producing Normal Year Forecasts

Forecasts are 'normalised' by applying normalisation or Normal Year (NY) factors. NY factors are regional but specific to the demand component and are applied using a simple multiplicative technique where by the relevant WRZ component are multiplied by the 'component' specific regional NY factor.

It is inappropriate to apply the NY peaking factors to leakage as it is not directly proportional to demand. Consequently, leakage is held constant across all scenarios and added to consumption (i.e. DI minus leakage) once multiplied by adjusted peaking factors (PFs) as illustrated below:

NY DI = NY Consumption +Total Leakage

NY Consumption = Consumption x NY Factor

Consumption = DI – Total Leakage

Producing Scenario Year Forecasts

Once forecasts are normalised they are then ‘peaked’ by applying the Dry Year (DY) or Critical Period (CP) factors to the NY forecasts. For this Plan, DY factors have been produced to align with the same meteorological analysis undertaken for NY determination. The method to produce CP factors has been aligned with the ‘Peak Demand Forecasting Methodology, (UKWIR, 2006)’.

Dry Year Forecasts

DY factors are initially regional and specific to the demand component and are applied using a simple technique whereby the relevant WRZ components are multiplied by the regional ‘component’ specific DY factor. Again leakage is excluded from this conversion.

WRZ equivalents of the DY factors are produced by dividing the WRZ DY total consumption by the WRZ NY consumption. These are then applied to WRZ NY total consumption forecast only.

Critical Period Forecasts

Our approach to produce peak demand forecasts follows the practitioner framework described within the ‘Peak Demand Forecasting Methodology, (UKWIR, 2006)’. The peak period is defined as a week and is determined as the maximum weekly value between the months of April and September for each WRZ and year of available data. Once peak week has been identified then the peak periods need to be rebased and normalised in line with techniques described within the Peak Demand Forecasting Methodology.

Critical period factors are WRZ specific but also specific to the demand component and are applied using a simple multiplicative technique whereby the relevant WRZ components are multiplied by the WRZ ‘component’ specific critical period factor. Again leakage is excluded from this conversion.

Summary of Adjustment Factors

Table 31 below gives an overall summary of the regional adjustment factors used.

Component	2015/16 Outturn to Normal Year	Normal Year To Dry Year	Normal Year To Critical Period
Unmeasured Household	0.9980	1.0258	1.0635
Unmeasured Non-Household	0.9998	1.0026	1.0063
Measured Household	0.9984	1.0206	1.0508
Measured Non-household	0.9996	1.0052	1.0127
Water Taken Legally Unbilled	0.9998	1.0026	1.0063
Water Taken Illegally Unbilled	0.9998	1.0026	1.0063
Distribution System Operational Use	0.9998	1.0026	1.0063
Total Consumption	**0.9998**	**1.0182**	**1.2196**
Trunk Main and SR Leakage	1.0000	1.0000	1.0000
District Meter Area Leakage (inc. SPL)	1.0000	1.0000	1.0000
Distribution Input	**0.9989**	**1.0140**	**1.1699**

Table 31 - Summary of component specific scenario year factors

Table 32 below shows the WRZ level NY to DY and NY to CP factors applied to consumption to produce the baseline DY and CP scenario year forecasts.

WRZ	NY:DY	NY:CP	WRZ	NY:DY	NY:CP
8001	1.016442	1.177201	8105	1.017338	1.323250
8012	1.017658	1.207547	8106	1.019026	1.383068
8014	1.015864	1.236264	8107	1.019055	1.236824
8020	1.016718	1.395658	8108	1.015755	1.208890
8021	1.015204	1.349990	8110	1.015412	1.484293
8026	1.020801	1.266324	8111	1.015160	1.360056
8033	1.014690	1.729210	8121	1.018860	1.129281
8034	1.015529	1.457975	8201	1.019306	1.169297
8035	1.017307	1.212845	8202	1.016833	1.328586
8036	1.016756	1.296219	8203	1.015675	1.352983
8101	1.018149	1.433302	8206	1.016234	1.271207
8102	1.017025	1.416358	DCWW	1.018154	1.219593
8103	1.016439	1.210116			

Table 32 - WRZ level scenario year factors

Micro-component Apportionment

The WRMP tables require that household consumption forecasts are split out into various Micro-components. This is achieved by applying an assumed '%' split which varies by year for each of the micro components categories listed in the WRMP tables. The process is fully explained in Appendix 15 – Demand Forecasting Technical Report.

Under the CP scenario the MC assignment is slightly different in that the extra demand under the CP scenarios is allocated to certain micro-components rather than across the board.

4.5.Summary of the Baseline Forecasts

Figure 24 below shows historical DI and the Baseline Normal, Dry Year and Critical Period Total Demand forecasts as per the **Draft** Plan for the period 1992/93 to 2050/51 inclusive for the DCWW Region. In comparison, Figure 25 shows historical DI and the Baseline Normal, Dry Year and Critical Period Total Demand forecasts as per the **Final** Plan for the same period.

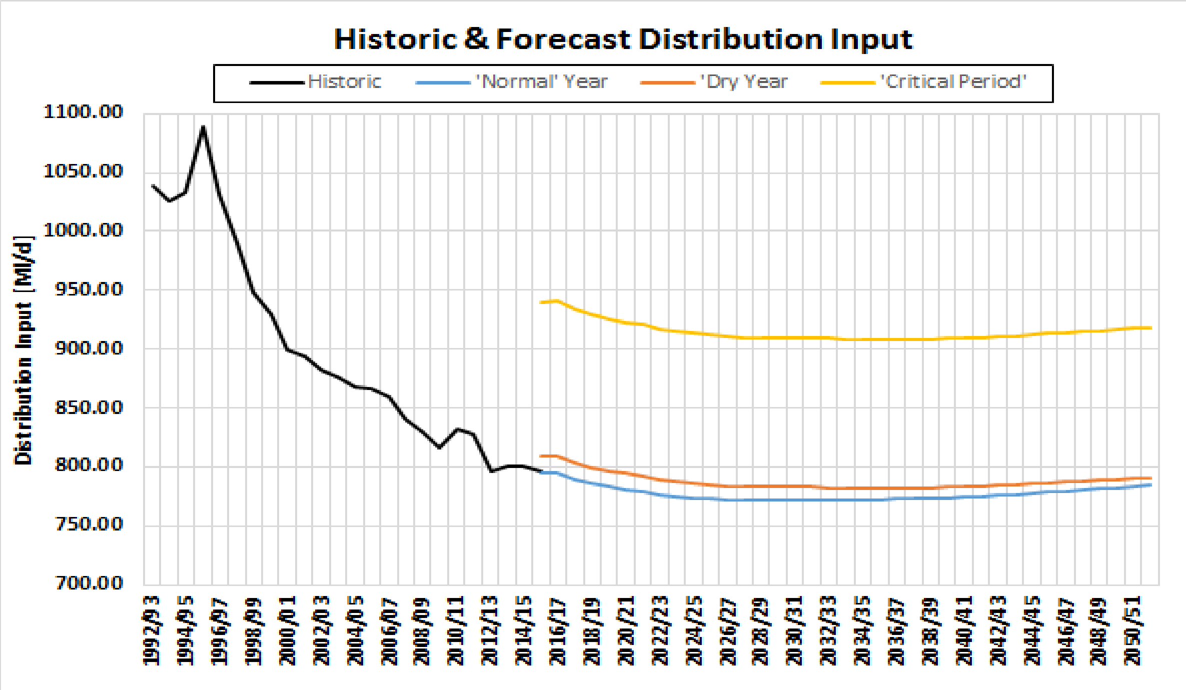


Figure 24 - Regional baseline scenario year forecasts (Draft)

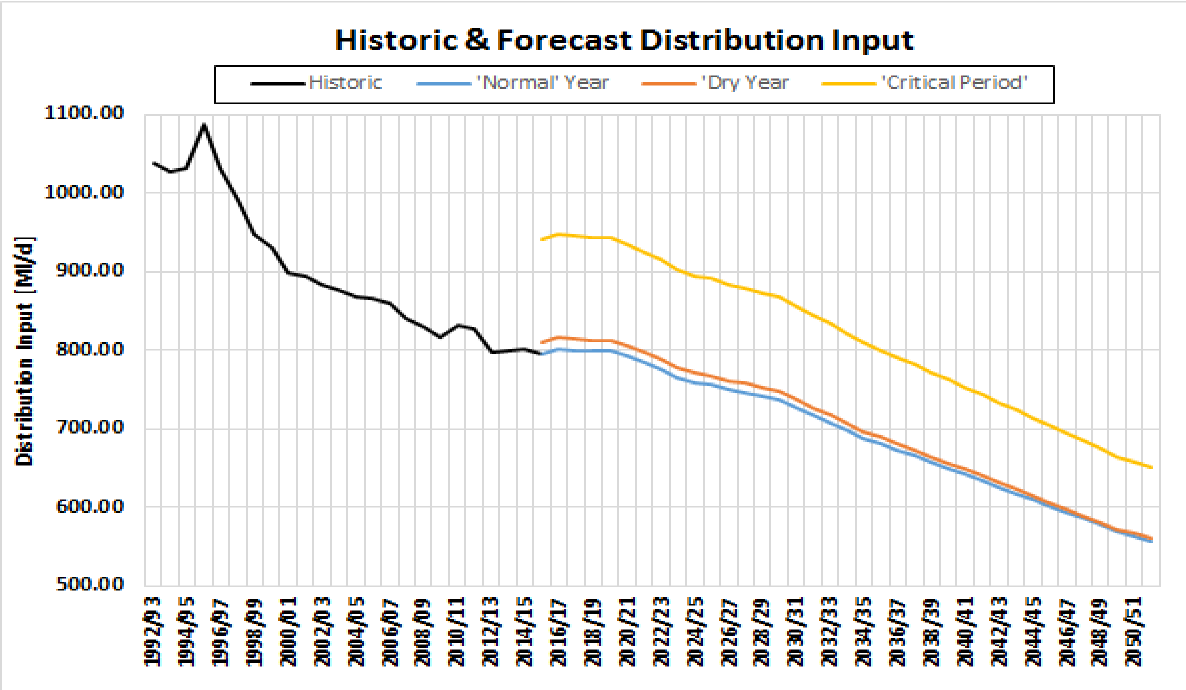


Figure 25 - Regional baseline scenario year forecasts (Final)

Figure 26 below shows a comparison of the proportion of the regional Total Dry Year Demand attributed to each component in the Base Year and 2049/50.

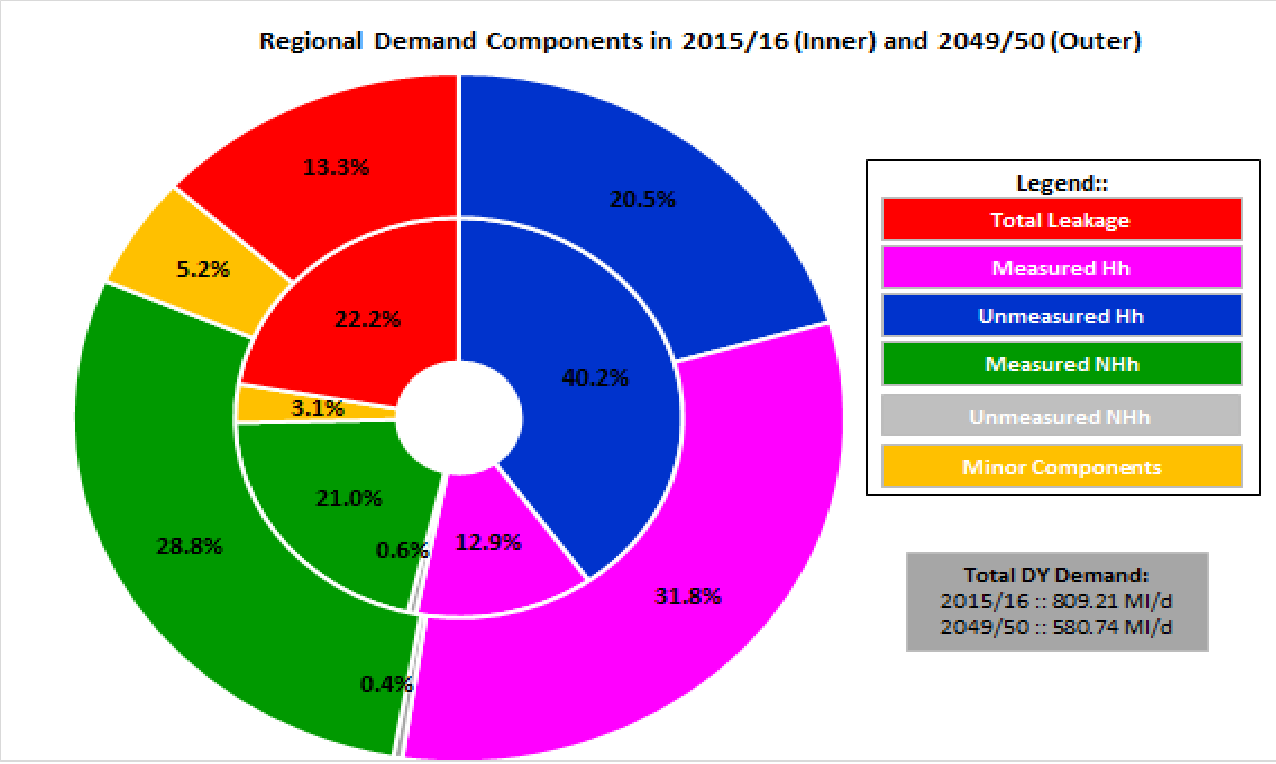


Figure 26 - Comparison of Dry Year demand components between base year and 2049/50

Figure 27 below shows a comparison of the proportion of the WRZ Total Dry Year Demand attributed to each component in the Base Year and 2049/50.

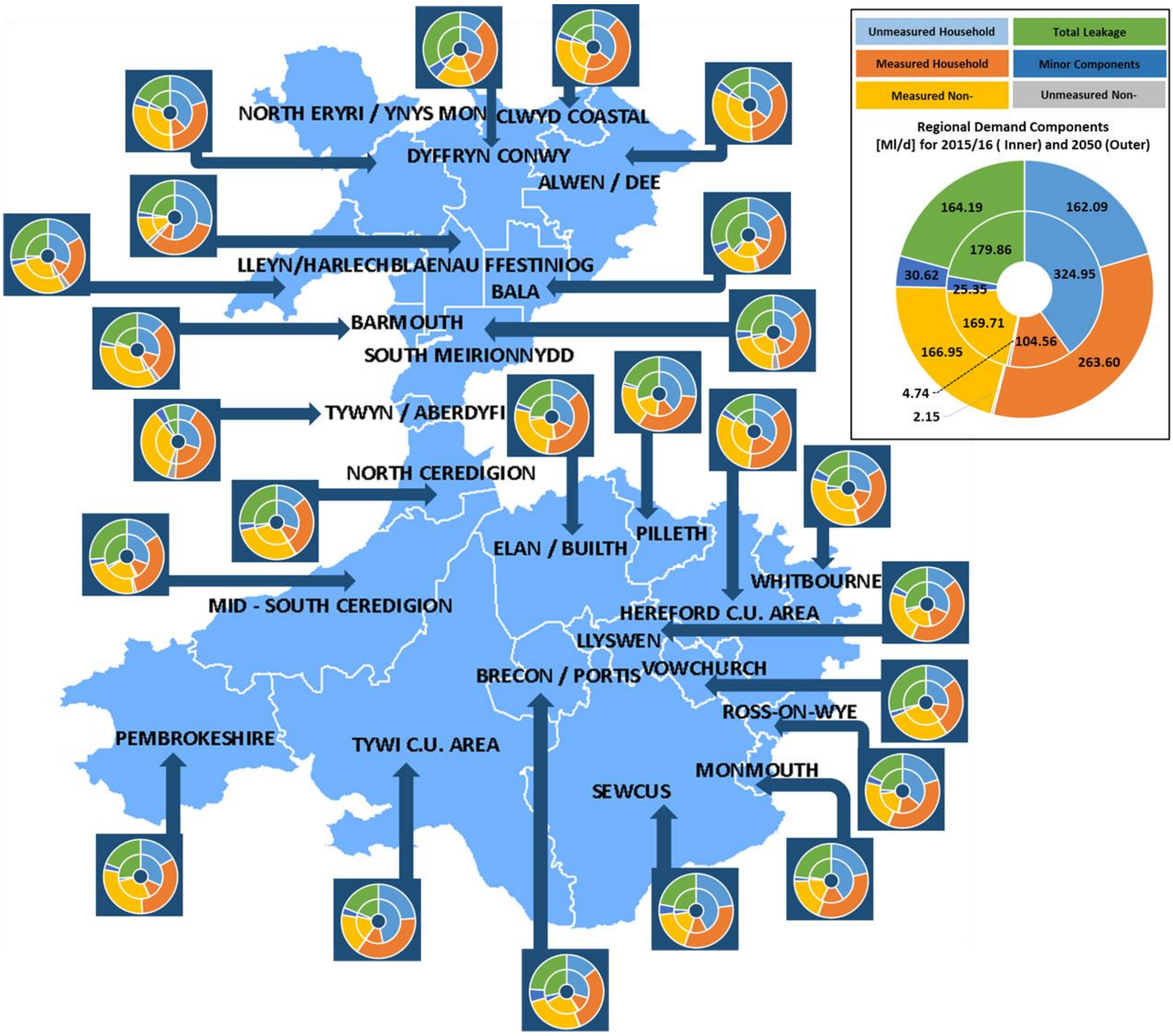


Figure 27 - WRZ Dry Year demand component changes between base year and 2050

4.6.Additional Forecast Considerations

4.6.1.1. Assessing the Impact of Climate Change on Demand

The impacts of climate change have been considered and quantified within both the Household and Non-household demand components.

Household Demand

In line with the 'Impact of Climate Change on Water Demand (UKWIR, 2013)' a 1.40% increase in household demand attributed to climate change between 2012 and 2040 (extrapolated to extend across the full planning period) has been imposed onto the forecast of household demand.

Non-households

The impact of climate change has not been separated out from unmeasured non-household forecasts and is assumed to be contained within the forecasts. For measured non-households the base econometric regression models, which include climate variables as inputs, have been applied to forecasts of the climate at the WRZ level based on the *UK Climate Projections 2009 (UKCP09)*, 'A1B-Medium' Emission scenario (90% probability level). This equates to a 2.07% increase to demand by 2049/50.

Total Consumption & Distribution Input

By 2049/50 climate change accounts for a 10.78 Ml/d increase in demand which is 1.93% of DI or 2.23% of Consumption by the end of the planning period. Whilst these ranges are slightly above the 1% lower threshold generally expected, they are deemed acceptable, are based on best practice and well within the 3% upper limited stipulated.

4.6.1.2. Water Efficiency Strategies

Water Efficiency Consideration in Household Demand Forecasts

'Trends' have been superimposed onto the initial WRZ Measured and Unmeasured Hh forecasts produced from the regression model. This effectively adjusts the demand forecast to account for future water efficiency measures including policy and strategic changes and also technological change and other behavioural trends not forecast / captured by the MLR model *per se.*

As noted previously, the alternative 'trend' aligns to our commitment of year on year reductions in overall household demand and PCC out to 2050. Whilst the trends are regional, the impacts of their application will be WRZ specific based on the magnitude of initial MLR model measured and unmeasured household demand levels.

Water Efficiency Consideration in Non-Household Demand Forecasts

Our approach to measured Non-household (mNHh) forecasting incorporates the mathematical technique termed 'fuzzy logic' to convert business rules around expected water efficiency changes and potential demand impacts into tangible demand adjustments across the forecast horizon. Baseline mNHh forecast currently consider Water Efficiency around 'Improvement in technology' and 'take up of water efficiency measures'

The 'fuzzy logic' process is explained in more detail in Appendix 15 – Demand Forecasting Technical Report.

At a regional level its consideration results in a demand reduction of 6.58 Ml/d at the end of the planning period (2049/50).

Company Meter Policy

In terms of baseline forecasting there are no anticipated changes to the company metering policy over the planning period. Company metering is based on two main streams:

New connections - All new properties / new connections 'i.e. new builds' are fitted with a meter and are therefore considered 'measured' in terms of their property categorisation.

Meter Option Programme - Since 2000 we have operated a 'meter option' programme which gives existing 'unmetered' customers (household or non-household) the choice to become metered.

We do not operate a wide scale 'compulsory metering' policy nor operate a policy to 'meter on change of occupier'. Household properties may be compulsory / selectively metered if they are converted from a single property to several separate properties or have undergone substantial renovations altering the use at the property. Similarly, very few Non-households are unmetered (c. 9,000 (1.2%)) but these may be compulsory / selectively metered if they are found to be using excessive amounts of water, but we do not actively seek these customers for the purpose of metering. These policies are reflected in 'base year' and forecasts of the metered household sub-categories and population forecasts.

Retail Separation

Around 110 of our customers are eligible for switching suppliers. To date none have switched retailer or indicated they are proposing to, which would warrant consideration outside of the current approach / framework to forecast the measured non-household demand.

5. Our Water Supply Systems

5.1. Introduction

Wales has a relatively wet climate when compared to other parts of the UK. However, the regional picture masks important geographical differences within our supply area: for example, at up to 3,000mm per annum, rainfall in Snowdonia can be more than four times the levels recorded in the border areas and Herefordshire, where 700mm per annum is typical.

The diversity of our water supply systems reflects these regional variations, which can range from discrete small-scale local supplies, through to large scale multi-source integrated networks, such as the South East Wales area, that is more typical of many other water company areas. On average we abstract around 800 million litres a day (Ml/d) for public water supply. This normally increases by around 15 – 20 per cent during the summer. During periods of extreme conditions – long hot summers or sudden thaws following freezing weather – the demands on our supply systems can increase by over 25 per cent, and in some localised areas by more than this.

Continued improvements to our supply systems and a steady decline in the demand for water, as shown in Figure 28, have meant we have not had to impose restrictions of any kind on our customer's water use since hosepipe bans were in place during the 1989 drought. The last challenging drought event was 1995 which severely tested our supply capability but we did not have recourse to implement any hosepipe bans or other drought order and drought permit measures. Since 1995, the most significant events have been 2003 which posed some winter refill concerns following a very dry late summer and autumn, and the recent summer of 2018 which has been the second warmest on record in Wales[11] and included an extremely dry 2 month period. The purpose of this Plan is to ensure our supplies are resilient to these historic and more extreme drought events, whilst accounting for the effects of climate change, increased demand and ever tighter drinking water and environmental standards.

[11] https://www.metoffice.gov.uk/news/releases/2018/end-of-summer-stats

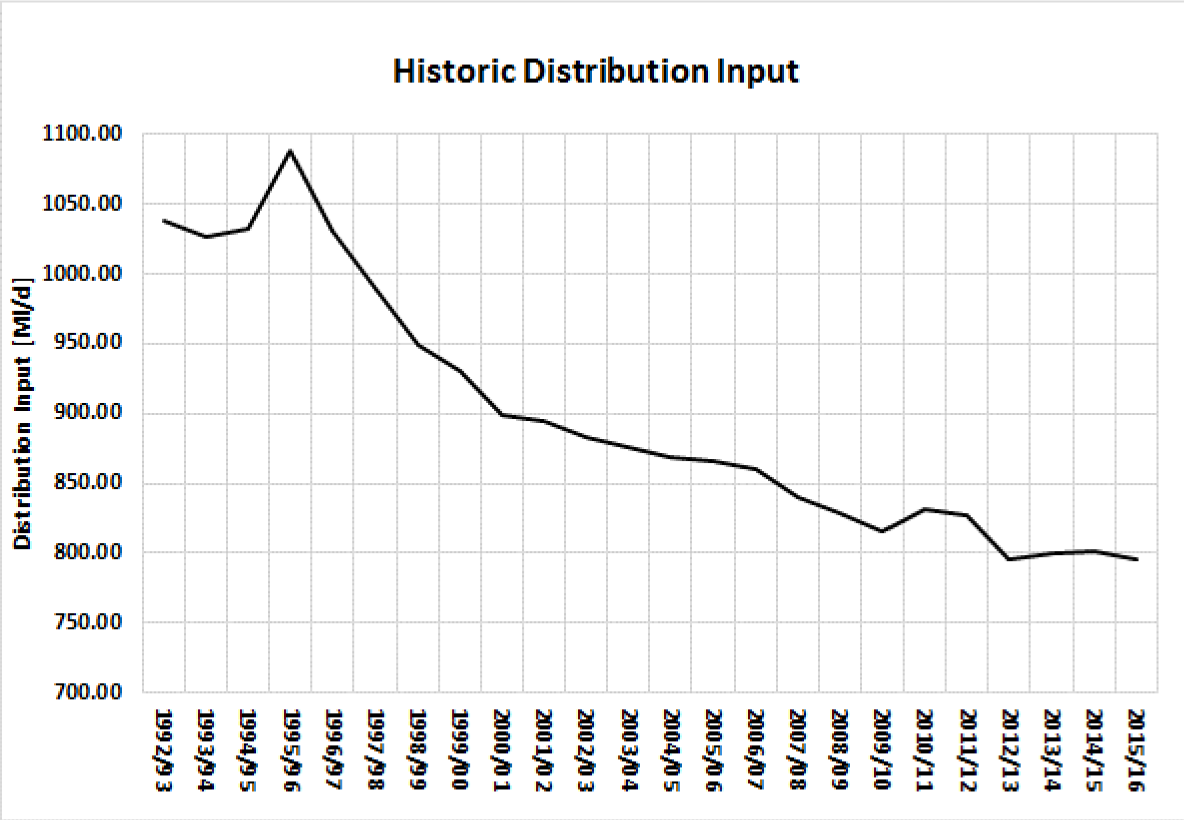


Figure 28 - Welsh Water historic demand data

5.2.North Wales Region

Our North Wales region (Figure 29) serves over half a million people living mainly in Chester and Deeside, Anglesey, the Bangor and Caernarfon area and the coastal strip from Llandudno to Prestatyn. We also supply several large non-potable customers in the area, most notably on Deeside and Anglesey.

Some parts of North Wales experience a significant tourism influx during the summer months, which has a direct impact on the quantity of water supplied during that time. As a consequence the resources and the associated infrastructure supplying these areas need to be able to meet the summer peaks whilst operating at lower levels throughout the remainder of the year.

The rainfall across North Wales varies from upwards of 3,000mm per year on the mountains of Snowdonia to 1,200mm per year around the coastline. However, evaporation throughout the region is also similarly high, reaching over 600mm per year (actual evaporation) across some parts of the area, which offsets the high rainfall to some degree. Our supply areas vary from small areas supplied entirely from run-of-river abstractions to larger areas supplied from a combination of impounding reservoirs, run-of-river abstractions and groundwater sources.

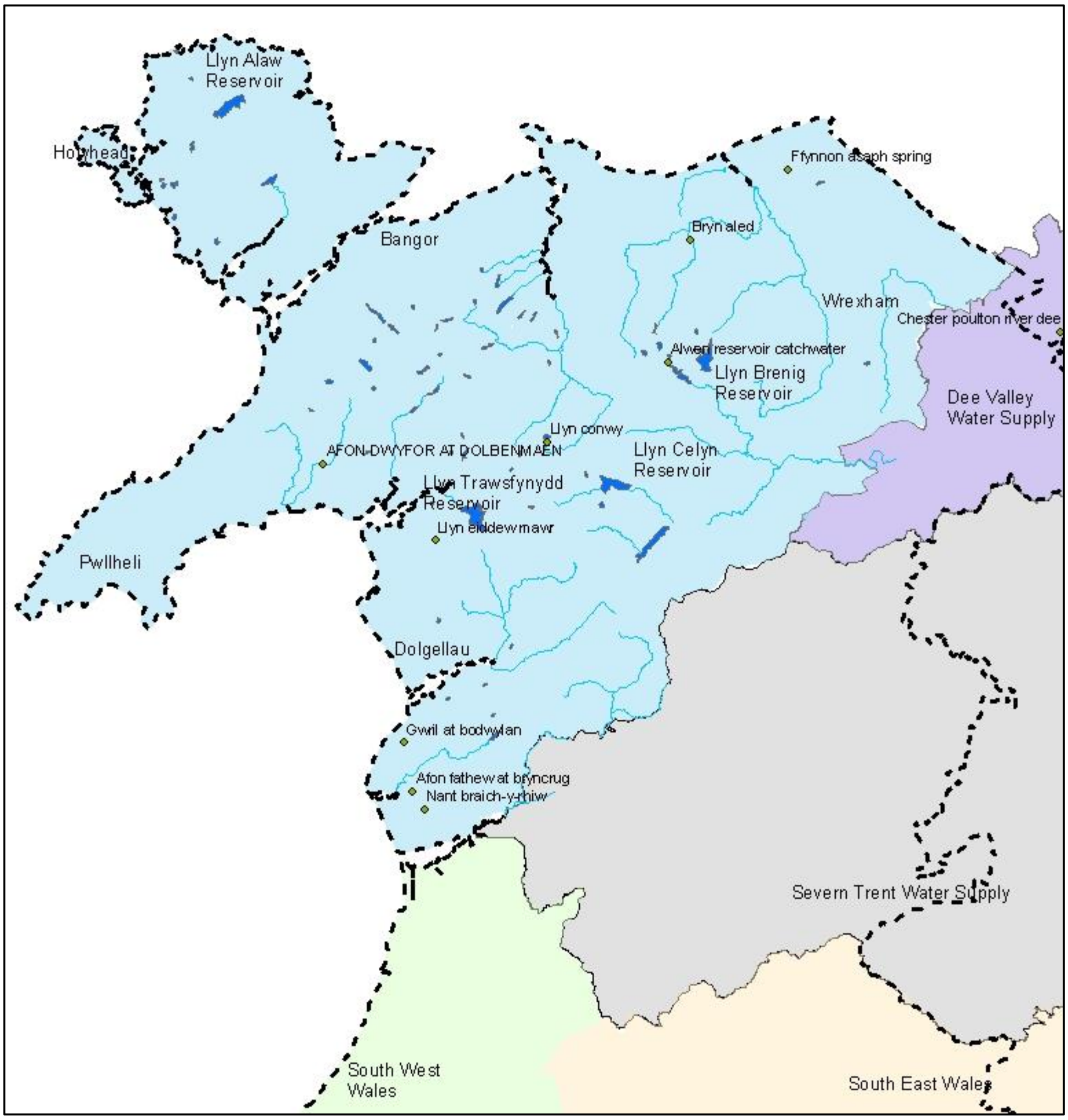


Figure 29 - Overview of our North Wales supply area

5.3. South West Wales Region

Our South West Wales region (Figure 30) serves over 900,000 people living mainly in and around Swansea, Bridgend, Llanelli, Carmarthen and the coastal towns and villages from Pembroke to Aberystwyth. We also supply several large non-potable customers in the Pembroke Dock / Milford Haven area and in the Swansea area. Much of South West Wales experiences a significant tourism influx during the summer months which has a direct impact on the quantity of water supplied.

The rainfall across South West Wales varies from a low of 1,047mm per year at Nevern on the north-west Pembrokeshire coast to a high of 2,220mm per year in the uplands of the Rheidol valley in Ceredigion. Rainfall in the main Tywi catchment averages around 1,600mm per year.

Supply areas in the region fall into two categories; the relatively simple systems in the north west of the area that serves Ceredigion and the complex and highly conjunctive systems in the southern part of the region that serve Pembrokeshire, Carmarthenshire, Swansea and Bridgend.

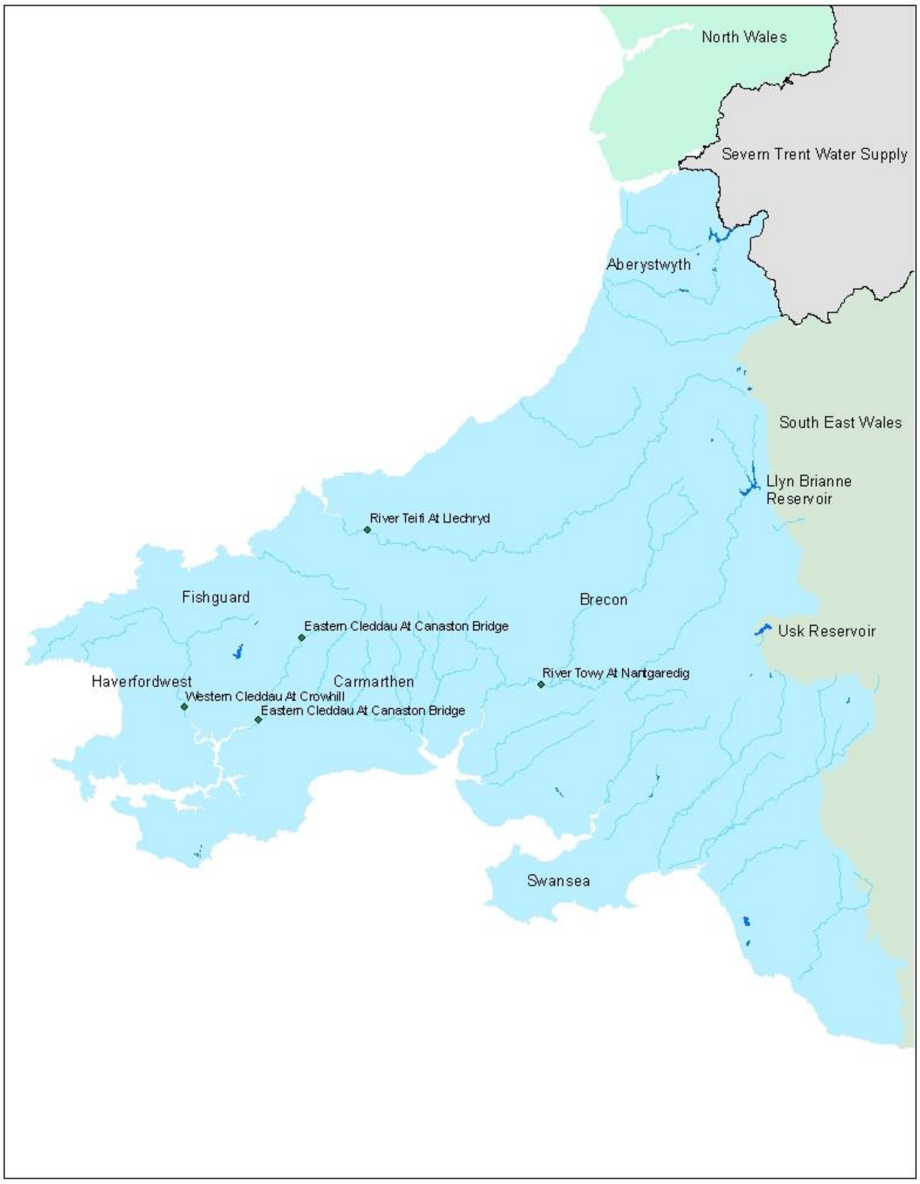


Figure 30 - Overview of our South West Wales supply area

5.4. South East Wales Region

Our South East Wales region (Figure 31) serves nearly 1.6 million people living mainly in Cardiff, Newport and the South Wales valleys and parts of Herefordshire. We also supply a number of relatively large non-potable customers throughout the area.

The rainfall across the South East of our supply area varies greatly from as little as 700mm per year in the eastern parts around Hereford to some 2200mm in mid-Wales and uplands of the South Wales valleys. The main lowland urban areas such as Cardiff receive around 1200mm per year, slightly under the average for Wales. Supply areas vary from simple, single sources of water to the extremely large, complex and fully conjunctive areas supplied from a combination of impounding reservoirs and river abstractions that have to be managed carefully to ensure sufficient resource is always available.

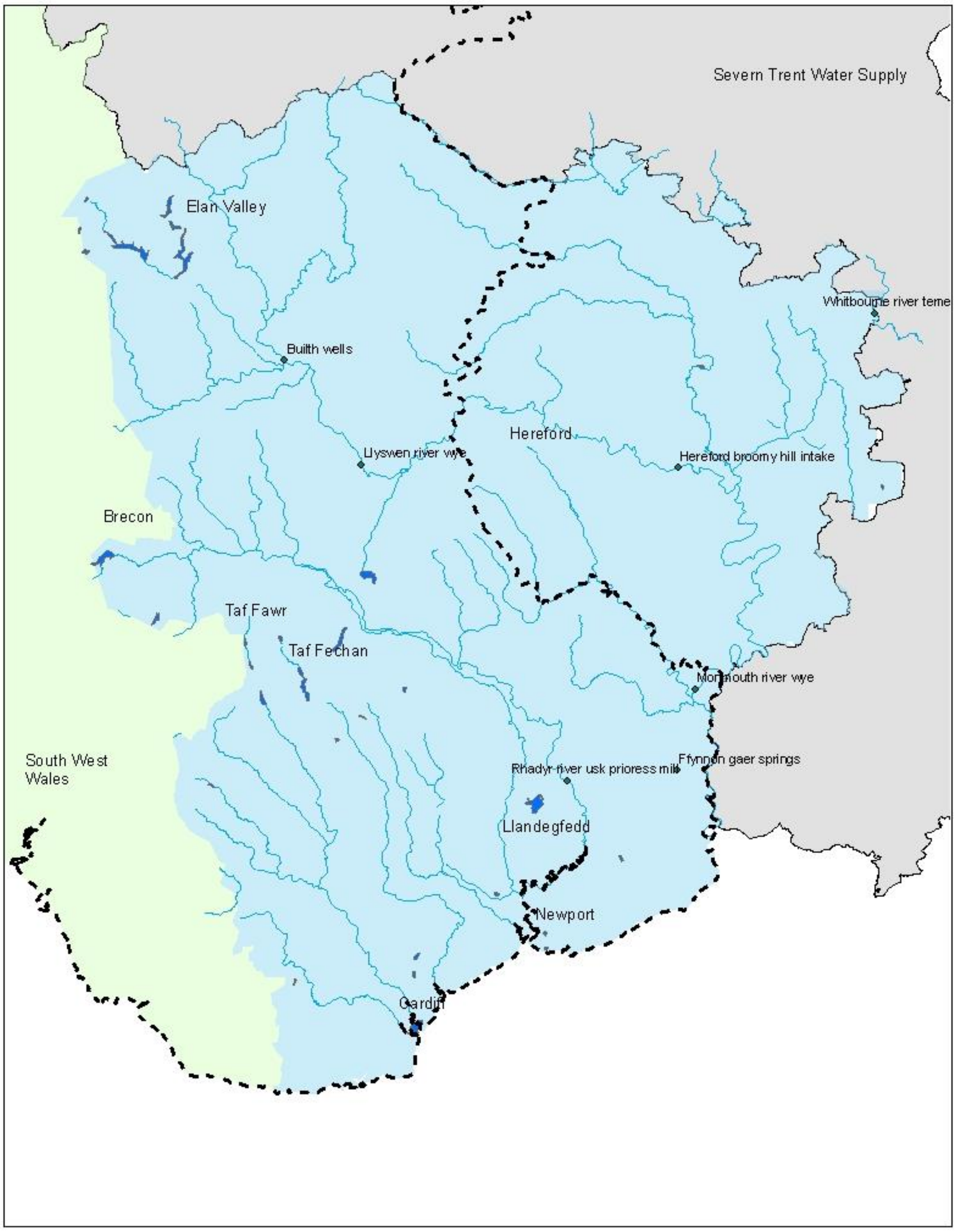


Figure 31 - Overview of our South East Wales supply area

5.5.Water Resource Zones

For water resource planning, each of these regions are further subdivided into individual Water Resource Zones (WRZ). By definition, each of the WRZs is self-contained, and the scope to move water between them is limited. We continue to plan on the basis of twenty four WRZs and have provided detailed justification for this in our Water Resource Zone Integrity assessment presented in Appendix 18 – Water Resource Zone Integrity Assessment.

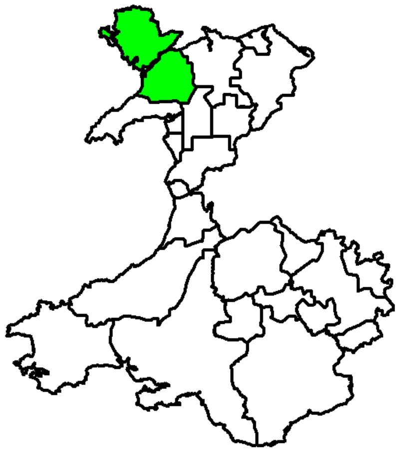
The chapter provides a high level description of the supply system for each water resource zone along with the water resource risks over the 30 year planning horizon. Table 33 below gives some summary information for each WRZ, based on 2016-17 data.

WRZ No.	WRZ Name	Area (km2)	Population served ('000)	Distribution Input (Ml/d)	Main Source of Water
North					
8001	North Eryri Ynys Môn	1,336	128.7	35.9	Reservoir storage
8012	Clwyd Coastal	152	79.1	18.9	Reservoir storage
8014	Alwen Dee	1,142	158.7	45.1	Reservoir storage
8020	Bala	391	3.8	1.6	Reservoir storage
8021	Tywyn Aberdyfi	68	4.7	1.2	River abstraction
8026	Blaenau Ffestiniog	332	6.2	1.5	Reservoir storage
8033	Barmouth	85	4.3	1.3	Reservoir storage
8034	Lleyn Harlech	648	34	11.5	Reservoir storage
8035	Dyffryn Conwy	841	94	27.4	Reservoir storage
8036	South Meirionnydd	584	6.9	2	Reservoir storage
South West					
8201	Tywi CUS	3,524	725.1	172.4	Reservoir storage
8202	Mid & South Ceredigion	1,780	60	18.6	Reservoir storage
8203	North Ceredigion	469	31.1	8	Reservoir storage
8206	Pembrokeshire	1,699	123.2	38.8	Reservoir storage
South East					
8101	Ross on Wye	198	22.2	5.6	Bulk supply import
8102	Elan Builth	1,229	18.6	4.7	Reservoir storage
8103	Hereford CUS	1,258	135.8	33.8	River abstraction
8105	Llyswen	353	8.6	2.4	River abstraction
8108	Brecon Portis	447	11.5	3.7	Groundwater abstraction
8106	Monmouth	104	14.3	3.3	River abstraction
8107	Pilleth	366	8.2	2.1	Groundwater abstraction
8110	Vowchurch	250	6.7	2.2	Groundwater abstraction
8111	Whitbourne	354	15.8	5.1	River abstraction
8121	SEWCUS	2,756	1340.8	356.8	Reservoir storage
TOTAL		20,366	3042.2	804	

Table 33 - Water Resource Zones - key facts and figures

5.6.North Wales Water Resource Zones

5.7.8001 North Eryri Ynys Môn



This Water Resource Zone covers the mainland adjacent to the Menai Straits (North Eryri) and Anglesey (Ynys Môn), including the major towns of Bangor, Caernarfon and Holyhead.

5.7.1. Operation of the Water Resources

Water is supplied from five impounding reservoirs; Ffynnon Llugwy, Llyn Cwellyn and Llyn Marchlyn Bach on the mainland and Llyn Alaw and Llyn Cefni on Anglesey. As highlighted in Section 7.16, investment is planned to maintain the capability of these assets.

The three reservoirs on the mainland feed into two water treatment works with the reservoirs on the island supporting two independent treatment works.

The resources and associated treatment works are operated conjunctively, with those on the mainland being at much higher elevations and so they are able to gravitate supplies of water over to Anglesey. However, the works on Anglesey can only support the demand on the island. The objective when operating the reservoirs is to ensure that there is always sufficient water even during the driest years but, when water is plentiful, to make full use of the mainland sources.

This operation is controlled through the use of set rules which govern the amount of water fed to each of the works in relation to the amount of water in the reservoirs. As the storage in the reservoirs on the mainland declines, the amount of water supplied to Anglesey is reduced. This preserves the reservoir storage on the mainland to ensure that demand in this area can always be met. The use of Llyn Alaw and Llyn Cefni on Anglesey is increased to offset this reduction. By operating in this way the operational costs for the system as a whole can be kept to a minimum.

There are no exports or imports of water for North Eryri Ynys Môn.

5.7.2. Demand

The forecast demand for water in the zone has decreased by approximately 1 Ml/d since WRMP14; reflecting reduced leakage levels and improved understanding of customers' water demands.

Going forward, our forecasts include an increase in population from 128,000 in 2020 to over 134,000 by 2050 in the zone. However, the total demand is forecast to decrease very gradually until 2030 as the population growth will be mitigated by a reduction in how much water is used per person per day. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is forecast to rise from 44% of households in 2020 to 69% by 2050.

5.7.3. Climate Change

The modelling we have undertaken gives us confidence that the zone is generally resilient to climate change with only a small reduction in deployable output forecast to 2050.

5.7.4. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought scenario, supplies to the zone as a whole can be maintained in the near term but with a potential risk identified from 2030 onwards that will require further investigation in AMP7. Full details of the assessment are presented in Appendix 20.

5.7.5. Water Resource position

In WRMP14 the zone was forecast to have a shortfall of water from 2024/25 (Figure 32). Following a review of our demand allocations across the zone, the shortfall was forecast to begin earlier from 2020/21 (Figure 33); this position was reported in the 2016 WRMP Annual Review. The identified shortfall in WRMP14 was caused mainly by the predicted impacts of climate change reducing our available water resource, which meant we would have to implement restrictions on our customers' demand more frequently than we would otherwise expect to do.

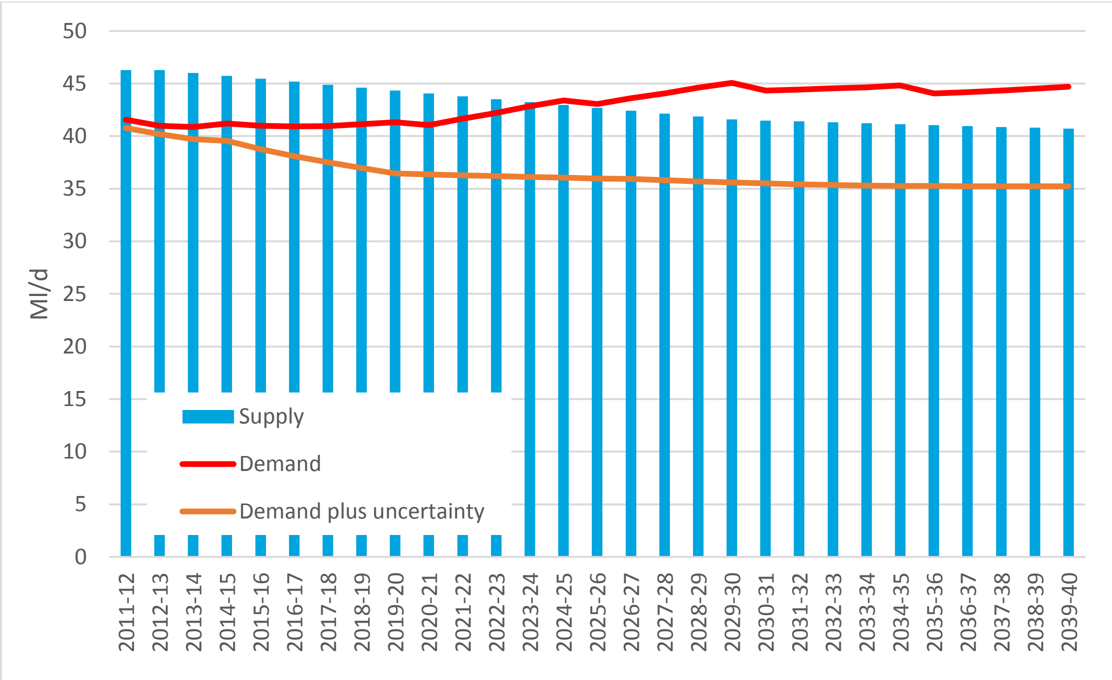


Figure 32 - North Eryri Ynys Mon WRMP14 Annual Average Supply Demand Balance

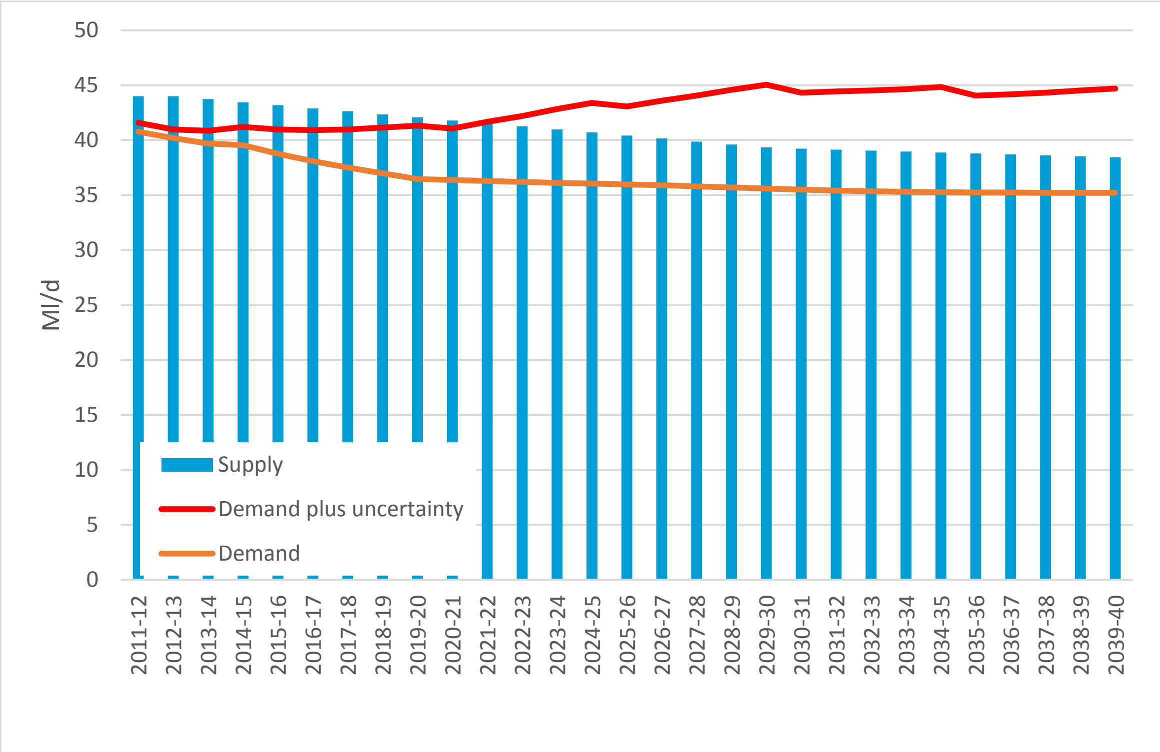


Figure 33 - North Eryri Ynys Mon - Annual Review 2016 Annual Average Supply Demand Balance

As set out in our 2015 Drought Plan, we have improved the way we manage a drought in this zone and would only restrict our customer's use of water if the storage in Llyn Cwellyn, or at least 2 of the other 3 main reservoirs (Ffynnon Llugwy, Llyn Cefni, Llyn Alaw) are at very low levels. This decision was made following network improvements that allow us to move water more effectively within the zone and alleviate the pressure on individual reservoirs. We are now less likely to issue customer restrictions and hence our level of service for this zone has improved.

This better management of our reservoir stocks, together with reduced demand, means that we will have more water in store to cope with future droughts and will be less vulnerable to climate change. Consequently the risks to our supplies are much lower than they were at WRMP 14.

We have also reviewed the yield of our individual water sources and the location of demand across the supply network. This extensive piece of work has provided an improved view of the supply demand position across the zone which is shown in Figure 34. This indicates a water resource surplus across the entire 30 year planning period from 2020 to 2050 with no direct requirement to invest in new water resource assets or demand management for purely drought management purposes.

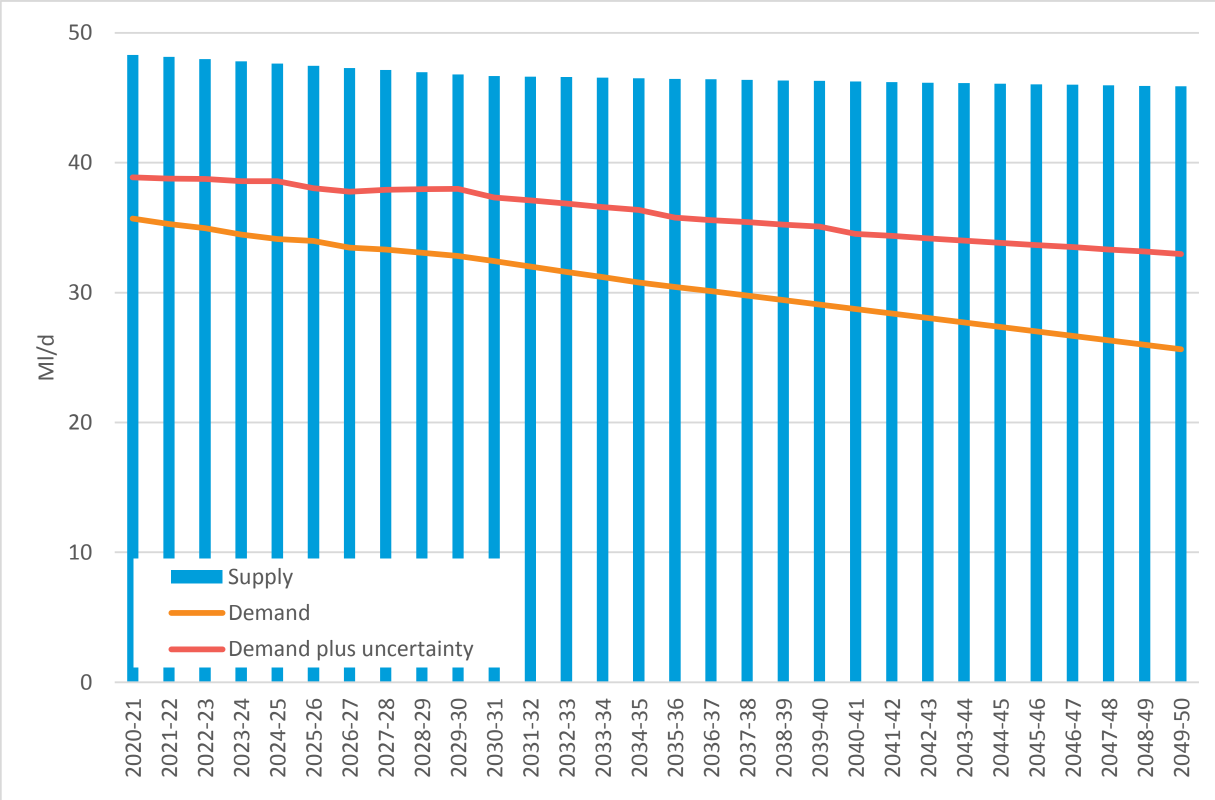


Figure 34 - North Eryri / Ynys Mon Annual Average Supply Demand Balance

5.7.6. Wylfa

Although the construction of Wylfa power station does not have planning permission yet we have undertaken testing within our plan to ensure we could meet our best estimate of the zonal increase in demand that this would cause. Since WRMP14, the forecast demand for water for construction of the power station has reduced from 6 Ml/d to 3 Ml/d, but this has still to be confirmed. There will also be ~4,000 employees resident on site and requiring water. Even with this increase in demand we will have a surplus of water within the zone in a dry year, see Figure 35.

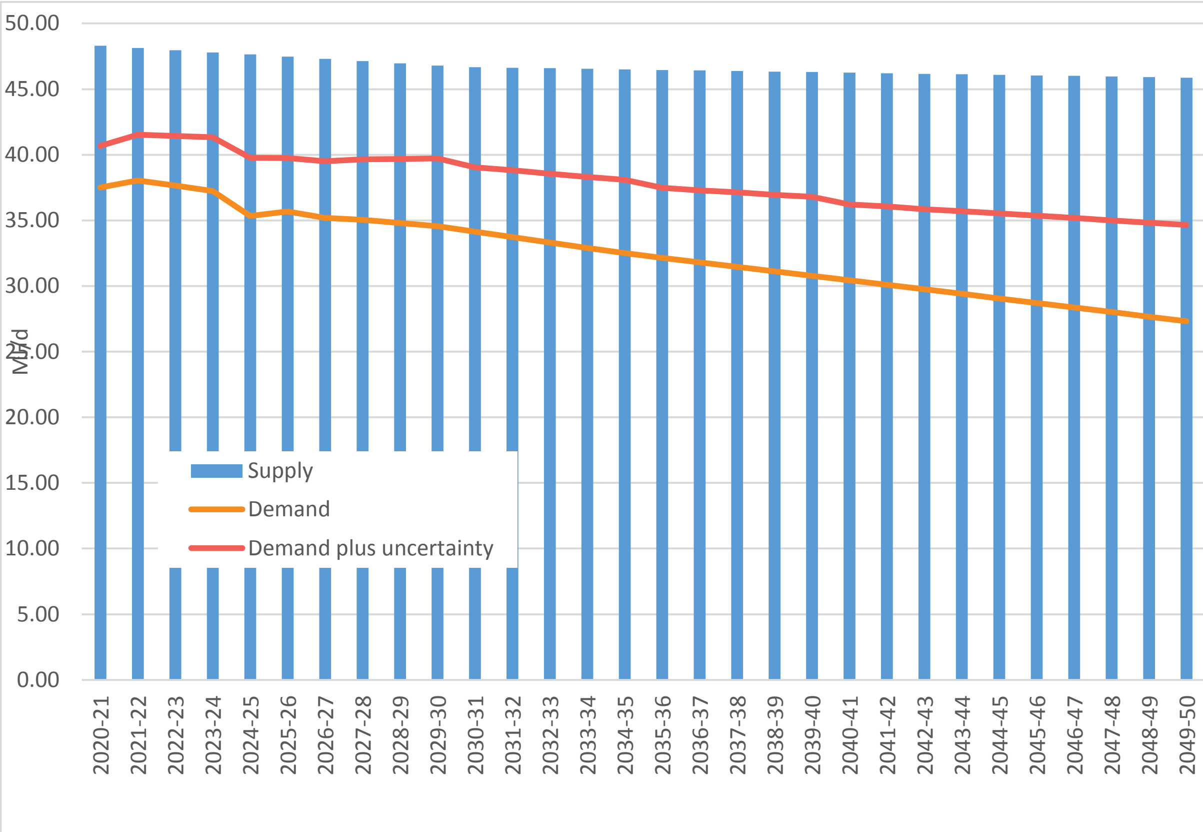
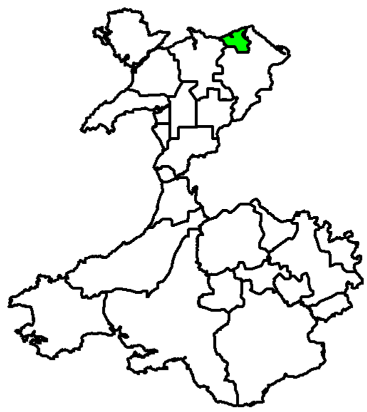


Figure 35 - North Eryri / Ynys Mon Annual Average Supply Demand Balance with Wylfa demand

Our resilience in the near term to a 1:200 year drought event would not be significantly affected by the construction of the power station but would increase the risk from 2030 onwards.

5.8.8012 Clwyd Coastal



This Water Resource Zone covers the coastal region from Prestatyn to Colwyn Bay and then further inland to St. Asaph.

5.8.1. Operation of the Water Resources

The zone is supplied by three water treatment works; Glascoed, Llanerch and Trecastell. Treated water from Llannerch is pumped up to Glascoed where it is blended with Glascoed water in the final water tank before it goes into supply.

The largest works in the zone is Glascoed. This is fed from Plas Uchaf reservoir which stores water abstracted from the Afon Aled via the Bryn Aled Pumping Station. The Bryn Aled abstraction is supported by river regulation releases from Aled Isaf and Llyn Aled reservoirs. This arrangement is the subject of the Aled Section 20 Operating Agreement between DCWW and NRW.

Llannerch works is supplied by 3 boreholes which abstract from the sandstone aquifer in the Vale of Clwyd. As well as abstracting water from the sandstone, the boreholes are known to draw water through the drift and reduce flows in the nearby Afon Clwyd. To mitigate this, when flows in the river are naturally low, we release water from a set of artesian boreholes (Llanynys, Glanywern, Ruthin, Plas yr Esgob, Llwyn Isaf and Efail Newydd) further up the Vale to augment the flow. This is known as the Clwyd augmentation scheme and is also covered under a S20 Operating Agreement between ourselves and NRW.

Trecastell works is supplied solely from a spring source at Ffynnon Asaph, however, during heavy rainfall the spring can be affected by turbidity and the works is unable to treat the water. During such times the Prestatyn area is supplied from Glascoed works

There are no exports or imports of water for Clwyd Coastal.

5.8.2. Demand

We are forecasting a moderate increase in population from 80,000 in 2020 to over 82,000 by 2050. However, the total demand for water is forecast to decrease very gradually until 2030 as the population growth will be mitigated by a reduction in how much water is used per person per day. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 61% of households in 2020 to 85% by 2050.

5.8.3. Climate Change

Since WRMP14 we have improved our modelled reservoir inflows and we are now confident there would be more water draining into the reservoirs in a dry summer than previously thought. This makes the zone less vulnerable to dry weather and our updated climate change modelling indicates only a very minor reduction in deployable output, so the zone can be deemed to have a good level of resilience to climate change.

5.8.4. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures. Full details of the assessment are presented in Appendix 19 – EVA resilience assessment (ATKINS)

5.8.5. Water Resource position

The supply demand balance for this zone predicts a surplus of water in a dry year over our 30 year planning period 2020 to 2050, as shown in Figure 36. As the forecast demand for water reduces over the planning period, the available surplus increases.

In WRMP14 we also forecasted a surplus, although this was predicted to decline over time (rather than increasing as it is now), mainly due to the impacts of climate change reducing our water resource availability.

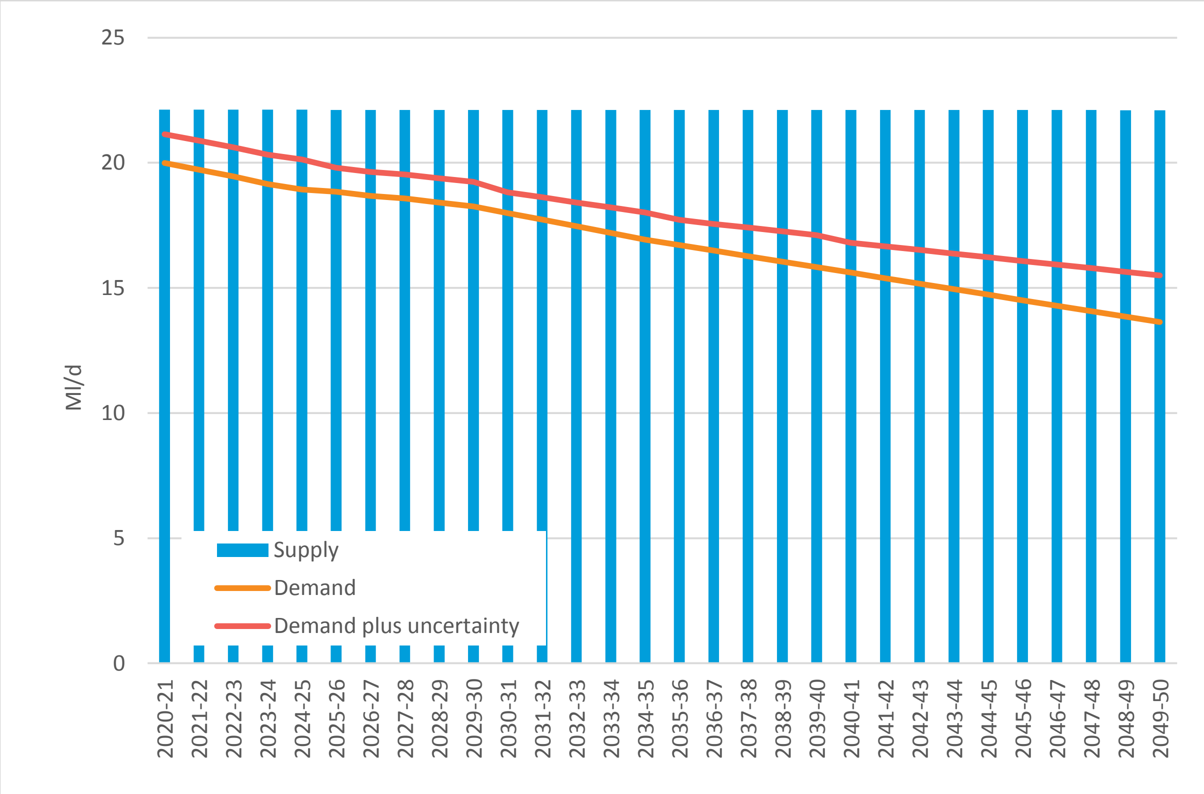
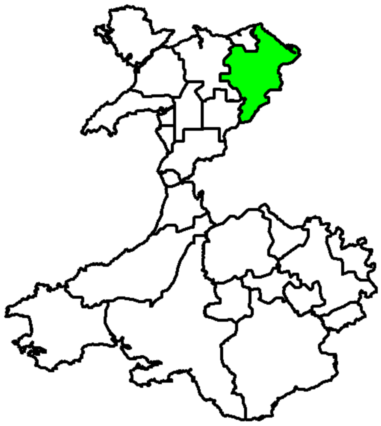


Figure 36 - Clwyd Coastal Annual Average Supply Demand Balance

5.9.8014 Alwen Dee



This Water Resource Zone stretches from the floodplains of the River Dee at Llangollen to the coastal waters at Prestatyn and the industrial complexes on Deeside.

5.9.1. Operation of the Water Resources

There are two water treatment works within the zone; Alwen and Bretton. Alwen is supplied from Alwen reservoir and Bretton is supplied from the River Dee abstraction at Poulton and Bretton boreholes when they are needed to supplement the demand in dry summers.

The River Dee is a regulated river with releases made from Llyn Celyn and Llyn Brenig to support abstractions downstream. The scheme is managed by NRW in accordance with the S20 Dee General Directions. Welsh Water, Dee Valley Water, United Utilities and the Canal & River Trust are the main abstractors from the River Dee and so have representatives on the Dee Consultative Committee. Flows in the River Dee are also managed to reduce flooding, enhance the biodiversity and fisheries and for recreational purposes.

There is a minor export of treated water from the WRZ to Dee Valley Water.

5.9.2. Demand

Although the population is forecast to increase from 161,000 in 2020 to 170,000 by 2050, demand in the zone is expected to decrease across the planning period. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 50% of households in 2020 to 81% by 2050.

5.9.3. Climate Change

Our modelling indicates a very minor reduction in deployable output as a result of climate change. The risk to our water supplies under climate change are relatively low as Alwen reservoir provides adequate storage.

5.9.4. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures. Full details of the assessment are presented in Appendix 19 – EVA resilience assessment (ATKINS).

5.9.5. Water Resource position

Over our 30 year planning period 2020 to 2050 the zone is forecast to have a surplus of water in a dry year, see Figure 37.

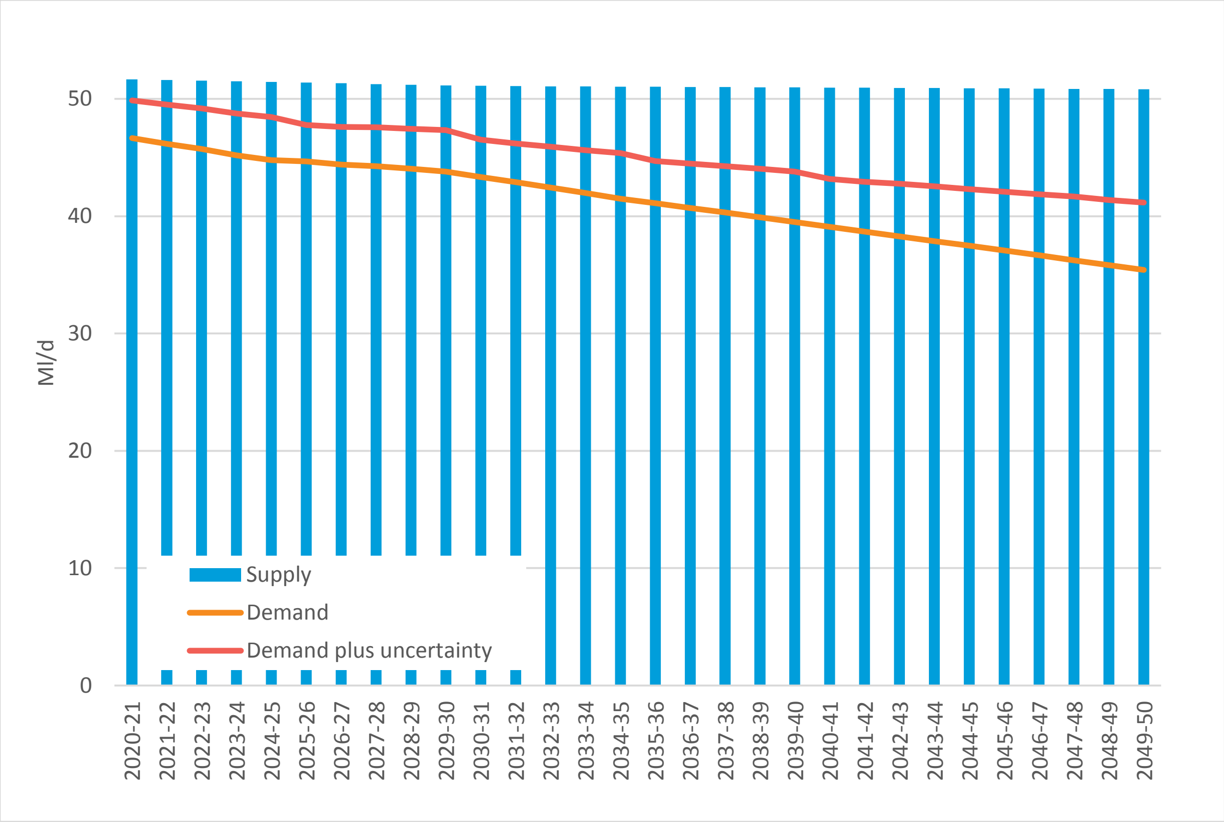
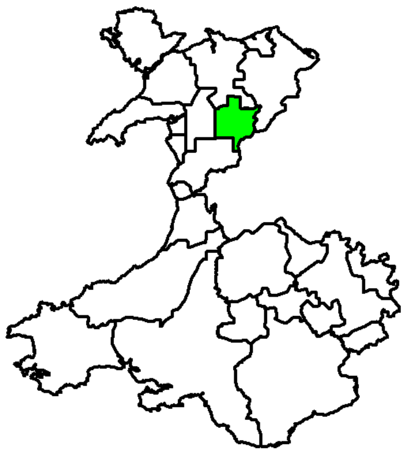


Figure 37 - Alwen Dee Annual Average Supply Demand Balance

5.10. 8020 Bala

This is the smallest of our water resource zones, serving a population of less than 4,000. It covers the town of Bala and the immediate surrounding area. In the summer the demand can increase significantly due to tourism.



5.10.1. Operation of the Water Resources

The zone is served from Bala water treatment works which receives its water from a single impounding reservoir, Llyn Arenig Fawr.

There are no exports or imports of water.

5.10.2. Demand

Population is forecast to marginally increase from 3,840 in 2020 to 4,230 by 2050. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 50% of households in 2020 to 83% by 2050.

5.10.3. Climate Change

Given the forecast of a relatively large surplus of water in a dry year, the vulnerability assessment has classed climate change risk as negligible for this zone. We have not therefore undertaken a detailed analysis but are confident climate change will not impact on our water resource in this zone.

5.10.4. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures. This reflects the relative size of Llyn Arenig Fawr compared with the demand for the zone. Full details of the assessment are presented in Appendix 19 – EVA resilience assessment (ATKINS).

5.10.5. Water Resource position

Over our 30 year planning period 2020 to 2050 the zone is forecast to have a healthy surplus of water in a dry year, see Figure 38.

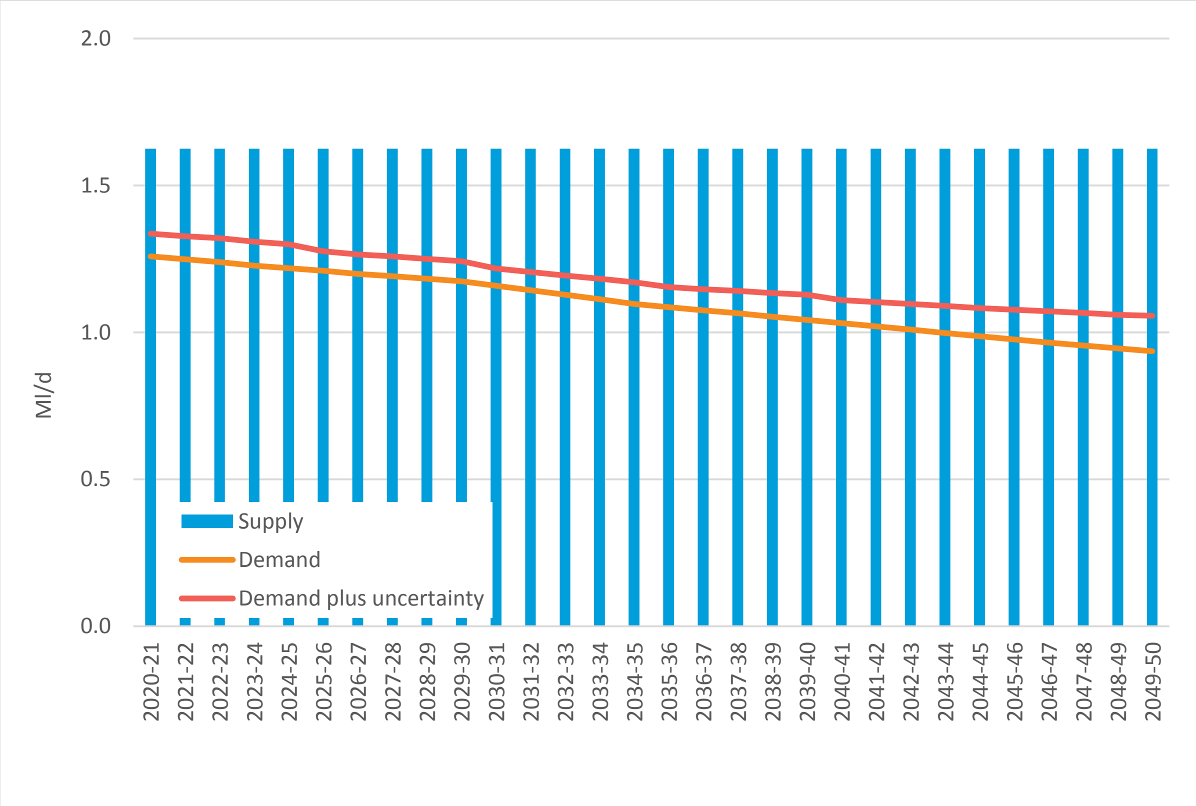
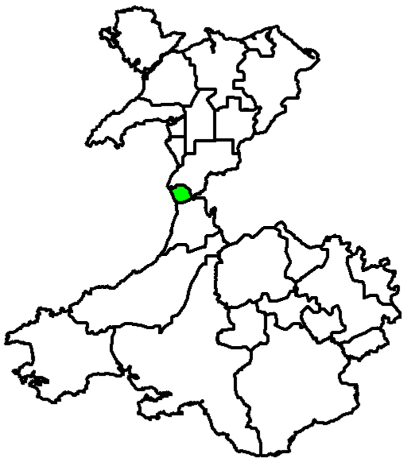


Figure 38 - Bala Annual Average Supply Demand Balance

5.11. 8021 Tywyn Aberdyfi



This water resource zone covers the small coastal area around the towns of Tywyn and Aberdyfi in Mid Wales. There are approximately 4,700 customers in this zone but the demand can increase significantly during the summer due to tourism.

5.11.1. Operation of the Water Resources

Penybont is the only water treatment works in the zone. It is fed from two small river abstractions; the Afon Fathew and the Nant Braich-y-Rhiw.

The Nant Braich-y-Rhiw abstraction licence has a condition which prevents us from using this source when the river levels are low. This comes into operation during most summer periods; we are then reliant upon the Afon Fathew.

There are no exports or imports of water.

5.11.2. Demand

Population is forecast to marginally increase from 4,730 in 2020 to 4,900 by 2050. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 66% of households in 2020 to 90% by 2050.

5.11.3. Climate Change

A detailed climate change assessment has been undertaken which indicates there is a high risk to our supplies in the future. The two river abstractions are highly vulnerable to low flows in the summer, which are forecast to become more severe due to the effects of climate change. It is likely that the current operation of the zone is not sustainable when accounting for potential future effects of climate change. We have therefore had to include a large uncertainty within our calculations meaning our Demand plus the Target Headroom uncertainty allowance is forecast to be higher than the supply capability for the system.

5.11.4. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought event, supplies to the zone as a whole cannot be maintained. River flows in the Afon Fathew and Nant Braich y Rhiw would not be sufficient during a 1 in 200 year drought to support the required levels of abstraction to meet zonal demand. Full details of the assessment are presented in Appendix 21 – Tywyn resilience assessment (ATKINS).

5.11.5. Water Resource position

The zone is forecast to have a significant shortfall in water in a dry year over the whole of our 30 year planning period 2020-2050 (See Figure 39). This shortfall occurs during the summer peak demand period and when abstraction is restricted due to low river levels. The abstraction licence prohibits us from using the Nant Braich y Rhiw source and data shows that there is not enough water in the Afon Fathew to meet all of the demand placed on Pen-y-Bont WTW.

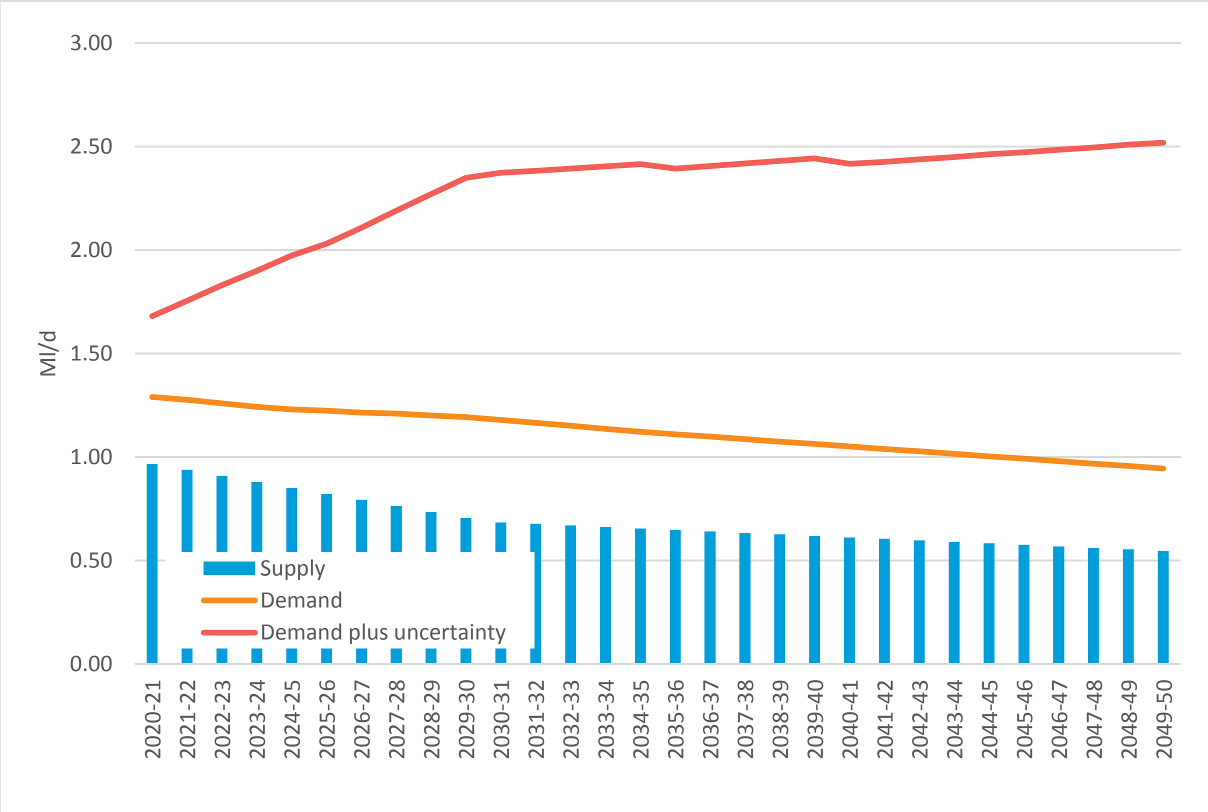


Figure 39 - Tywyn Aberdyfi Annual Average Supply Demand Balance

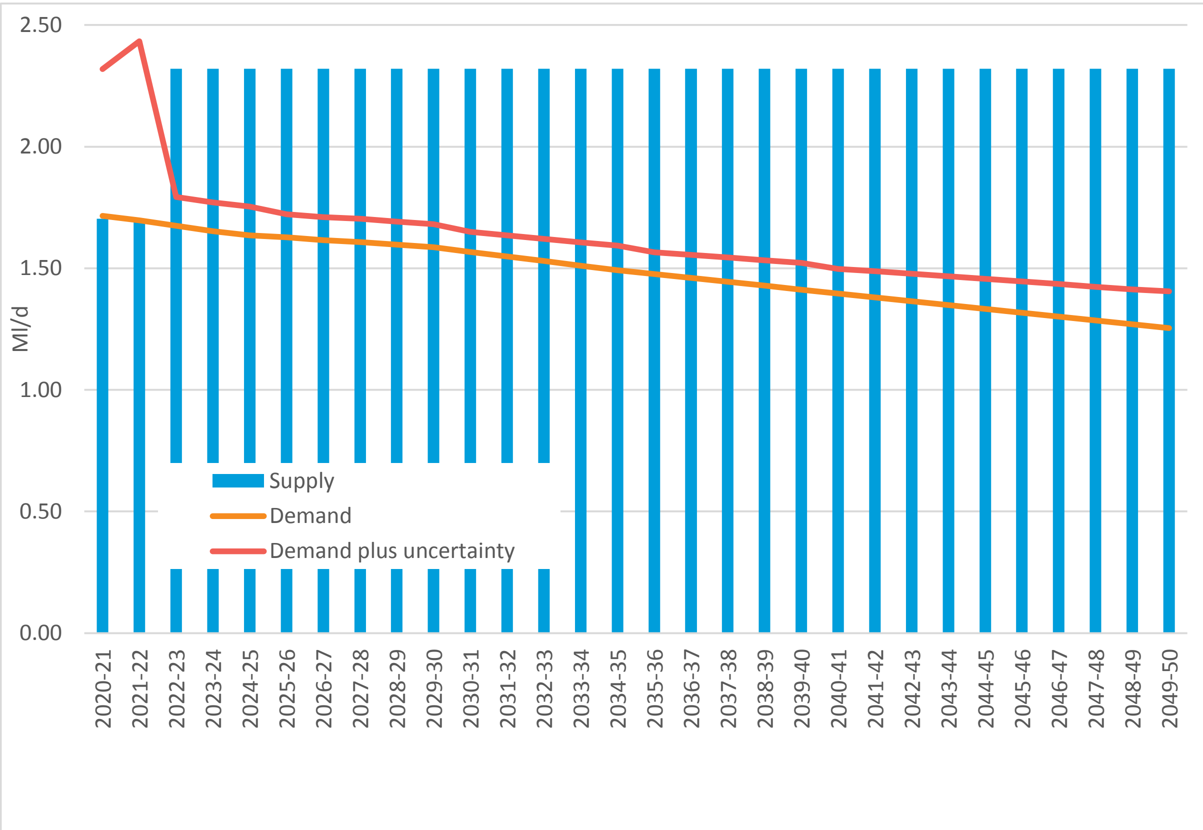


Figure 40 - Tywyn Aberdyfi Critical Period Supply Demand Balance

In WRMP14 we also forecast a deficit and looked into building a new intake on the Afon Dysynni in 2015. However, post the publication of our Final WRMP 2014 we saw a significant reduction in demands following the closure of the Halo Foods Factory, delaying the need for the Afon Dysynni scheme until 2020/21. This was reported in the 2016 WRMP Annual Review and is shown in Figure 41.

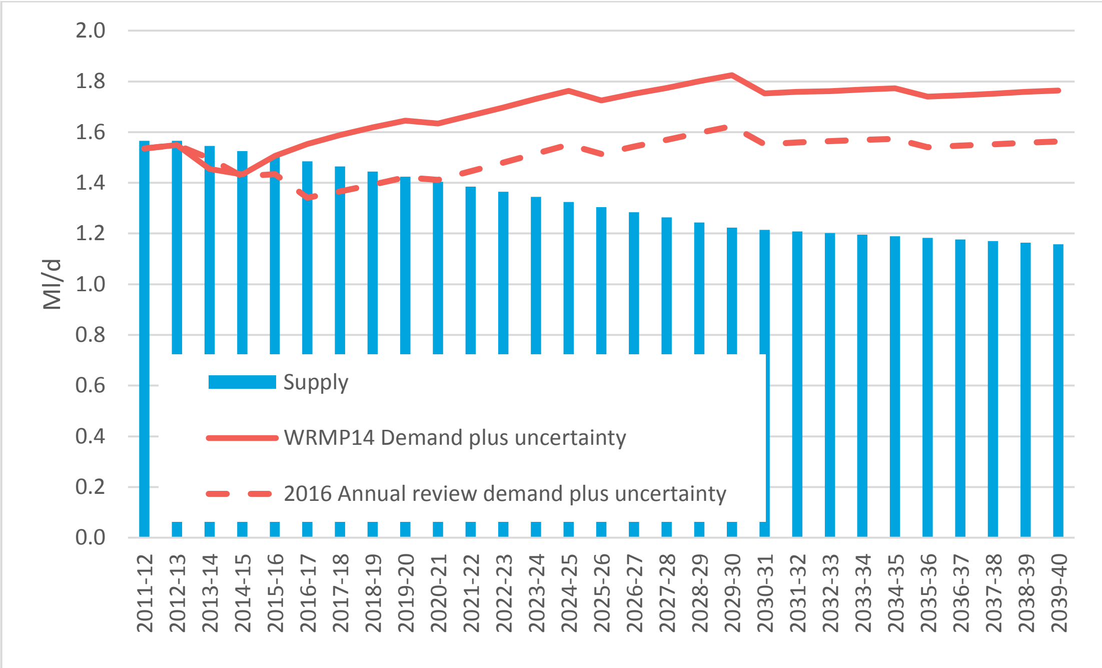
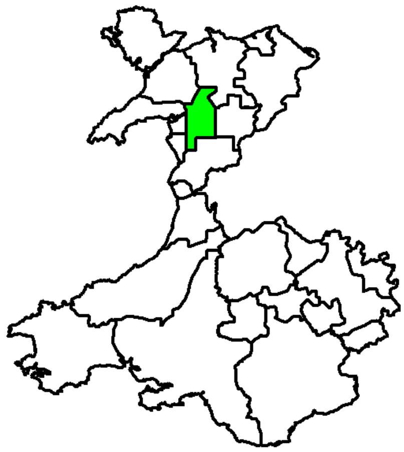


Figure 41 - Tywyn Aberdyfi WRMP14 and 2016 Annual Review demands comparison

Despite the lower demands forecast for this Plan, we have investigated further the catchment hydrology and now believe the river flows in a dry summer are likely to be lower than previously thought and so there is less water available for abstraction. This makes the zone extremely vulnerable to dry periods, an effect which is exacerbated when we take account of climate change. This means that the water available to us across the planning period is less than we need to meet the predicted demands for water plus our Target Headroom uncertainty allowance. For this Plan we are therefore forecasting a supply demand shortfall in the zone.

5.12. 8026 Blaenau Ffestiniog



This Water Resource Zone covers the town and surrounding area of Blaenau Ffestiniog.

5.12.1. Operation of the Water Resources

Blaenau Ffestiniog is a single-source zone with Llyn Morwynion supplying Garreglwyd water treatment works. When the storage in Llyn Morwynion is low, water is transferred from the nearby Afon Gam.

Since WRMP14 Welsh Water have had to modify the abstraction licence for Llyn Morwynion and Afon Gam due to the outcomes of NRW's Habitats Directive Review of Consents. Previously the use of the Afon Gam transfer was optional and an operational decision to use it was made by ourselves, but now the Morwynion abstraction licence states that we must transfer water from the Afon Gam if the lake level drops below certain thresholds. This is to prevent deterioration of the designated features in the SAC (*Littorelletea uniflorae* and *Isoëto-Nanojuncetea)*. There is concern that if the flora is exposed for prolonged periods during a drought it may not recover.

There are no exports or imports of water.

5.12.2. Demand

Population is forecast to increase slightly from 6,390 in 2020 to 6,760 by 2050. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 66% of households in 2020 to 90% by 2050.

5.12.3. Climate Change

Given the forecast of a relatively large surplus of water in a dry year, the vulnerability assessment has classed climate change risk as negligible for this zone. We have not therefore undertaken a detailed analysis but are confident climate change will not be sufficient to place this zone in a deficit position.

5.12.4. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures. The Afon Gam transfer is key to the resilience of the zone as it can be used to maintain storage levels when they would otherwise be stressed. Details of the assessment are presented in Appendix 19 – EVA resilience assessment (ATKINS).

5.12.5. Water Resource position

The zone is forecast to have a surplus of water over the whole 30 year planning period 2020-2050, as shown in Figure 42. Investigations undertaken since the publication of the Final WRMP14 have highlighted that Garreglwyd is unable to treat as much water as we previously thought due to pressure restrictions in the raw water main that feeds the works. This means the volume of surplus has been reduced since WRMP14 as our calculated deployable output has dropped from ~2.95Ml/d to 1.95Ml/d, although there remains plenty of water in store in Llyn Morwynion that could be accessed via upgrades to the Garreglwyd inlet main, if required.

The new Habitats Directive licences have had little impact on our ability to supply water in this zone.

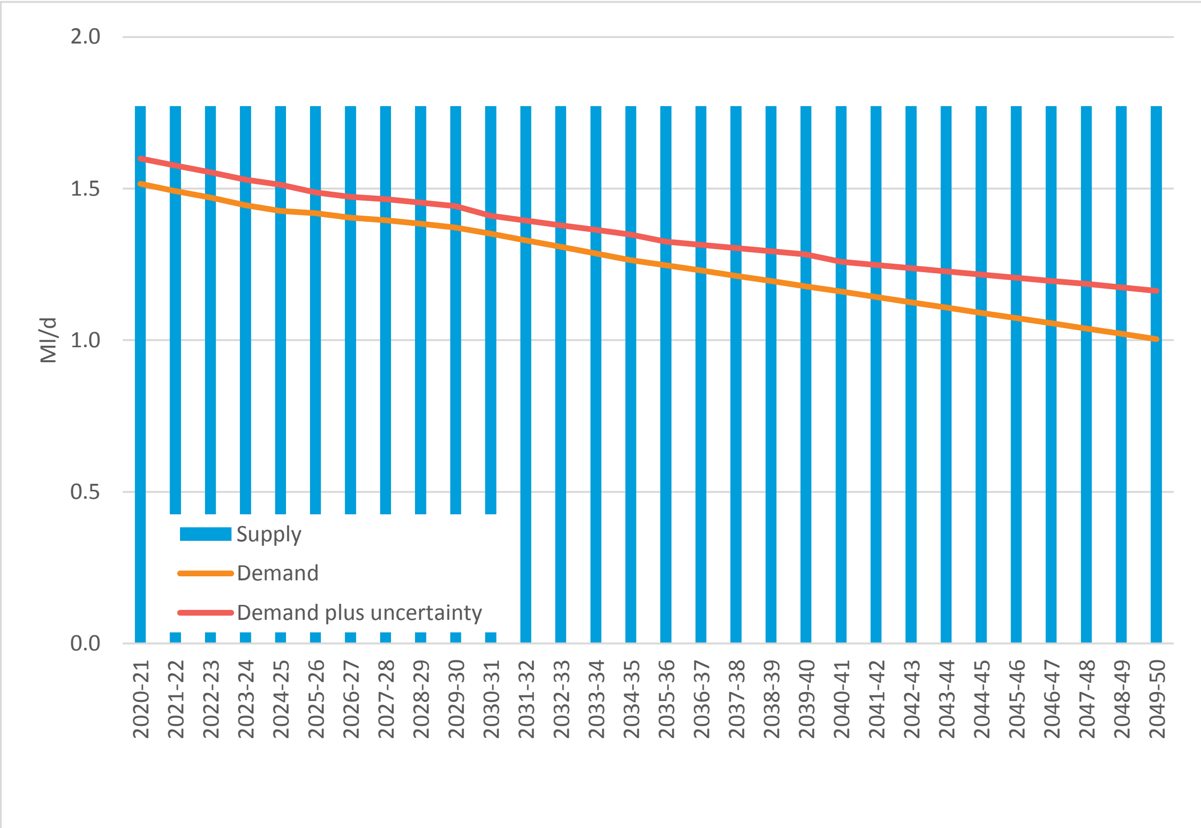
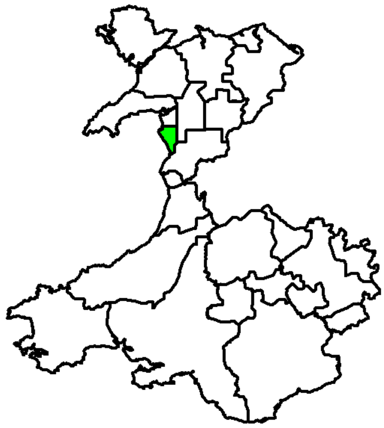


Figure 42 - Blaenau Ffestiniog Annual Average Supply Demand Balance

5.13. 8033 Barmouth



The Barmouth Water Resource Zone covers the coastal region from Harlech to Barmouth. Although it is only a relatively small area, the demand can increase significantly in the summer due to tourism.

5.13.1. Operation of the Water Resources

This small zone is served from a single impounding reservoir, Llyn Bodlyn, which feeds Eithinfynydd water treatment works. Peak demands (caused primarily by tourism) often approach the maximum amount we can treat at Eithinfynydd. When this happens we can transfer treated water southwards from the Rhiw Goch works, in the Lleyn Harlech zone, to help meet the demand. Water can also be transferred north from Barmouth to Lleyn Harlech to allow Rhiwgoch works to be mothballed during the winter, reducing operational costs to the business.

5.13.2. Demand

Population is forecast to increase slightly from 4,380 in 2020 to 4,530 by 2050. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 54% of households in 2020 to 79% by 2050.

5.13.3. Climate Change

Our modelling indicates a very minor reduction in deployable output as a result of climate change. The risk to our water supplies under climate change is relatively low as Llyn Bodlyn provides adequate storage. This analysis was carried out without the Rhiw Goch transfer, including this would further reduce the climate change risk.

5.13.4. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures. Full details of the assessment are presented in Appendix 19 – EVA resilience assessment (ATKINS).

5.13.5. Water Resource position

Although Eithinfynydd works cannot meet the demand in the peak summer weeks by itself, with the extra water from Rhiw Goch we can ensure that there would be no shortage of water even in a dry year over the 30 year planning period 2020-2050. We do not generate a surplus of water in the zone as we only transfer the volumes needed from the Lleyn Harlech zone to meet the shortfall in existing supplies, meaning there is additional capacity available above that shown in Figure 43.

In WRMP14 we did forecast a minor surplus of water in a dry year up until 2025, after which the inter-zonal transfer would be needed to meet the demand. This slight change in position is mainly due to the reported maximum treatment capacity at Eithinfynydd being reduced from 3.5 Ml/d to 2.7 Ml/d. We have brought our modelling in line with operational reality and if required, will investigate the feasibility of increasing the works output.

In 2017 we replaced the break pressure tank on the raw water main from Llyn Bodlyn to Eithinfynydd which has reduced the losses.

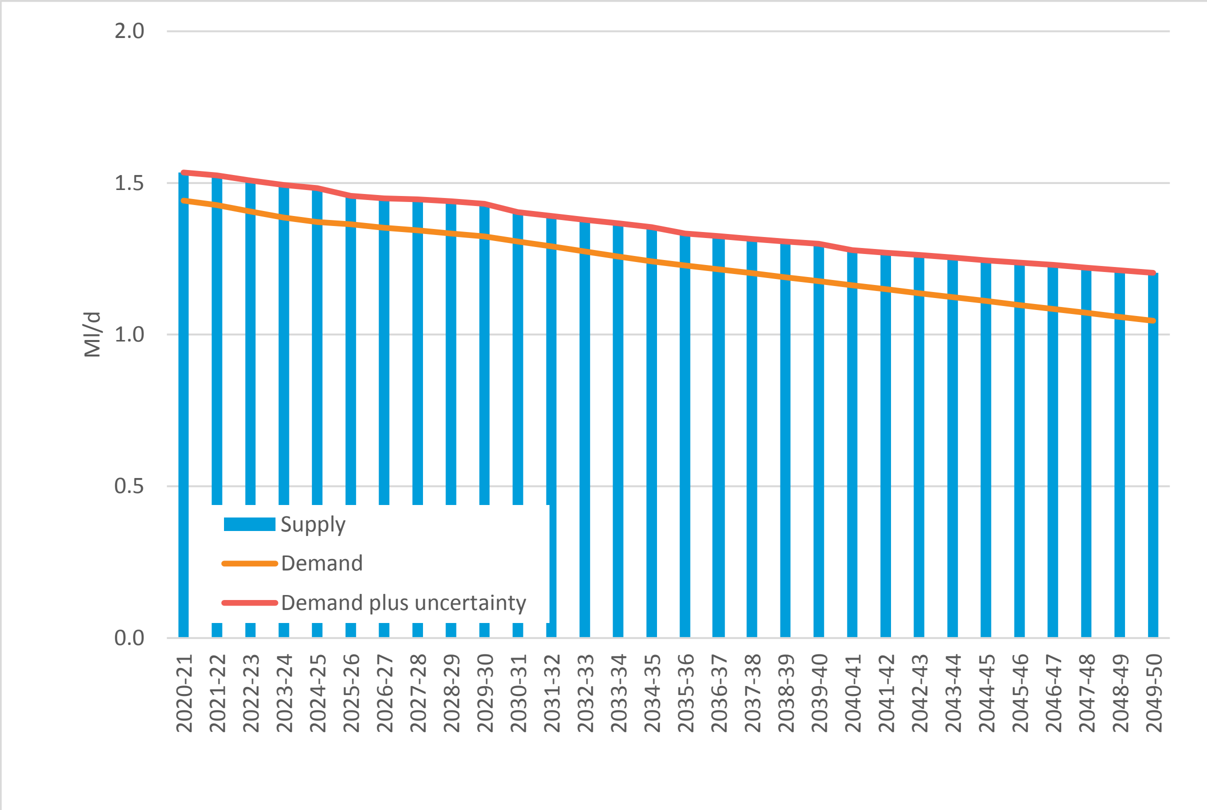
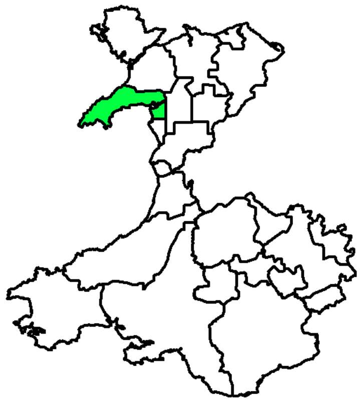


Figure 43 - Barmouth Annual Average Supply Demand Balance

5.14. 8034 Lleyn Harlech



This Water Resource Zone covers the entire Lleyn Peninsula and the coastal strip south to Harlech.

5.14.1. Operation of the Water Resources

Water is supplied from four impounding reservoirs; Llyn Cwmystradllyn and Llyn Cwm Dulyn to the east of the Lleyn Peninsula and Llyn Eiddew Mawr and Llyn Tecwyn Uchaf to the south. There is also a river abstraction on the Afon Dwyfor downstream of Llyn Cwmystradllyn.

Since WRMP14 we have built a new water treatment works at Dolbenmaen with a treatment capacity of 18 Ml/d which is fed by the Afon Dwyfor abstraction and Llyn Cwmystradllyn. This has replaced the old Dolbenmaen and Cwmystradllyn works. Llyn Cwm Dulyn has its own works. Llyn Tecwyn Uchaf and Llyn Eiddew Mawr are served by Cilfor and Rhiwgoch works respectively.

The Dwyfor abstraction is the subject of a Section 20 Operating Agreement with NRW. When we abstract from this source, if river levels are low we have to release a specified volume of water from Llyn Cwmystradllyn to ensure we do not negatively impact the ecology of the river.

There is also an inter-zonal transfer of treated water between this zone and the Barmouth WRZ. In a dry summer, treated water from Rhiw Goch is transferred southwards to the Barmouth zone to help meet peak demands in excess of the Eithinfynydd works capacity. In the winter however, water can be moved northwards to allow Rhiwgoch works to be mothballed, reducing our operating costs.

5.14.2. Demand

Population is forecast to increase from 34,420 in 2020 to 36,370 by 2050. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 48% of households in 2020 to 74% by 2050.

5.14.3. Climate Change

Our modelling indicates a very minor reduction in deployable output as a result of climate change. The risk to our water supplies under climate change are therefore relatively low.

5.14.4. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that overall the zone is resilient to a 1 in 200 year drought event but locally, Llyn Tecwyn Uchaf and Llyn Cwmystraddlyn may not be resilient. We will undertake further work in AMP7 to better understand this potential risk.

5.14.5. Water Resource position

The zone is forecast to have a surplus of water over the whole 30 year planning period 2020-2050, as shown in Figure 44. There has been a reduction in our modelled deployable output driven by an improved understanding of the timing of peak demands in the zone. The latest data suggests that the peak demands in the summer will be higher and occur slightly earlier in the year, this causes Dolbenmaen works to reach its maximum capacity at slightly lower zonal demands.

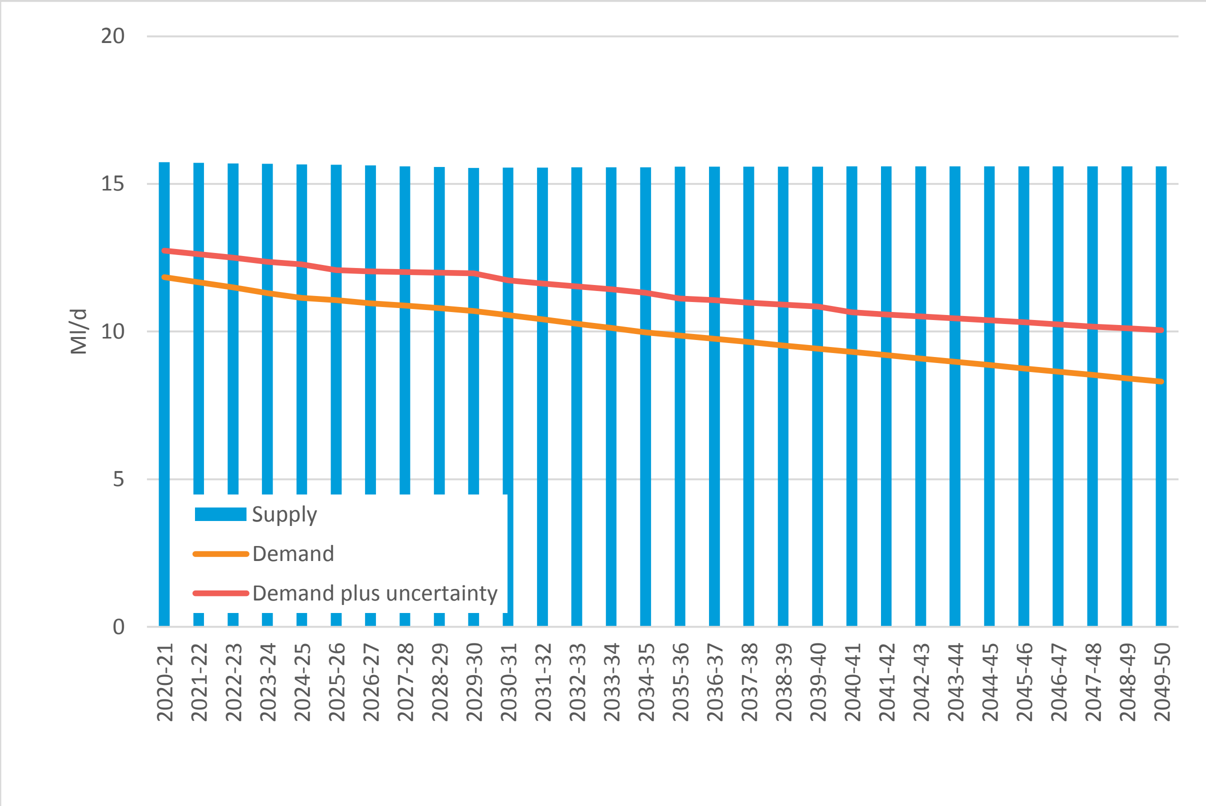
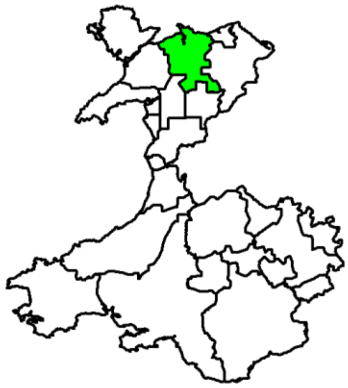


Figure 44 - Lleyn Harlech Annual Average Supply Demand Balance

5.15. 8035 Dyffryn Conwy



This WRZ stretches from the coastal region of Llandudno, inland to the Snowdonia National Park close to Blaenau Ffestiniog.

5.15.1. Operation of the Water Resources

The area is supplied from two reservoirs; Llyn Cowlyd and Llyn Conwy.

The principal resource is Llyn Cowlyd which feeds Bryn Cowlyd water treatment works with a maximum capacity of ~45 Ml/d. The storage in Llyn Cowlyd is managed between ourselves and RWE Innogy, who operate a Hydro Electric Power scheme. The top 47% of the storage is shared but, to ensure we have enough water in a dry year, the bottom 53% is for our use only. Our ability to supply water in this zone is constrained by the Cowlyd annual volume on the abstraction licence.

Llyn Conwy works is much smaller and previously could only treat ~2.5 Ml/d but a scheme was completed in 2015 that increased its capacity to 3.4 Ml/d. This now means that, when storage allows, Llyn Conwy can help supply more of the zone under gravity rather than pumping water up from Bryn Cowlyd which reduces our operating costs.

There are no exports or imports of water.

5.15.2. Demand

Population is forecast to increase from 94,830 in 2020 to 100,180 by 2050. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 57% of households in 2020 to 85% by 2050.

5.15.3. Climate Change

Given the relatively large amount of storage available in the zone, our modelling does not indicate any impact upon deployable output from climate change

5.15.4. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures.

5.15.5. Water Resource position

Figure 45 shows the zone is forecast to have a surplus of water in a dry year throughout the whole planning period.

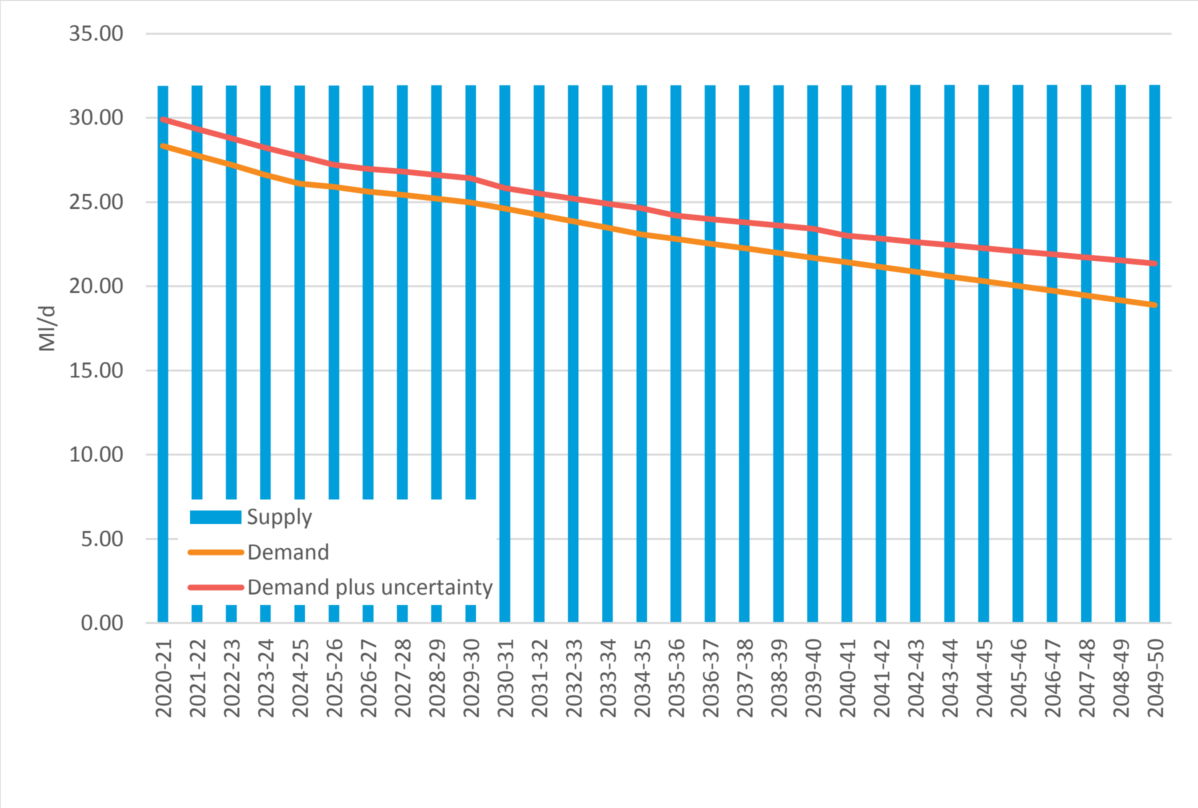
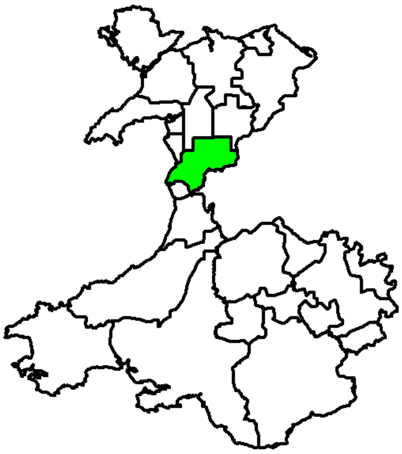


Figure 45 - Dyffryn Conwy Annual Average Supply Demand Balance

5.16. 8036 South Meirionnydd



This WRZ stretches from the coastal town of Tywyn and the Dysynni estuary, north westwards to Dolgellau and the western fringes of Lake Vyrnwy.

5.16.1. Operation of the Water Resources

There is only one reservoir in the zone, Llyn Cynwch, which feeds Penycefn water treatment works. The catchment area is relatively small compared with the storage volume and so it is slow to refill. For example, in the aftermath of the 1995 dry summer Llyn Cynwch did not spill until April 1999. To overcome this risk we have installed a pump refill scheme from the Afon Wnion.

We have two river abstractions; Afon Gwril and Afon Calettwr which feed Garreglwyd water treatment works, and three small spring sources with their own associated works supplying the local communities of Abergynolwyn, Llanymawddwy and Brynllys (Dinas Mawddwy). The Brynllys spring can run dry, so as part of our normal dry weather operation we will tanker from Penycefn to maintain supplies.

Water transfers include an export to Severn Trent Water to supply a small number of domestic properties where it is operationally challenging for them to meet the demand. There is a corresponding and larger import of water from Severn Trent Water where it is operationally difficult for us to supply customers.

5.16.2. Demand

Population is forecast to rise slightly from 6,950 in 2020 to 7,410 by 2050. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 51% of households in 2020 to 82% by 2050.

5.16.3. Climate Change

Overall the zone is generally resilient to climate change with only a modest reduction in deployable output expected. This is primarily due to the relatively small abstractions from the rivers compared with the minimum summer flows. However, locally there may be an increased risk at our small spring sources which would drive increased tankering from Penycefn works. This would place extra demand on Llyn Cynwch but the pump refill from the Afon Wnion would help maintain storage levels.

5.16.4. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought event we would overall not need to implement extreme supply side measures, although risks remain locally for the spring sources which we will look to better understand in AMP7.

5.16.5. Water Resource position

The zone is forecast to have a healthy surplus of water in a dry year over the whole 30 year planning period 2020-2050 as shown in Figure 46.

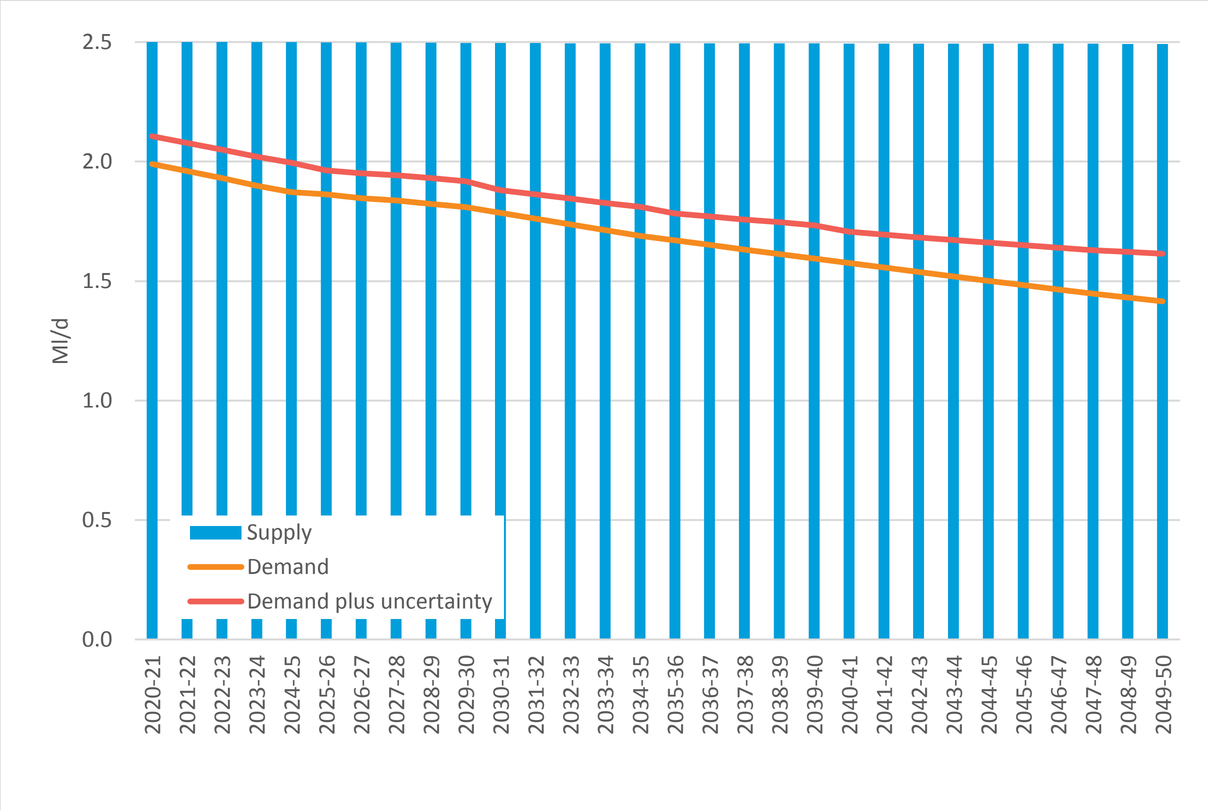
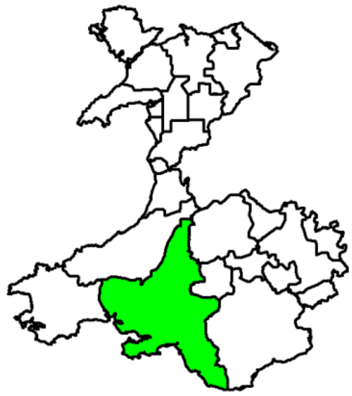


Figure 46 - South Meirionnydd Annual Average Supply Demand Balance

5.17. South West Wales Water Resource Zones

5.18. 8201 Tywi Conjunctive Use System (CUS)



This is the largest WRZ in South West Wales, extending in the east from the Vale of Glamorgan to west of Carmarthen and stretching northwards past Llanwytrd Wells.

5.18.1. Operation of the Water Resources

The water resources within the zone consist of four impounding reservoirs and two river abstractions which are operated conjunctively to make best use of the available water during years of average and below average rainfall.

Water is abstracted from the River Tywi at two locations - Nantgaredig and Manorafon. When levels are low in the River Tywi it is necessary to make releases of water from Llyn Brianne reservoir to enable us to abstract the required volumes of water at our intakes further downstream.

At Nantgaredig, a small portion of the water we take from the river supplies Capel Dewi water treatment works which serves Carmarthen. The majority of the abstracted water is pumped to Felindre works, the largest in the company which supplies the bulk of our customer demand in Swansea, Neath, Bridgend and the Vale of Glamorgan. We have agreed with NRW an amendment to our abstraction licence at Nantgaredig which will restrict the operation of the pumping station from 2019 onwards, but this does not impact the amount of water resource available for treatment.

At Manorafon, water is only abstracted if storage in Usk reservoir is low. Under these conditions, water is pumped from Manorafon to Bryngwyn water treatment works. If storage in Usk is healthy, the reservoir provides the whole supply to Bryngwyn which feeds the upper Swansea Valley.

Ystradfellte and Crai reservoirs supply the upper parts of the Neath, Afan and Tawe Valleys. As storage in these reservoirs declines, the area served is gradually reduced in order to preserve supplies with this additional demand supported from Felindre.

There are no imports of water in to the zone but we export water to the neighbouring SEWCUS zone.

A review of hydrology, balance of demands, and asset capability was undertaken to support our modelling update for this Plan. This resulted in an improved understanding of demand for water across the zone but also highlighted some restrictions in our ability to move water around the system.

5.18.2. Climate Change

Our modelling has demonstrated that the zone is resilient to climate change with no loss of deployable output expected across the planning period. This is due to the substantial resource available in Llyn Brianne which can be used to support the demand on the other sources.

5.18.3. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures.

5.18.4. Demand

The population within the Tywi CUS zone is forecast to increase from 734,680 in 2020 to 783,200 by 2050 with large development in and around Swansea[12], and other significant housing allocations at Neath, Port Talbot[13] and Bridgend[14]. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 42% of households in 2020 to 73% by 2050.

5.18.5. Water Resource position

For this Plan we are reporting a reduced DO value for the zone, however overall the zone retains a healthy surplus as shown in Figure 47.

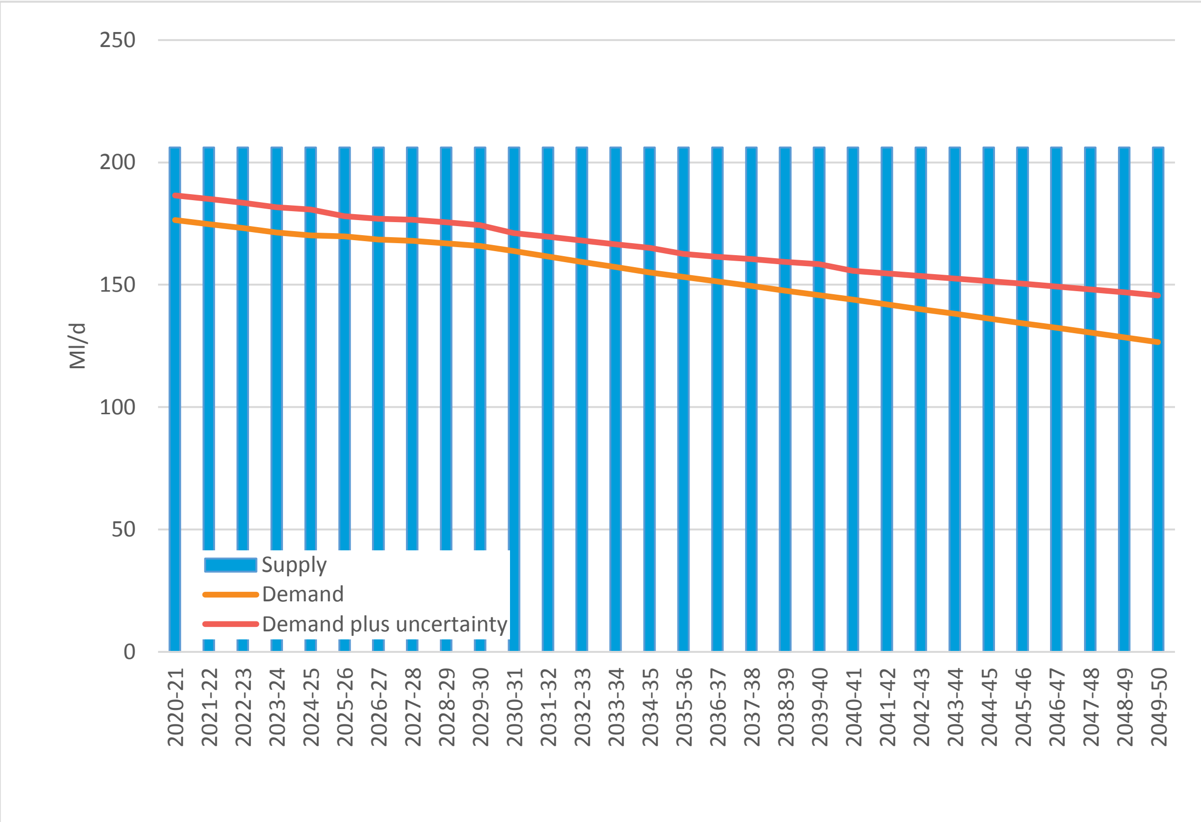
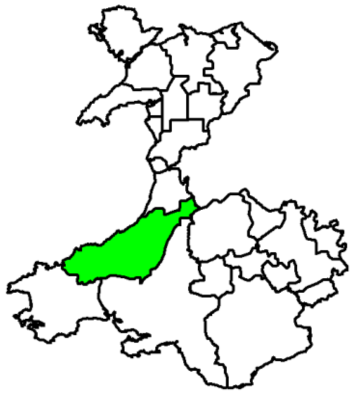


Figure 47 - Tywi CUS Annual Average Supply Demand Balance

[12] Swansea Local Development Plan, Deposit Plan, 1.3.13 – 1.3.47
[13] Neath Port Talbot Local Development Plan, Adopted Plan, pg. 49
[14] Bridgend Local Development Plan, Adopted Plan, pg. 57

5.19. 8202 Mid & South Ceredigion



This zone covers the Teifi Valley and the coastal area from south of Cardigan, northwards to just south of Aberystwyth.

5.19.1. Operation of the Water Resources

The zone is supplied from two sources:

Llechryd water treatment works, which is reliant on the river abstraction from the River Teifi at Llechryd, and;

Strata Florida water treatment works, located near Pontrhydfendigaid in the upper Teifi catchment, is supplied by three small reservoirs – Llyn Teifi, Llyn Egnant and Llyn Pondygwaith, collectively known as Teifi Pools.

Strata Florida supplies customers along the catchment of the Afon Teifi as far as Llandysul. As storage in the Teifi Pools declines in dry weather, the area served is gradually reduced in order to preserve storage, with this additional demand supplied by Llechryd.

There are no exports or imports of water.

A review of hydrology, balance of demands, and asset capability was undertaken to support our modelling update for this Plan. This improved our understanding of the constraints at our treatment works, which has resulted in a reduction in how much water we are able to supply to customers.

5.19.2. Climate Change

Overall the zone is generally resilient to climate change with only a modest reduction in deployable output expected as there is good storage in the reservoirs.

5.19.3. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures.

5.19.4. Demand

Population is forecast to increase from 60,800 to over 66,000 by 2050. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 45% of households in 2020 to 73% by 2050.

5.19.5. Water Resource position

For this plan we are reporting a lower supply position but overall, our resource position remains healthy. The supply demand balance for the zone is shown in Figure 48 and this indicates a surplus across the 30 year planning period from 2020 to 2050.

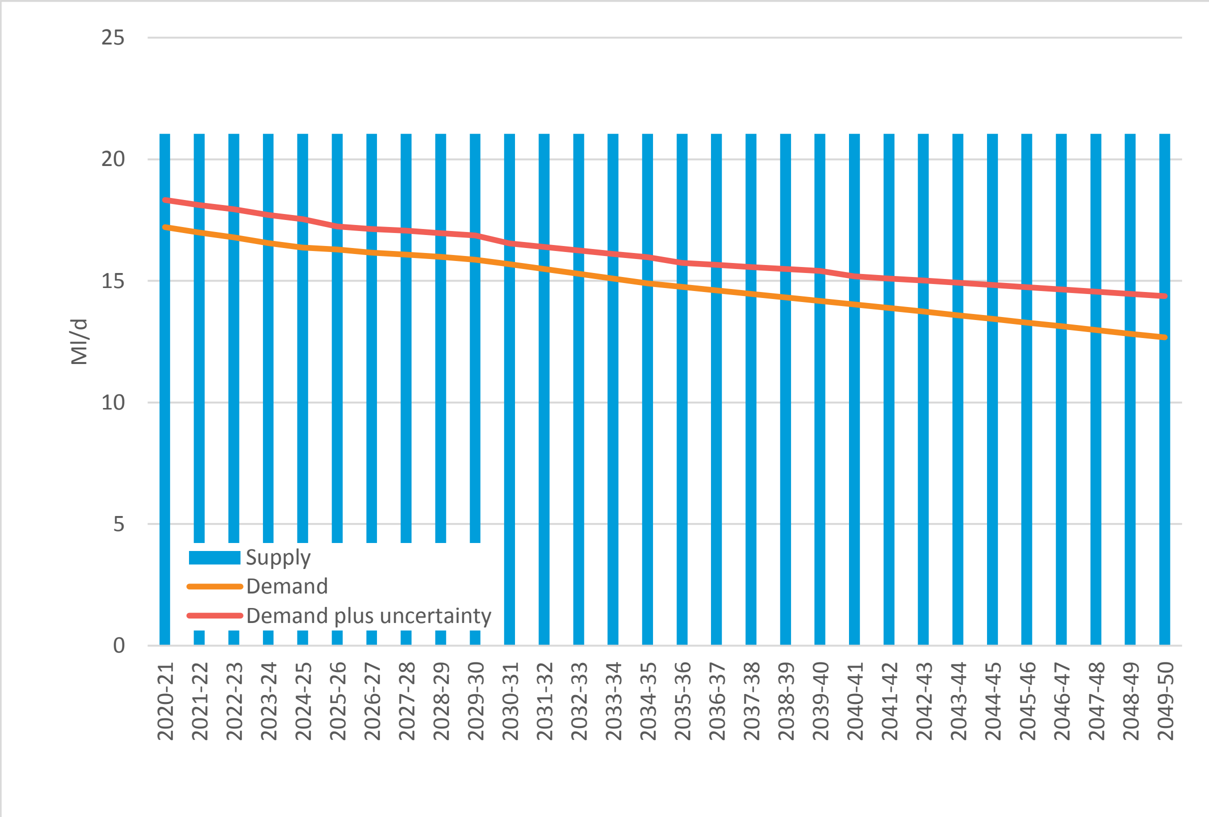
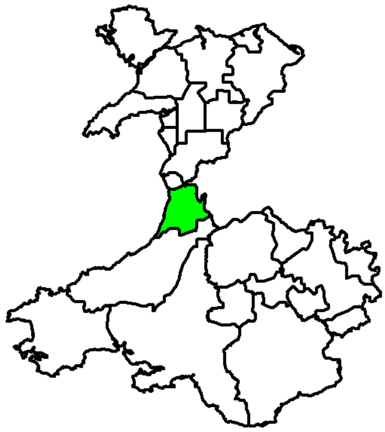


Figure 48 - Mid and South Ceredigion Annual Average Supply Demand Balance

5.20. 8203 North Ceredigion



This zone covers the land around the coastal and inland area surrounding Aberystwyth.

5.20.1. Operation of the Water Resources

The majority of the zone is supplied from the impounding reservoirs of Llyn Craig-y-Pistyll and Llyn Llyghad Rheidol, which are supported by river abstractions from the Nant-y-Moch and Maesnant streams.

In the south west of the zone, groundwater abstractions from the two boreholes at Lovesgrove meet the demand in Aberystwyth. As storage in the upland reservoirs decreases, water from the boreholes is pumped to serve the demand immediately north of Aberystwyth, in Clarach and Penglais.

The boreholes at Lovesgrove take water from the gravel deposits in the valley of the Afon Rheidol. Even under very dry weather conditions, the amount we take from the boreholes is small in comparison to the flow in the river.

There are no exports or imports of water.

A review of hydrology, balance of demands, and asset capability was undertaken to support our modelling update for this Plan. This resulted in an improved understanding of the water available in our reservoirs, but also some restrictions in our ability to treat water.

5.20.2. Climate change

Overall the zone is generally resilient to climate change with only a modest reduction in deployable output expected as there is good storage in the reservoirs and the boreholes are able to provide support.

5.20.3. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures. There are localised concerns over the robustness of the Maesnant and Nant y Moch stream sources which require further investigation in AMP7.

5.20.4. Demand

Population is forecast to increase from 31,600 to over 33,000 by 2050 with the majority of housing development in Aberystwyth[15]. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 48% of households in 2020 to 76% by 2050.

[15] Ceredigion LDP Housing Allowance Breakdown Table, Ceredigion Local Development Plan, Appendix 2, Adopted 2013

5.20.5. Water Resource Position

For this Plan we are reporting a lower deployable output but the overall resource position remains healthy. The supply demand balance for the zone is shown in Figure 49 which indicates a surplus across the 30 year planning period from 2020 to 2050.

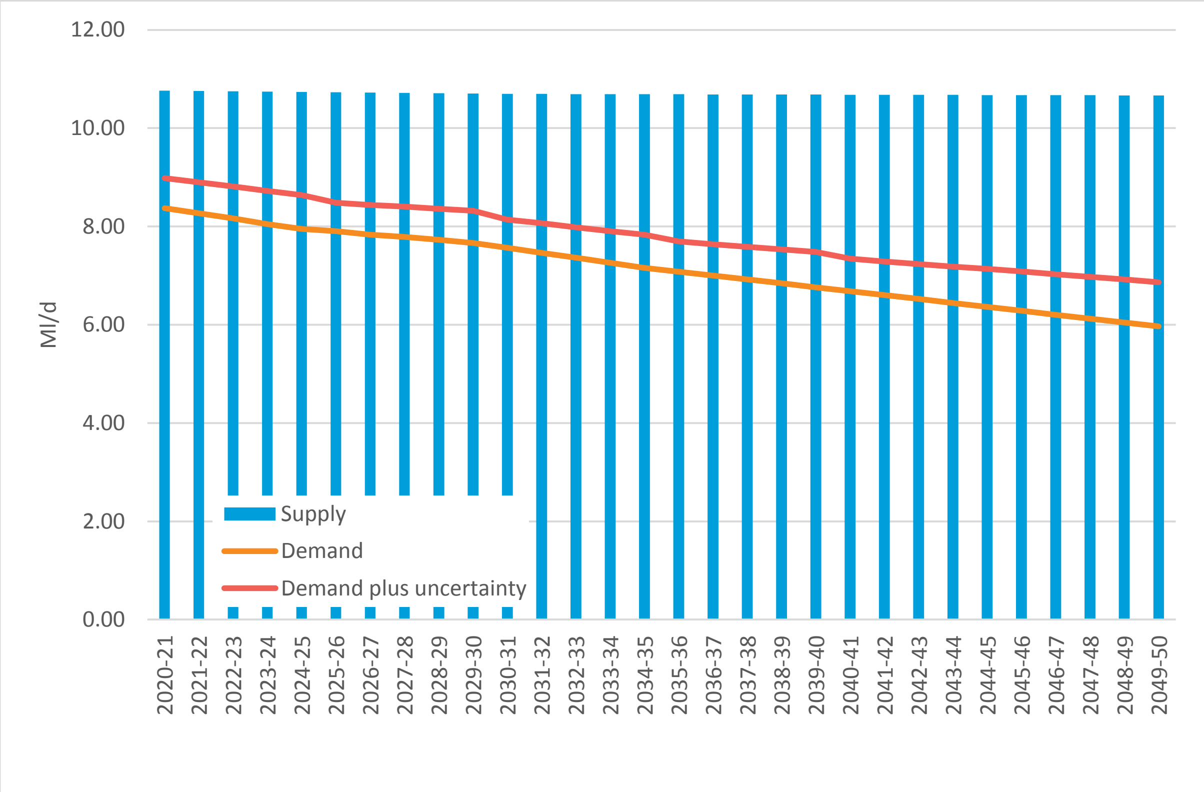
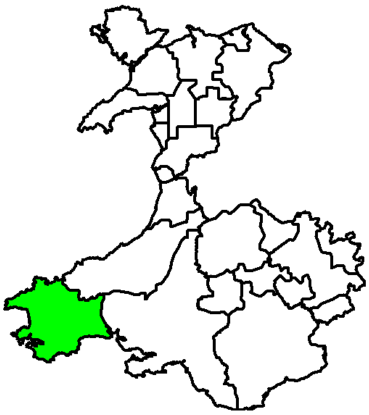


Figure 49 - North Ceredigion Annual Average Supply Demand Balance

5.21. 8206 Pembrokeshire



This zone covers the far south west corner of Wales, stretching from Pendine Sands in the east to the Pembrokeshire Coastal National Park in the west and from the villages of Manorbier in the south to Newport in the north.

5.21.1. Operation of the Water Resources

The largest treatment works in the zone is Bolton Hill, which is supplied by Canaston Bridge pumping station on the Eastern Cleddau and Crowhill pumping station on the Western Cleddau.

Canaston Bridge pumps water from two sources: a river intake on the Eastern Cleddau which is supported by releases of water from Llysyfran Reservoir, and a small piped supply from Valley Court springs. In addition to treated water for domestic customers, the Canaston Bridge – Bolton Hill arrangement supplies untreated water to the oil refineries south and north of Milford Haven.

The other major treatment works in the zone is Preseli, which is supplied from Rosebush reservoir. If storage in Rosebush is low, Preseli can be supported with water pumped from Llysyfran whilst Rosebush can be supported with water pumped from a river intake on the Eastern Cleddau at Pont Hywel but this supply is limited due to recent restrictions placed upon the abstraction licence for this source.

Pendine borehole supplies the eastern part of the WRZ with support able to be provided from the Bolton Hill system.

5.21.2. Changes to the zone

To protect the Afonydd Cleddau Special Area of Conservation, the amount of water we are allowed to take from the river will reduce in 2019.

At Pont Hywel, this reduces the support which can be provided to Rosebush and results in lower storage in the reservoir.

At Crowhill, this reduces the amount that can be taken from the river to supply Bolton Hill. This increases the reliance of Bolton Hill on Canaston Bridge.

At Canaston Bridge, a licence change reduces the amount that can be taken from the river in the spring and autumn and so increases the need for releases of water from Llysyfran to support the river.

In our 2014 Plan, we reported that these reductions resulted in a supply demand deficit for the zone. The supply in the zone was constrained by the limited storage of Rosebush which during a dry year would have declined to a point where zonal demand restrictions would have been needed more often than our preferred level of service. To resolve the deficit, a suite of schemes was put forward for delivery, starting with an increase to the amount of support which Llysyfran can provide to Preseli. This option increases the amount of water we can supply to our customers by utilising more of the storage in Llysyfran. It is scheduled for delivery in 2019 when the licence changes are effective and has been included in our modelling update for this Plan.

With increased demand on Llysyfran to support Rosebush and Canaston Bridge, the storage in the reservoir is fully utilised in dry years. This increases the vulnerability of the resource to the effects of climate change and more severe droughts than those we have seen historically.

5.21.3. Climate Change

Our modelling of climate change has shown it to impact our resources in two ways; firstly, it directly reduces the inflow to our reservoirs and secondly, it reduces the flows in rivers that are supported by reservoir releases. In Pembrokeshire this means less water would be available in Llysyfran into the future and more water would need to be released to support abstraction at the Eastern Cleddau at Canaston Bridge. Llysyfran is also required to provide greater support to Preseli works.

This combined pressure exacerbates low storage in drought years in Llysyfran. As the amount of water remaining in storage in Llysyfran and Rosebush in a dry year already limits the amount of water which can be put into supply, this further reduces the amount of water available to customers. The impact of climate change will increase across the planning period, hence our available supply steadily decreases.

5.21.4. Resilience

To assess the resilience of the zone to drought, we tested our model with more extreme and varied droughts than those in our historic record. This testing revealed that the zone is currently vulnerable to droughts between 1 in 50 and 1 in 100 year severity, as storage in Llysyfran becomes critical to maintaining supply to customers. Full details of this assessment are included in Appendix 22 – Pembrokeshire resilience assessment (ATKINS).

5.21.5. Demand

Population is forecast to increase from 123,000 to over 136,000 by 2050 Housing development, centred on 'Haverfordwest, Milford Haven, Neyland, Pembroke, Pembroke dock, Fishguard and Goodwick'[16]. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 44% of households in 2020 to 74% by 2050.

5.21.6. Water Resource Position

The supply demand balances for the zone are shown in Figure 50 and Figure 51. For the Annual Average scenario, Figure 50 shows a deficit starting in 2020/21 which increases to a maximum of 7.78 Ml/d by 2029/30. The deficit lessens after this as the effects of our demand reduction strategies take effect, falling to 6.55 Ml/d by 2050. The deficit is driven by the reduced storage in Llysyfran, which is forecast to worsen when the impacts of climate change are assessed. These trends are similar to those shown in our 2014 Plan and our 2016 Annual Review, however our calculated Total Water Available For Use and Uncertainty have both increased in this Plan. This additional drawdown is a consequence of the greater demands placed on Llysyfran, as described earlier. The pumpback scheme enables a change in operation of the zone, increasing the amount of water we can put into supply, but reduces storage in Llysyfran. This reduction in storage increases the allowance that we need to make for both the impact of climate change, and the uncertainty surrounding the potential scale of that impact.

[16] 5.56 Pembrokeshire County Council Local Development Plan, Adopted 2013

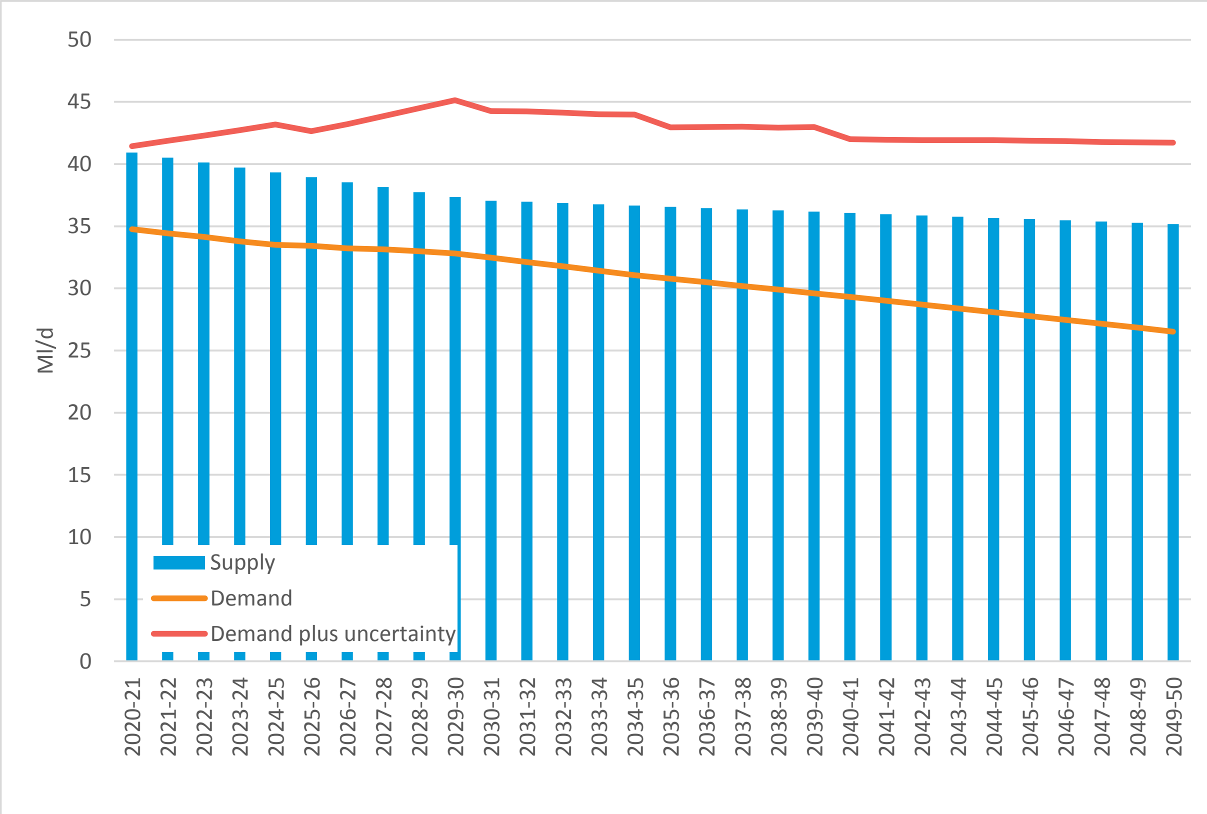


Figure 50 - Pembrokeshire Annual Average supply demand balance

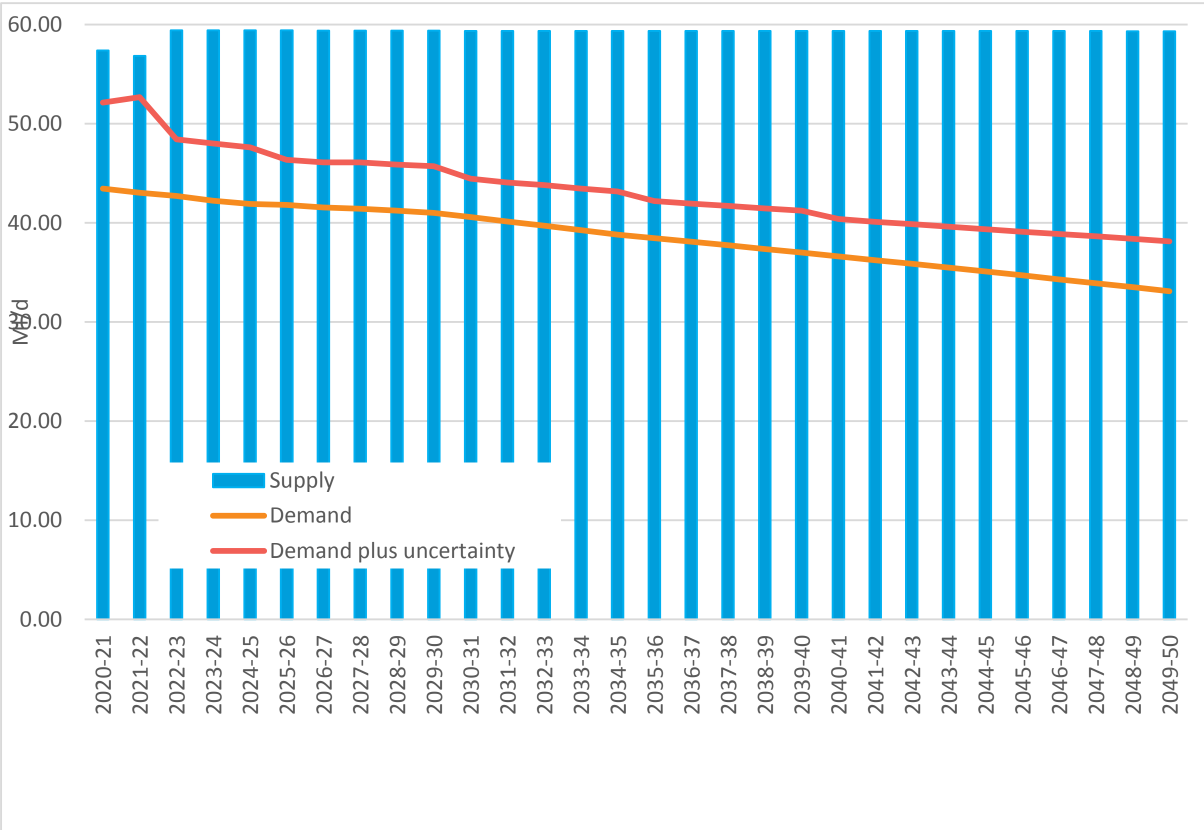
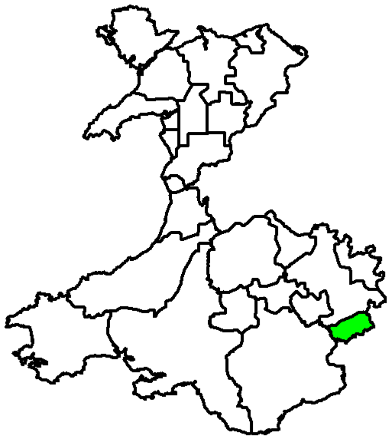


Figure 51 - Pembrokeshire Critical period supply demand balance

5.22. South East Wales Water Resource Zones

5.23. 8101 Ross-on-Wye

As the name suggests, this zone covers the small area and hamlets surrounding the market town of Ross-on-Wye.



5.23.1. Operation of the Water Resources

The zone is supplied in its entirety by the Bulk Supply of potable water from Severn Trent Water's Mitcheldean water treatment works. There is a small import of water from the neighbouring Hereford zone.

The raw water for Mitcheldean is abstracted from the River Wye at Lydbrook. Severn Trent have an abstraction licence of 55 Ml/d to supply Mitcheldean, however the licence contains conditions which allocate 9 Ml/d specifically to supply our Ross-on-Wye WRZ. Should the Ross-on-Wye demand be less than 9 Ml/d, the licence conditions preclude Severn Trent Water from using the surplus for their own supply.

5.23.2. Demand

We are forecasting a minor increase in population from 22,000 in 2020 to just under 23,000 by 2050. However, the total demand for water is forecast to decrease very gradually until 2030. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 55% of households in 2020 to 79% by 2050.

5.23.3. Climate Change

Given the forecast of a relatively large surplus of water in a dry year, the vulnerability assessment has classed climate change risk as negligible for this zone. We have not therefore undertaken a detailed analysis but are confident climate change will not place this water resource zone in deficit during the planning period.

5.23.4. Resilience

Severn Trent have tested their supplies against a range of extreme droughts and confirmed that under all scenarios, they were still able to maintain the export to Ross on Wye. We know from our own work that the Elan reservoir group that supplies regulation water to support this zone has been proved to be resilient to a greater than 1:200 year drought and so we are confident in the resilience of supplies to this zone.

5.23.5. Water Resource Position

Figure 52 shows that there is a relatively large surplus in the supply demand balance for the zone across the 30 year planning period from 2020 to 2050.

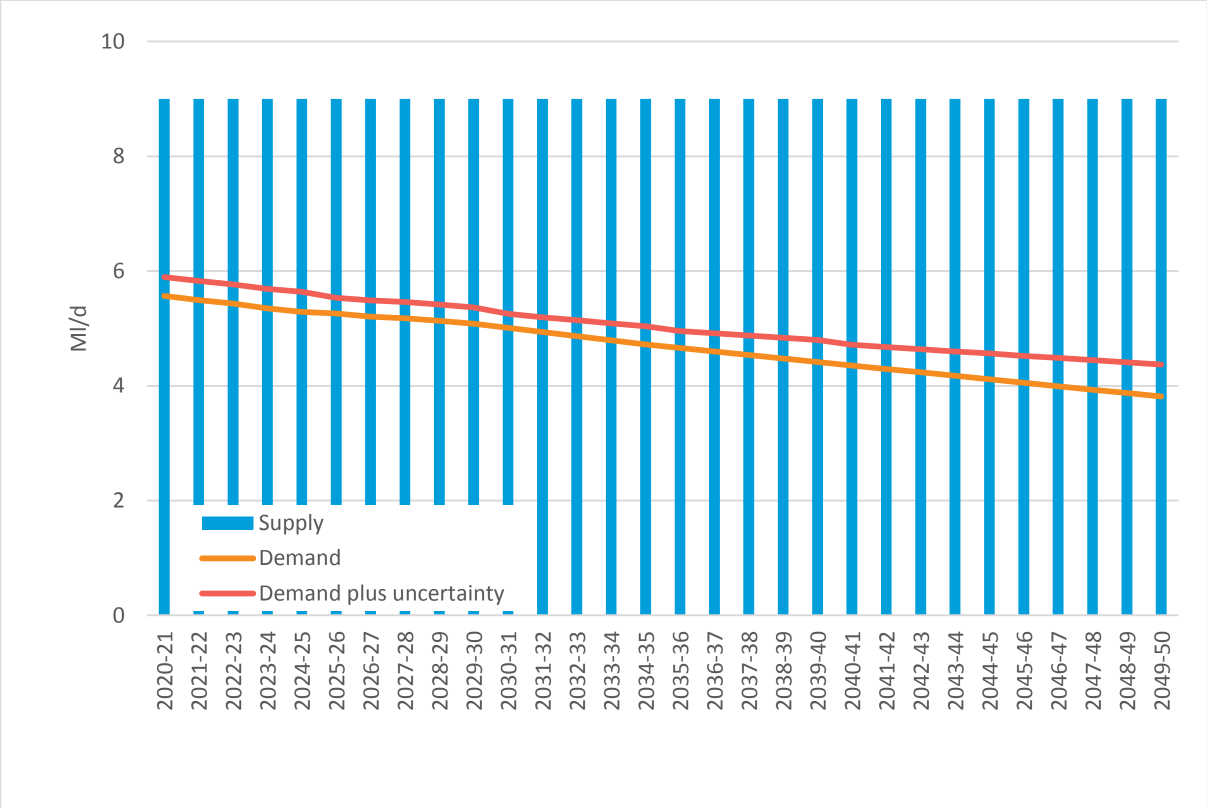
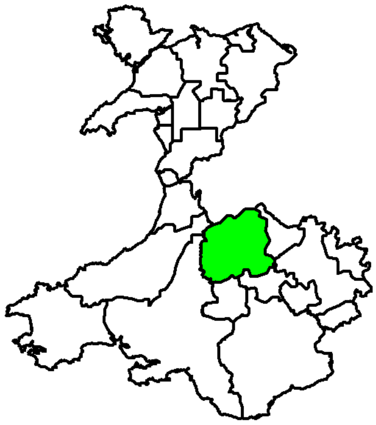


Figure 52 - Ross on Wye Annual average supply demand balance

5.24. 8102 Elan - Builth



This zone covers a large area of Powys, centred on the Elan Valley reservoirs and the town of Builth Wells.

5.24.1. Operation of the Water Resources

The zone is supplied from two sources, the Elan Valley Reservoirs and an abstraction from the River Wye at Builth Wells. These sources supply local water treatment works with the greater proportion of water coming from the Elan Valley works.

The Elan Valley reservoirs hold a significant volume of water that is predominantly used to supply Severn Trent Water. Our abstraction from the Elan Reservoirs for direct treatment and supply is a maximum of 5 Ml/d compared to the 381 Ml/d maximum quantity of raw water supplied to Severn Trent Water. In addition, the Elan Reservoirs provide regulation releases to support abstractions from the lower part of the River Wye by Severn Trent Water at Lydbrook (see the above Ross on Wye WRZ section) and by ourselves at Monmouth (see the sections on Monmouth WRZ and SEWCUS WRZ).

There are no imports or exports of water in this zone.

5.24.2. Demand

We are forecasting a moderate increase in population from 18,700 in 2020 to just under 20,000 by 2050 however, the total demand for water is forecast to decrease very gradually until 2030. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 55% of households in 2020 to 79% by 2050.

This zone is heavily influenced by the additional demand for water that is placed on Builth Wells WTW during the Royal Welsh Show week. Additional work has been completed to better understand the demands for water that the Show places on this zone which has resulted in a more accurate demand representation and provides more certainty in our ability to meet this demand. For this reason we have examined the supply demand balance for the zone under both the Dry Year Annual Average and peak week demand Critical Period scenarios.

5.24.3. Climate Change

The zone is not considered to be at risk of impact from climate change due to the very small volume of water supplied from the Elan reservoirs in comparison to the total volume in storage. Similarly the abstraction from the Wye at Builth Wells is relatively small when compared with the upstream catchment and flows in the River Wye, even under the driest scenarios. Given the forecast of a relatively large surplus of water in a dry year, the vulnerability assessment has classed climate change risk as negligible for this zone. We have not therefore undertaken a detailed analysis but are confident climate change will not place this zone in deficit during the planning period.

5.24.4. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures.

5.24.5. Water Resource Position

The Critical Period supply demand balance is shown in Figure 53 and this indicates a surplus across the 30 year planning period from 2020 to 2050. The deployable output for the zone has reduced from that reported in our 2014 Plan due to a rebalancing of demand allocation in the zone which ensures that they correctly represent demand, particularly the effect of the Royal Welsh Show.

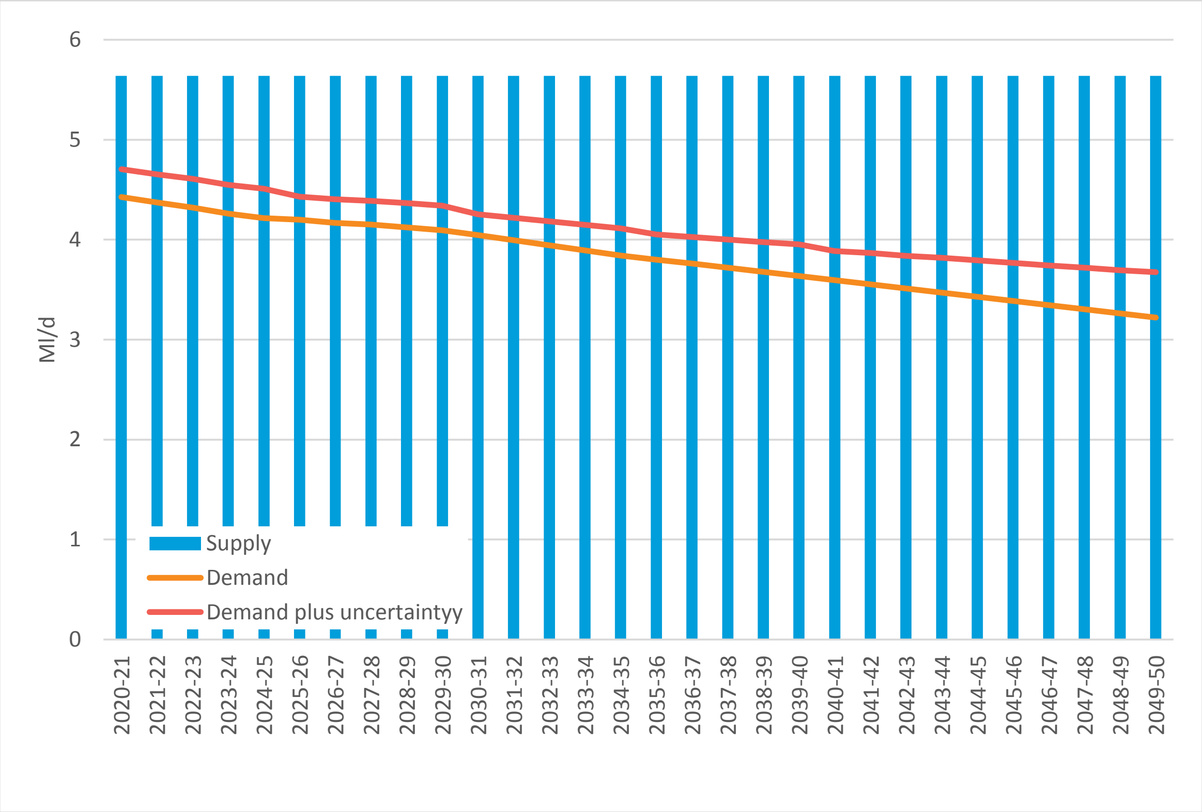
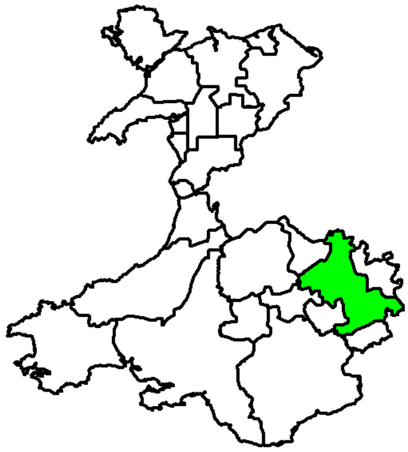


Figure 53 - Elan Builth Dry Year Critical period supply demand balance

5.25. 8103 Hereford Conjunctive Use System

As the name suggests, this WRZ covers the city of Hereford, the surrounding area and rural villages as far north as Leintwardine.



5.25.1. Operation of the Water Resources

The main supply of water for this zone is an abstraction from the River Wye at Hereford which is treated at the nearby Broomy Hill water treatment works. In addition we abstract water from two separate borehole sources at Dunfield and Leintwardine which are treated on site and supply their local areas. We are able to provide a limited transfer of water from Broomy Hill to support the areas supplied from the much smaller boreholes.

There are small exports of water from the Hereford WRZ into the adjacent Ross-On-Wye, Whitbourne and Vowchurch WRZ's.

There are no imports of water to the zone.

5.25.2. Demand

We are forecasting a moderate increase in population from 135,500 in 2020 to just over 141,000 by 2050 however, the total demand for water is forecast to remain relatively stable until 2030. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 59% of households in 2020 to 85% by 2050.

5.25.3. Climate Change

Risks to our supplies of water in the zone are low, with limited impact expected on our water sources from climate change. This is primarily due to the large extent of the River Wye catchment compared to the volume of water that we are licenced to take from the Wye at Hereford. Given the forecast of a relatively large surplus of water in a dry year, the vulnerability assessment has classed climate change risk as negligible for this zone. We have not therefore undertaken a detailed analysis but are confident climate change will not place this water resource zone in deficit during the planning period.

5.25.4. Resilience

An initial analysis of extreme drought events has been undertaken for the Broomy Hill source, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures. We have been unable to fully assess the resilience of the Dunfield and Leintwardine sources independently but aim to progress this analysis during AMP7. Should these smaller resources be shown not to be resilient to a 1 in 200 year drought event, then we would confirm the volume of tankering support available from Broomy Hill before looking at investment in new infrastructure.

5.25.5. Water Resource Position

Figure 54 shows that that there is a surplus in the supply demand balance for the zone across the 30 year planning period from 2020 to 2050.

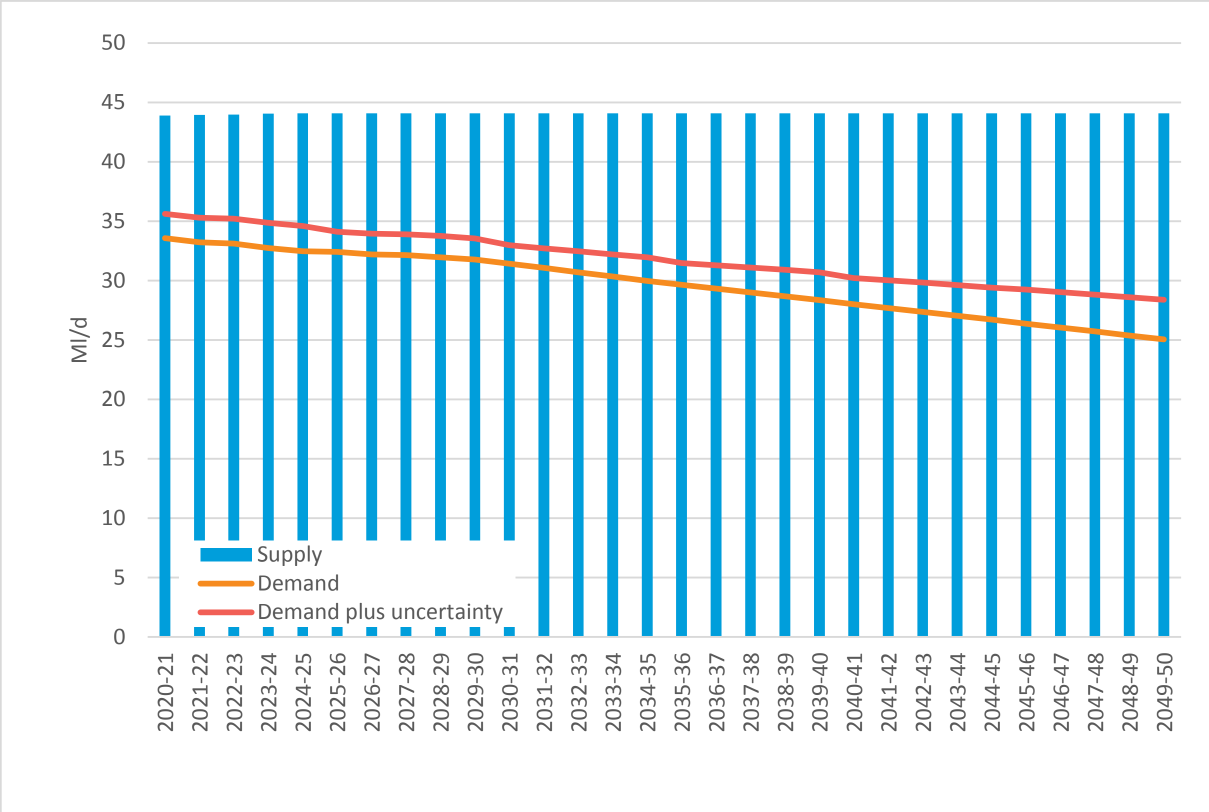
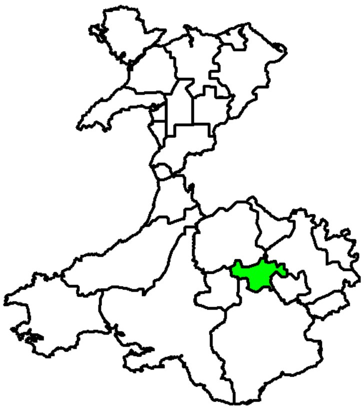


Figure 54 - Hereford Annual Average Supply Demand Balance

5.26. 8105 Llyswen

This zone covers the small rural communities in and around Hay-on-Wye.



5.26.1. Operation of the Water Resources

Water is abstracted from the River Wye at Llyswen where it is treated at the associated water treatment works before it enters the supply network.

There are no imports of water to Llyswen from neighbouring WRZ's however a small export to the Vowchurch zone is available for use when required.

5.26.2. Demand

We are forecasting a moderate increase in population from just under 9,000 in 2020 to just under 10,000 by 2050 however, the total demand for water is forecast to remain relatively stable until 2030. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 56% of households in 2020 to 83% by 2050.

5.26.3. Climate Change

Given the forecast of a relatively large surplus of water in a dry year, the vulnerability assessment has classed climate change risk as negligible for this zone. We have not therefore undertaken a detailed analysis but are confident climate change will not place this zone in deficit during the planning period. This is primarily due to the large extent of the River Wye catchment compared to the volume of water that we are allowed to take from the Wye at Llyswen.

5.26.4. Resilience

An initial analysis of extreme drought events has been undertaken for the Llyswen source, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures.

5.26.5. Water Resource Position

Figure 55 shows that that there is a healthy surplus in the supply demand balance for the zone across the 30 year planning period from 2020 to 2050.

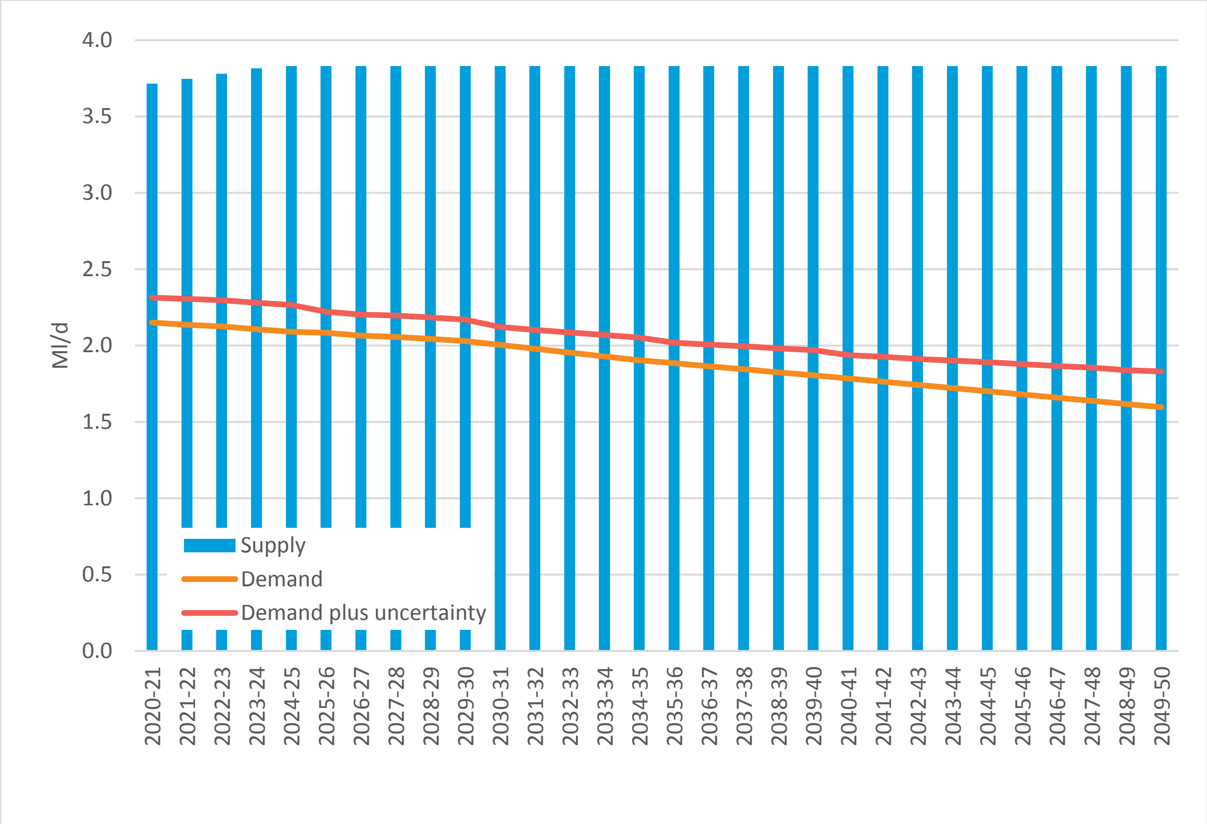
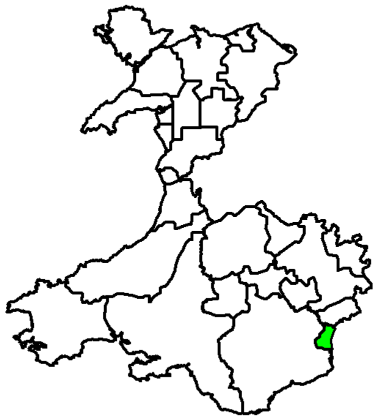


Figure 55 - Llyswen Annual Average Supply Demand Balance

5.27. 8106 Monmouth

This zone supplies the market town of Monmouth and the surrounding villages.



5.27.1. Operation of the Water Resources

The zone is heavily dependent on the Mayhill abstraction from the River Wye at Monmouth. There is also a spring abstraction at Ffynnon Gaer which supplies a small localised area south of Monmouth.

There are no exports or imports of water for Monmouth.

5.27.2. Demand

We are forecasting a moderate increase in population from 14,500 in 2020 to just over 15,000 by 2050. However, the total demand for water is forecast to remain relatively stable until 2030. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 49% of households in 2020 to 77% by 2050.

5.27.3. Climate Change

Given the forecast of a relatively large surplus of water in a dry year, the vulnerability assessment has classed climate change risk as negligible for this zone. We have not therefore undertaken a detailed analysis but are confident climate change will not place this water resource zone in deficit during the planning period, due to the large extent of the River Wye catchment compared to the volume of water that we are allowed to take from the Wye at Monmouth.

5.27.4. Resilience

An initial analysis of extreme drought events has been undertaken for the Monmouth (Mayhill) source, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures. We have been unable to assess the resilience of the Ffynnon Gaer source independently but aim to progress this analysis in AMP7. Should this smaller resource be shown not to be resilient to a 1 in 200 year drought event, then we would confirm the volume of tankering support available from Mayhill before looking at investment in new infrastructure.

5.27.5. Water Resource Position

The supply demand balance for the zone is shown in Figure 56 and this indicates a surplus across the 30 year planning period from 2020 to 2050. Only the annual average planning scenario is reported for this zone.

The limit on deployable output for this zone is the treatment capacity at Mayhill water treatment works in combination with the restriction placed on Ffynnon Gaer springs by the daily abstraction licence limit. These are different to the restrictions presented in the 2014 Plan which still included the now unused Buckholt Spring source. Refinements to our understanding of our works output has been completed which has confirmed a lower maximum capacity for Mayhill works than previously reported. This has reduced the deployable output of the zone but the overall water resource position remains healthy.

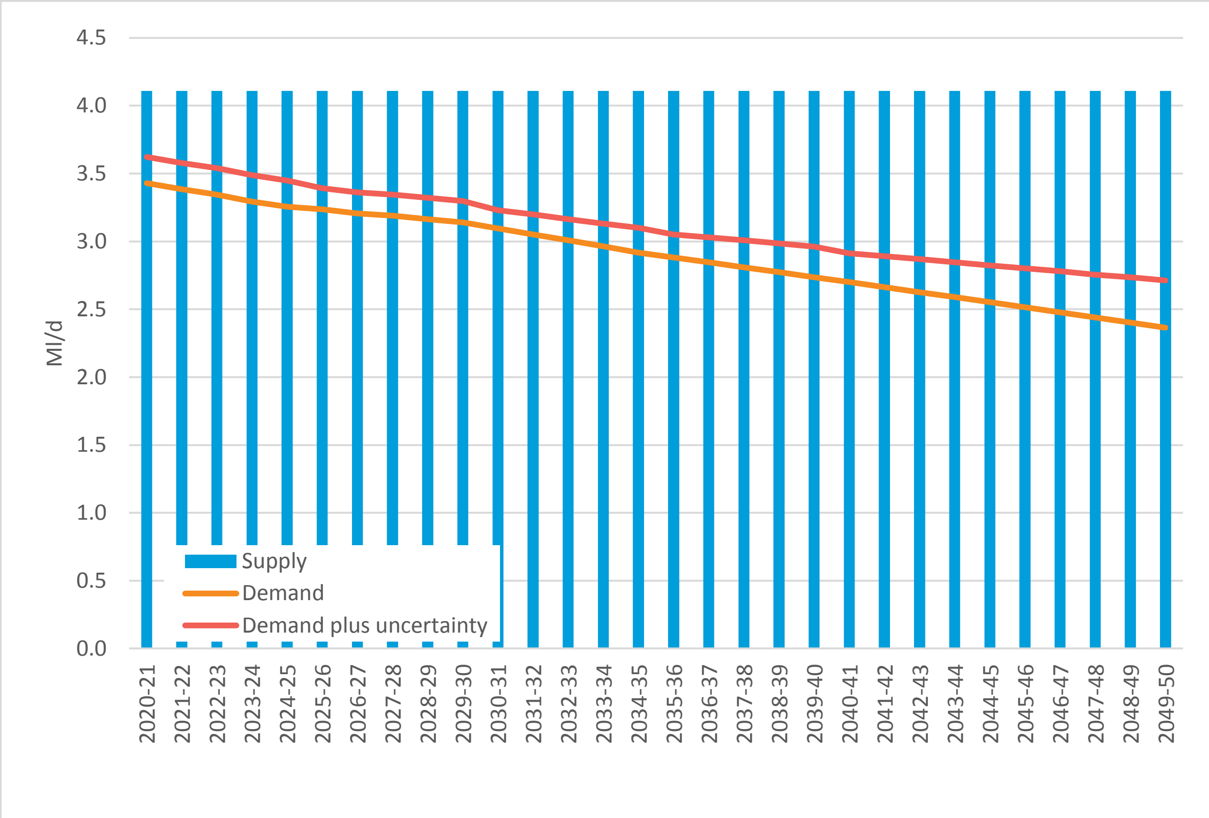
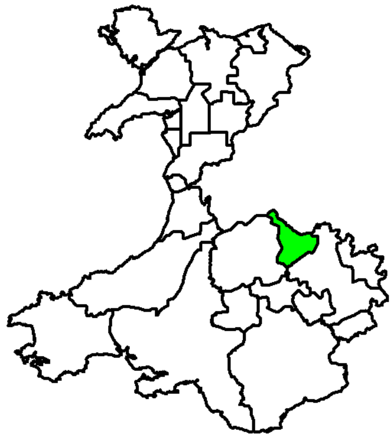


Figure 56 - Monmouth Annual Average Supply Demand Balance

5.28. 8107 Pilleth



This zone supplies the small rural area surrounding Presteigne and extends into the adjacent catchment of the River Teme and serves Knighton.

5.28.1. Operation of the Water Resources

The zone is supplied from a single group of four individual boreholes located in the gravel aquifer adjacent to the upper River Lugg at Pilleth. Industrial usage in Presteigne is a disproportionately large component of demand.

There are no exports or imports of water for the Pilleth zone.

5.28.2. Demand

We are forecasting a small increase in population from 8,190 in 2020 to 8,760 by 2050 however, the total demand for water is forecast to remain relatively stable until 2030. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 42% of households in 2020 to 71% by 2050.

5.28.3. Climate Change

Given the relatively large surplus, the vulnerability assessment has classed climate change risk as negligible. We have not therefore undertaken a detailed analysis but are confident climate change will not place this zone in deficit during the planning period.

5.28.4. Resilience

Although we have been unable to undertake an assessment for this zone, we have no indicators from historic experience that the zone is not resilient to extreme drought events. We aim to progress this analysis during AMP7.

5.28.5. Water Resource Position

The supply demand balance for the zone is shown in Figure 57 and this indicates a surplus across the 30 year planning period from 2020 to 2050.

An improved understanding of the supply capacity used in our modelling has resulted in a reduced deployable output compared to that reported in our 2014 Plan. However, the overall water resource position for this zone remains healthy.

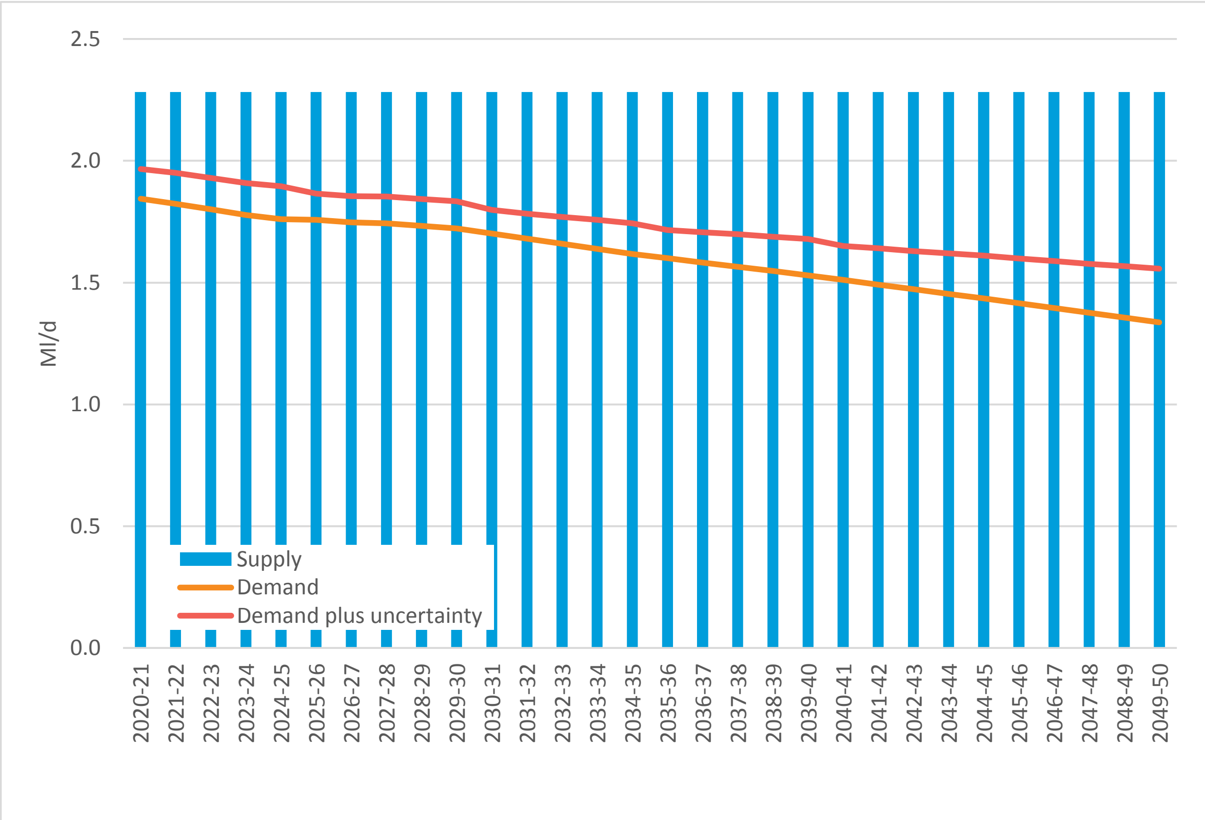
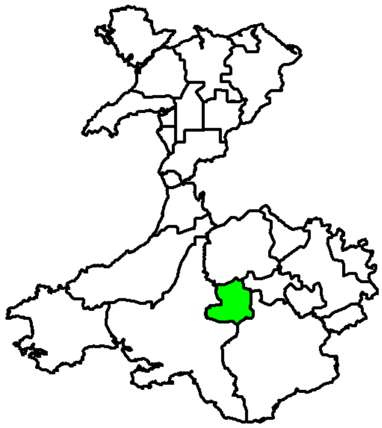


Figure 57 - Pilleth Annual Average Supply Demand Balance

5.29. 8108 Brecon – Portis



This zone is situated in the headwaters of the River Usk, in the immediate vicinity of the towns of Brecon and Sennybridge and the Usk Reservoir.

5.29.1. Operation of the Water Resources

The Usk Reservoir has two main direct supply uses:

- to supply Bryngwyn water treatment works that serves the upper area of the Tywi CUS;
- to supply Portis water treatment works that serves the Sennybridge area of this zone.

Usk reservoir is also able to provide regulation releases to support our lower River Usk abstractions in the SEWCUS zone during drought periods.

In addition to Portis supplying the zone there are three boreholes at Brecon which meet the larger proportion of the demand. The boreholes are located in the gravel aquifer at Brecon, adjacent to the River Usk. The conditions of the abstraction licence reduce the volumes available as flows in the River Usk decrease. This reduction then triggers regulation releases from the Usk reservoir to augment river flows and maintain a higher level of abstraction.

There are no imports of water, the only transfer of water is from Usk reservoir to the Tywi CUS.

5.29.2. Demand

We are forecasting a small increase in population from just under 12,000 in 2020 to just over 12,600 by 2050 however, the total demand for water is forecast to remain relatively stable until 2030. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 49% of households in 2020 to 77% by 2050.

5.29.3. Climate Change

Given the relatively large surplus, the vulnerability assessment has classed climate change risk as negligible and so we have not therefore undertaken a detailed analysis but are confident climate change will not place this water resource zone in deficit during the planning period.

5.29.4. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures.

5.29.5. Water Resource Position

The supply demand balance for the zone, is shown in Figure 58 and this indicates a surplus across the 30 year planning period from 2020 to 2050.

The limit on the amount of water that can be supplied to customers in the zone is a combination of the amount of water that Portis can treat and how much we are allowed to take from the reservoir in conjunction with the abstraction from Brecon boreholes.

The total amount of water that is available to meet customer demand in the zone has increased from the value that we reported in our 2014 Plan and the 2016 Annual Review. We have included the Usk regulation scheme within our baseline deployable output modelling, which effectively allows us to maintain our full licensed abstraction.

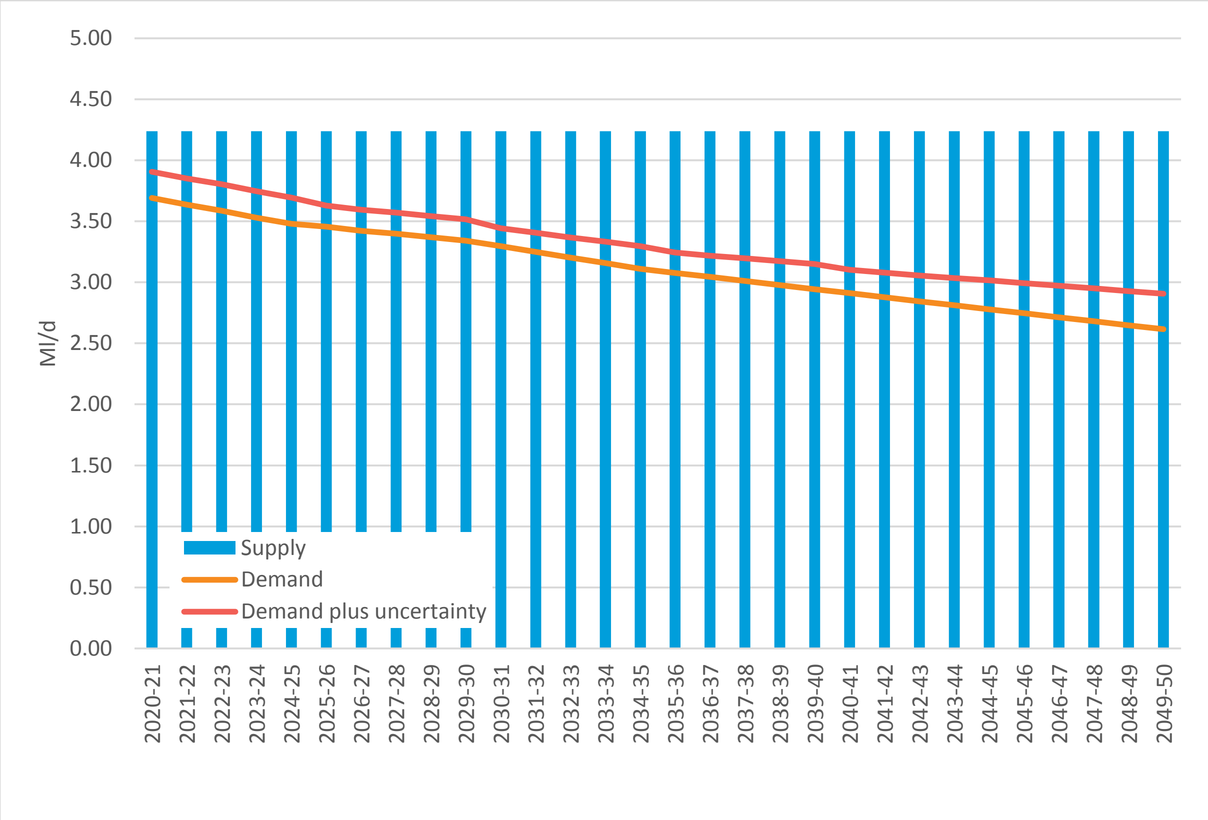
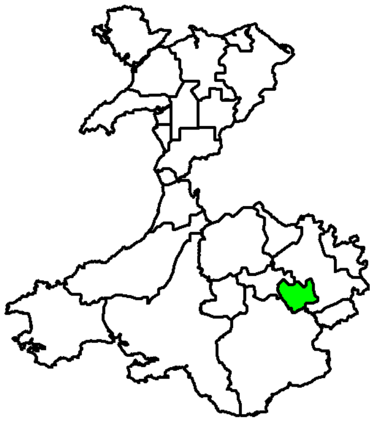


Figure 58 - Brecon Portis Annual Average Supply Demand Balance

5.30. 8110 Vowchurch



This zone covers the small rural area south of Hay-on-Wye.

5.30.1. Operation of the Water Resources

The zone is supplied by four boreholes that are located adjacent to the River Dore at Vowchurch. The River Dore is a tributary of the Monnow that in turn is a tributary of the River Wye.

There are small imports of water from the Hereford and Llyswen zones which have the capacity to match any additional customer water needs over the planning period. There are no exports of water.

5.30.2. Demand

We are forecasting a minor increase in population from just over 6,800 in 2020 to just over 7,000 by 2050. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 52% of households in 2020 to 79% by 2050.

5.30.3. Climate Change

The vulnerability assessment has classed climate change risk as negligible for this zone. We have not therefore undertaken a detailed analysis but are confident climate change will not place this water resource zone in deficit during the planning period.

5.30.4. Resilience

Initial indications from our resilience assessment show that the zone is likely to be susceptible to less than a 1:200 drought event (See Appendix 19 – EVA resilience assessment (ATKINS)). The analysis suggests that in a 1:200 year severe drought event, the boreholes and the associated River Dore may only provide up to 0.83 Ml/d compared to our abstraction needs of up to 3 Ml/d. This is based upon our knowledge of the aquifer from which the Vowchurch boreholes abstract water and the currently available River Dore flow record where relatively low flows have been experienced. This is lower than we would like and we plan to invest to improve this level of zonal resilience. We have examined options to improve the resilience of our Vowchurch supply system and this is detailed further in Chapter 7.14.

The Vowchurch site has been subject to a Restoring Sustainable Abstraction investigations and we are aware that the current abstraction licence is viewed at its limit of sustainability by the Environment Agency. We will look to ensure that we have a limited impact on the site under severe drought conditions through this improvement plan.

5.30.5. Water Resource Position

The supply demand balance for the zone is shown in Figure 59.

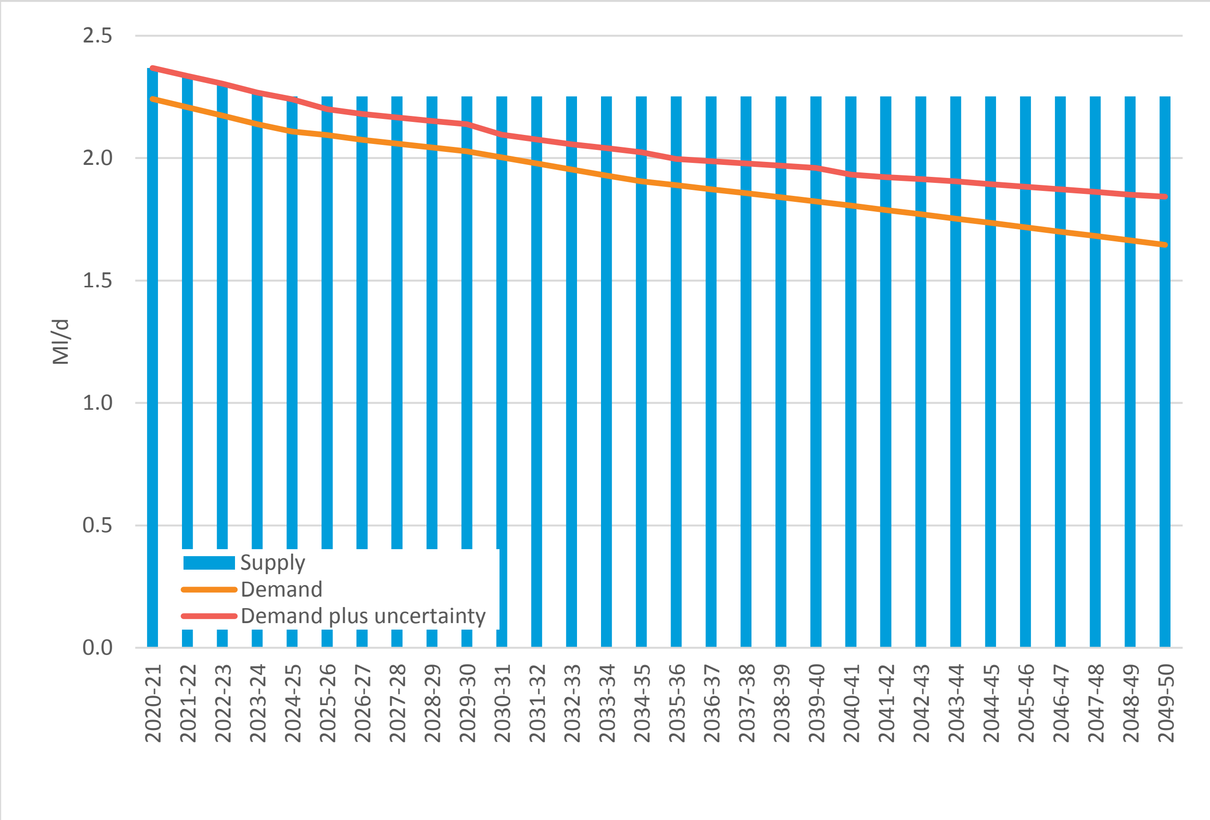
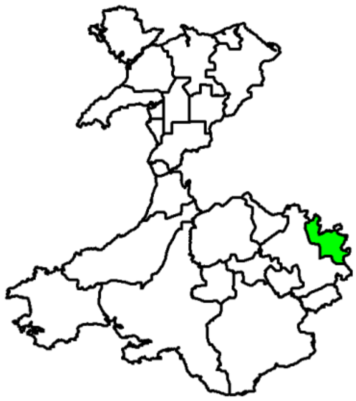


Figure 59 - Vowchurch Annual Average Supply Demand Balance

5.31. 8111 Whitbourne



The zone is located in east Herefordshire adjacent to the Worcestershire border and supplies the rural towns and villages in the area surrounding Bromyard.

5.31.1. Operation of the Water Resources

The supply is from a single abstraction from the River Teme at Whitbourne some 20 km upstream of its confluence with the River Severn.

Operationally it is possible for limited support to the zone to be provided through adjustments to our water supply network. There is a small internal import of water from the Hereford zone which has the capacity to match any additional demands placed on the zone over the planning period. There are no exports of water.

5.31.2. Demand

We are forecasting a minor increase in population from 15,600 in 2020 to 16,200 by 2050. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 54% of households in 2020 to 75% by 2050.

5.31.3. Climate Change

The vulnerability assessment has classed climate change risk as negligible for this zone. We have not therefore undertaken a detailed analysis but are confident climate change will not impact on our water resource in this zone due to the large flows in the River Teme in relation to our much smaller abstraction licence.

5.31.4. Resilience

An initial analysis of extreme drought events has been undertaken for the zone, the results of which show that under a 1 in 200 year drought event we would not need to implement extreme supply side measures.

5.31.5. Water Resource Position

The supply demand balance for the zone is shown in Figure 60 and this indicates a surplus across the 30 year planning period from 2020 to 2050.

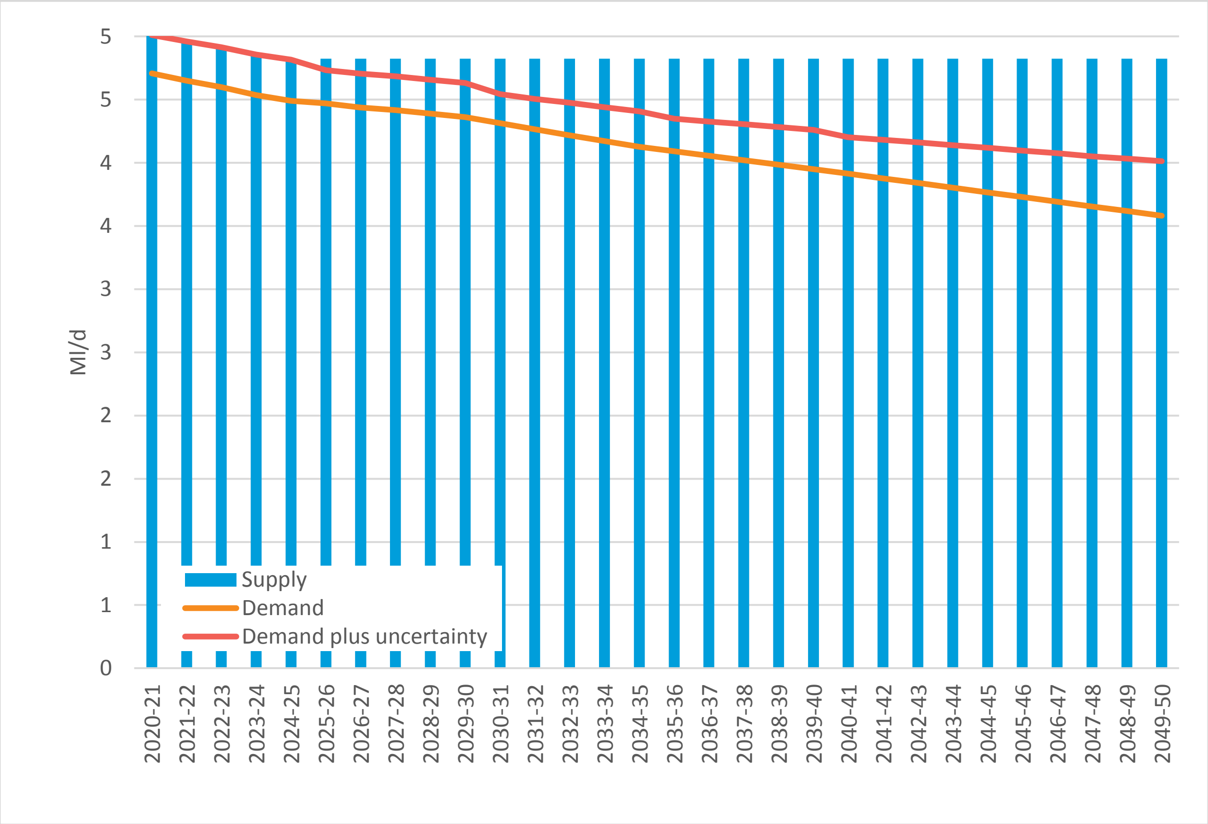
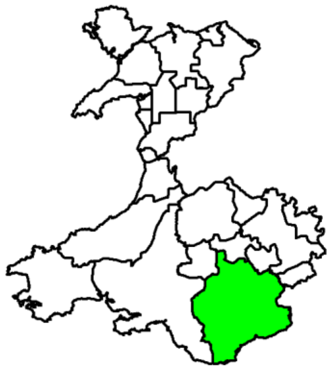


Figure 60 - Whitbourne Annual Average Supply Demand Balance

5.32. 8121 SEWCUS



This is the largest of all our 24 water resource zones and serves some 1.3 million domestic customers. It covers the large conurbations of Cardiff and Newport as well as the towns and villages of the South Wales valleys as far west as the Rhondda Valley and as far east as Chepstow.

5.32.1. Operation of the Water Resources

In total, there are over 40 resources that are used for supply which range from upland reservoirs to large river abstractions from the bigger rivers in the east of the zone.

The abstractions from the Rivers Wye and Usk are taken from the lowland stretches of the rivers and are supported by large catchment areas which are able to sustain the flow in the river for longer throughout the year. Under low river flow conditions the abstractions from the Wye at Monmouth are maintained by regulation releases from the Elan Valley Reservoirs in the headwaters of the River Wye. Similarly in prolonged dry periods water can be released into the River Usk from Usk reservoir to allow us to take it out of the river upstream of Usk town at our Prioress Mill pumping station.

The SEWCUS zone is connected by a series of large water mains to allow water from the lowland river sources in the east to be transferred further west and north, to relieve the demand on the upland impounding reservoirs whose storage declines relatively quickly in dry weather. This preserves the storage in these sources and allows them to supply their immediate demand areas through an extended drought.

The objective when operating the reservoirs and associated works is to ensure that there is always sufficient water across the zone even during the driest years but when water is plentiful to make best use of the cheaper upland reservoir sources. This operation is controlled through the use of set rules which govern the amount of water fed to each of the works in relation to the amount of water in the reservoirs.

Of the 40 sources that supply SEWCUS, there are five major reservoir systems (the 'Big 5'), which provide the bulk of the water going into supply. These are: Usk Reservoir; Talybont Reservoir; Llandegfedd Reservoir; Taf Fawr Reservoirs (Llwynon, Cantref & Beacons Reservoirs); and Pontsticill Reservoir.

Llandegfedd Reservoir utilises a refill strategy which relies on our ability to abstract the majority of the water we require from the River Usk at Prioress Mill during winter periods when there is a lot of water in the river in order to reduce our impact on the environment.

There is an import of water from the Tywi CUS WRZ, which supplies the area north-west of Cardiff around Talbot Green and Llantrisant. There are no exports of water.

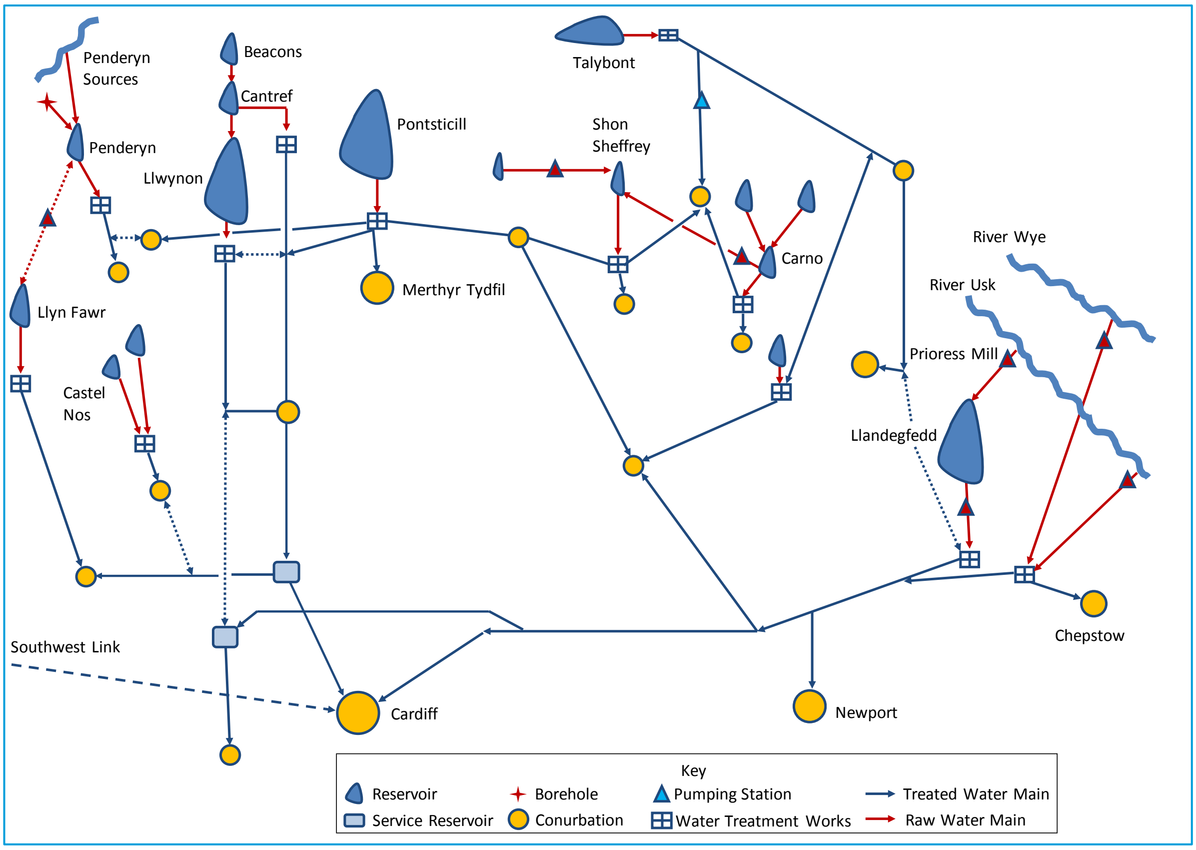


Figure 61 - Schematic representation of the SEWCUS system

5.32.2. Demand

The population within the zone is forecast to increase by around 4% by the end of the planning period to 1,408,000. However total demand for water in the SEWCUS zone is set to remain relatively stable throughout the planning period until 2030. We are anticipating a decline in the demand for water over the planning period, driven by our ambitious Company-wide target to reduce leakage during AMP7 and then to just 10% of current demands by 2050 whilst at the same time working with our domestic customers to achieve an average company-wide PCC of 100 l/hd/d. Metering in the zone is expected to rise from 33% of households in 2020 to 62% by 2050.

For this Plan a full review of the balance of water demands across the zone was undertaken to support our modelling update. This improved understanding has allowed us to more accurately model the supply required from each reservoir and associated works across the zone, both jointly and individually. This has altered the way in which we will utilise our water resources through a dry year and therefore improved our understanding of the way in which our reservoirs will respond to drought conditions.

5.32.3. Climate Change

The improved understanding of how our system performs, as described above, means we can ensure that more water will remain in storage in our reservoirs during droughts. This in turn has made our reservoirs better able to deal with both an increase in customer demand and the predicted impacts from climate change. This work has allowed us to demonstrate that there is now sufficient water within the zone to meet customer demands in dry years and to meet the additional stresses that climate change may bring.

As explained in Chapter 3 we have agreed with NRW that for the purpose of this Plan we will utilise the 2030s climate change factors for baseline planning and use the 2080s factors as a sensitivity check in SEWCUS.

In this scenario we have compared the impact of climate change from the 2030's UKCP09 factors (Figure 62) with the 2080's UKCP09 factors (Figure 63). This has allowed us to gain an understanding of the sensitivity of the zone to climate change and the potential need for any investment. At this stage it should be recognised the assessment is intended to provide an indication of the 'envelope' of scenarios that is possible in this zone but will then be reviewed and reinterpreted following publication of UKCP18 and associated guidance.

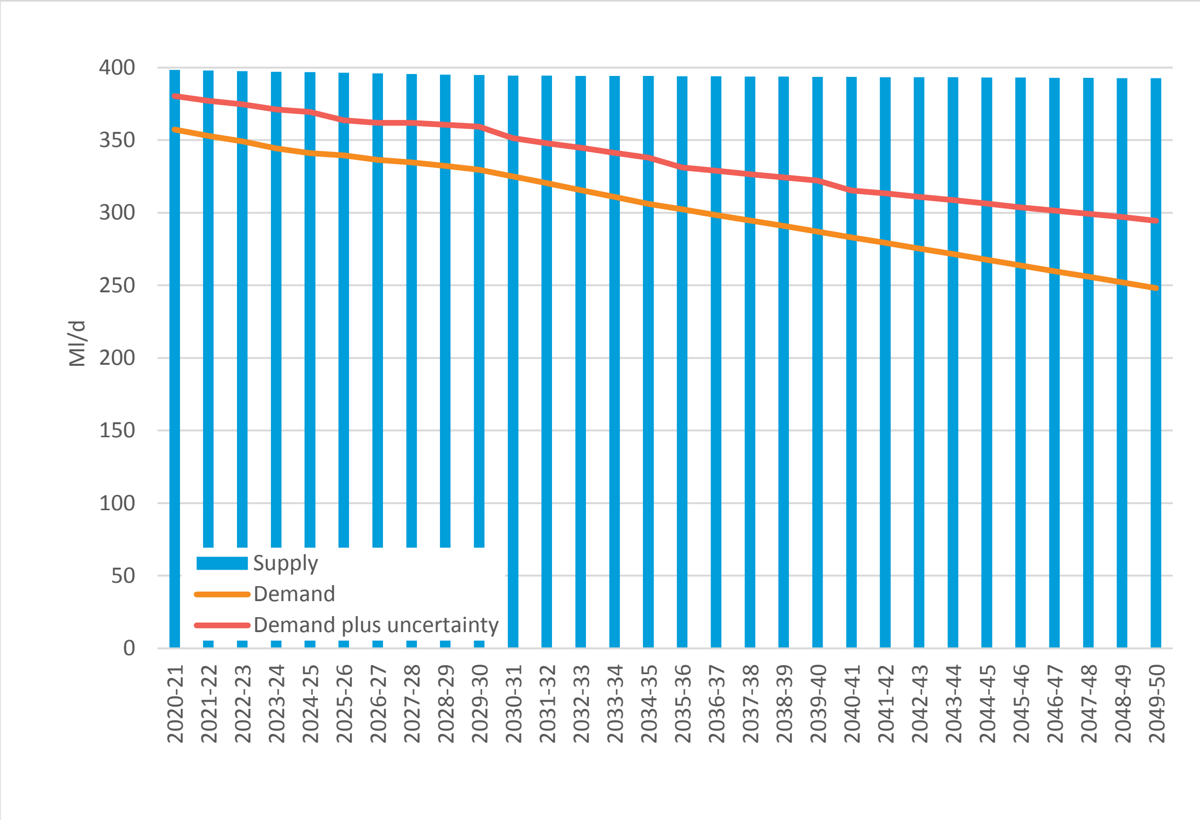


Figure 62 - SEWCUS Annual Average Supply Demand Balance (with 2030s climate change factors)

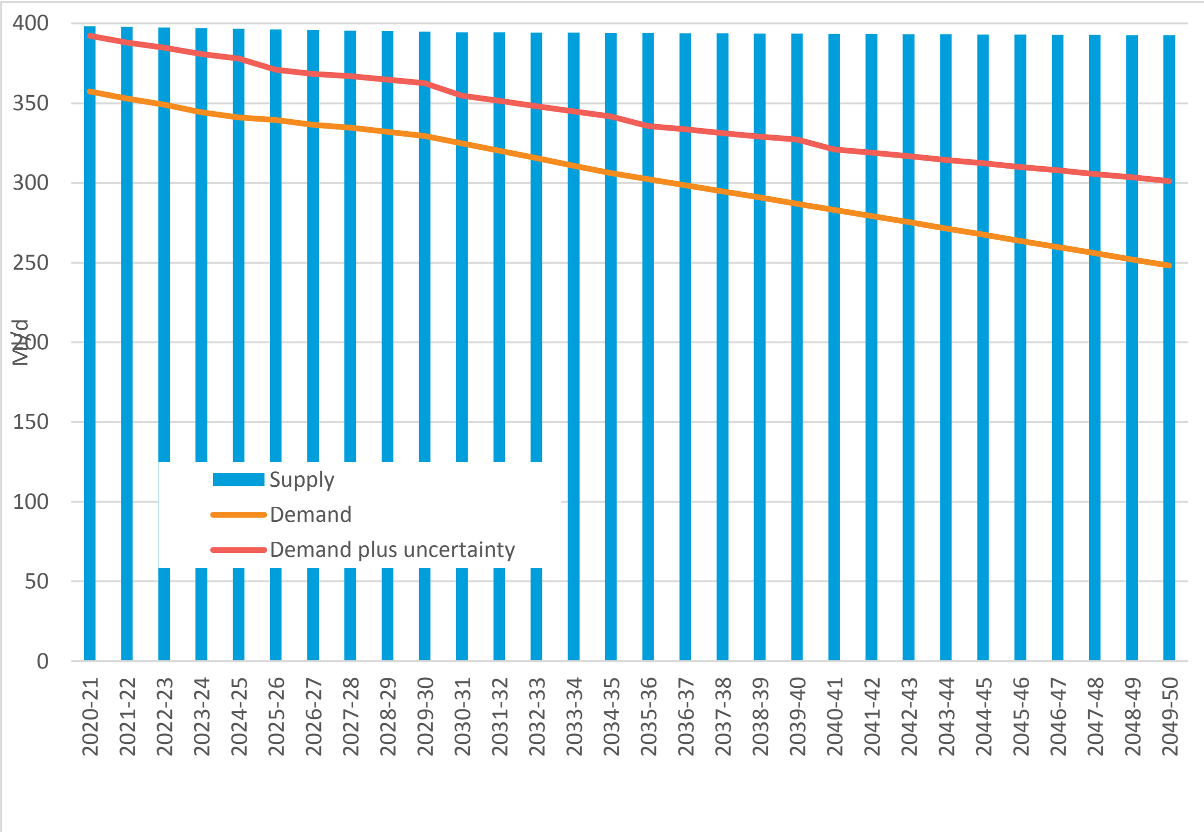


Figure 63 - SEWCUS Annual Average Supply Demand Balance (with 2080s climate change factors)

It should be noted that these results are indicative only as they do not include a detailed assessment for the 2080s as the Headroom, Losses, Outage and Demand Forecast are the same as for the 2030's scenario. The scenario is therefore an assessment of how the Deployable Output and Climate Change component in Headroom would change within the current Plan for the zone.

Based on this provisional scenario assessment it can be concluded that the impact of climate change from the 2080's factors would be to reduce the supply demand balance surplus in SEWCUS at the end of the planning period to 91 Ml/d compared to 98 Ml/d using the 2030's factors. This gives further confidence in the resilience of this zone but we will update our assessment when the new UKCP18 scenarios and UKWIR guidance are issued.

5.32.4. Resilience

To assess the resilience of the zone to drought, we tested our model with more extreme and varied droughts than those in our historic record. This testing revealed that the interconnectivity of the zone makes it resilient to at least a 1 in 200 year drought event, in that we would not need to implement extreme supply side measures to maintain supplies. The testing highlighted some potential localised risks that require further investigation in AMP7. Full details of the assessment are presented in Appendix 23 – SEWCUS resilience assessment (ATKINS).

5.32.5. Water Resource Position

The supply demand balance for the zone, as shown in Figure 62, indicates a surplus across the 30 year planning period from 2020 to 2050. Our reported baseline deployable output, including the effects of NRW's amendments to our abstraction licences on the Rivers Wye and Usk, is 422 Ml/d. This differs from both the 2014 Plan and the 2016 Annual Review.

In our 2014 Plan deployable output was forecast to reduce by 34 Ml/d from 436 Ml/d to 402 Ml/d as a result of reductions in the amount of water, set by NRW, we were allowed to take from the Rivers Usk and Wye to meet the Habitats Directive outcomes. This would have left us with a much reduced surplus in the zone and eventually a small deficit to resolve at the end of the planning period (Figure 64). Following this, the Usk & Wye Abstractions Group (UWAG) was set up as a collaboration between ourselves, Severn Trent Water, the Canal and Rivers Trust and the Wye & Usk Foundation to create an alternative set of abstraction licence rules that would satisfy NRW's requirements to improve the environment and provide a better solution for all stakeholders. This collaboration resulted in a new set of rules defining how and when we can take water from the Rivers Wye and Usk.

These rules, which were included in our 2016 Annual review (Figure 65), resulted in a less severe reduction in our deployable output of 18 Ml/d, from 436 Ml/d to 418 Ml/d. However, the overall supply demand deficit was larger than that presented in 2014. This was driven by a greater forecast impact from the climate change scenarios upon DO and the consequent impact to our Target Headroom assessment. The deficit was forecast to be around 5 Ml/d by the end of AMP7, increasing to approximately 28 Ml/d by the end of the planning period. As detailed in the 'Demand' section above, our improved understanding of how and where customers use water across the zone has changed the way that we model the supplies from our reservoirs, with the larger demands now better allocated to where the greatest supply is available. This rebalancing means that more water is left in store in our reservoirs and so our current forecast impacts of climate change are much less, meaning the overall balance in the Plan is much healthier.

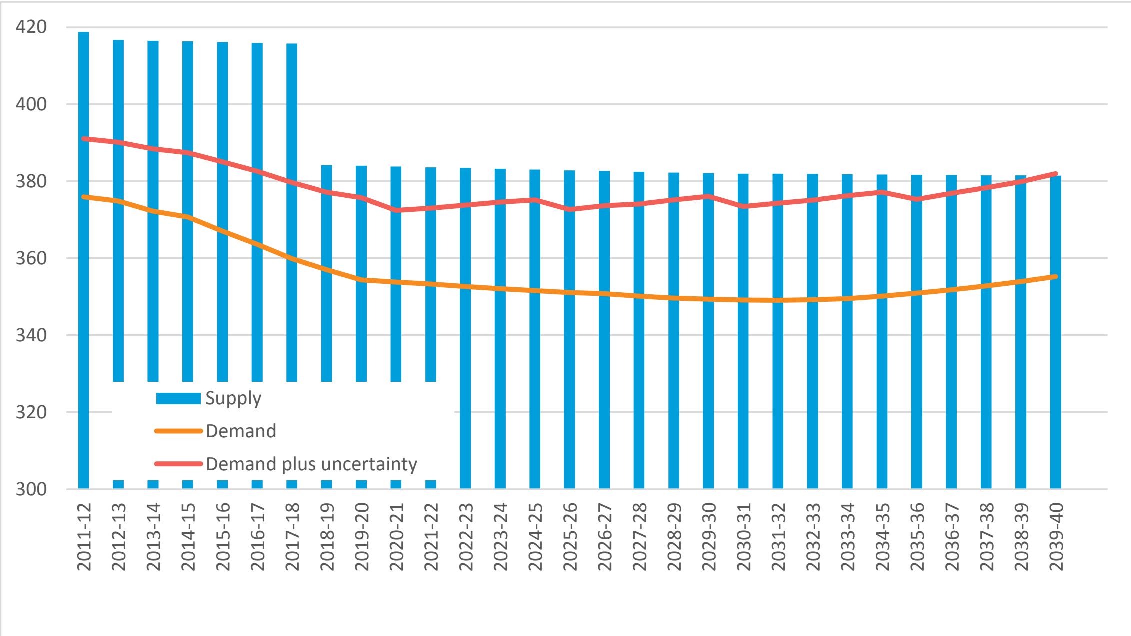


Figure 64 - WRMP14 SEWCUS Annual Average Supply Demand Balance

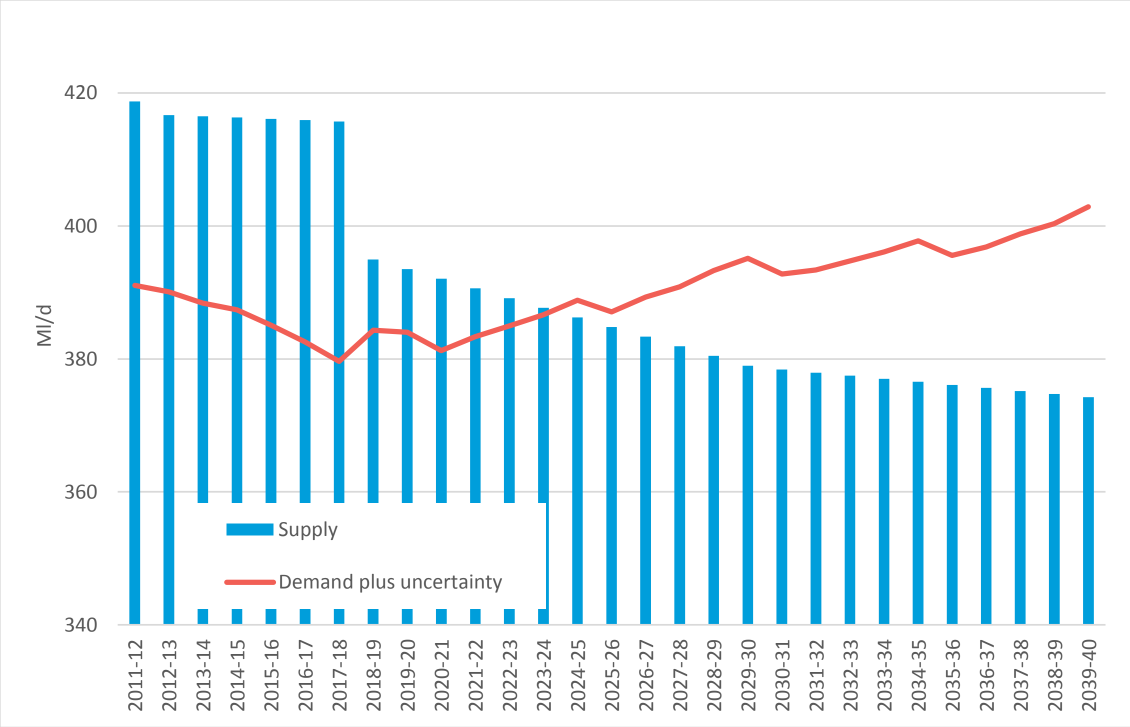


Figure 65 - Annual Review 2016 SEWCUS Annual Average supply demand balance

5.33. Overall Water Resources Position

As described above, we are forecasting that only two zones; Tywyn Aberdyfi and Pembrokeshire, will have a supply demand deficit across the 30 year planning period. This compares favourably with the positions reported in both the Final WRMP 2014 and the Annual Review 2016 where we were forecasting five deficit zones albeit with varying start dates and size of imbalance. Table 34 summarises the Dry Year Annual Average reported positions.

WRZ	WRMP14 deficit start date	Max deficit (Ml/d)	Annual Review 2016 deficit start date	Max deficit (Ml/d)	dWRMP19 deficit start date	Max deficit (Ml/d)
SEWCUS	2039/40	-0.5	2024/25	-28.6	N/A	N/A
Pembrokeshire	2018/19	-12.0	2021/22	-11.0	2020/21	--6.46
Brecon/Portis	2015/16	-0.2	2015/16	-0.2	N/A	N/A
Tywyn Aberdyfi	2015/16	-0.6	2020/21	-0.4	2020/21	-1.97
North Eryri Ynys Mon	2024/25	-4.0	2021/22	-6.3	N/A	N/A

Table 34 - Summary WRZ deficit position

6. Decision Making

6.1.Introduction

This chapter summarises the decision making process we follow to ensure our Plan delivers resilient and sustainable water supplies for our customers. We have generated supply demand balances for our 24 WRZs and identified that two zones, Tywyn Aberdyfi and Pembrokeshire, are forecast to have shortfalls in supply across the 30 year planning period. To resolve these imbalances we need to identify options which either reduce demand or increase supplies. Guidance requires us to justify best value solutions based on a combination of least cost, customer views and environmental impact.

Welsh Water's company vision is "To earn the trust of customers every day". Understanding our customers' needs and their priorities for how they would like to see us manage water resources, is vital to the development of this Plan. We also need to work closely with our key stakeholders, including Welsh Government, Ofwat, Natural Resources Wales, Environment Agency and the Consumer Council for Water to ensure we take fully on board their views on key policy areas and guidance.

Our options appraisals work and our customer and stakeholder engagement has taken place in parallel with the development of our supply demand balances. We do this to gain a holistic understanding of the supply position and then build this understanding into the development of solutions. Our preferred schemes to resolve the forecast supply demand deficit are therefore selected to provide complimentary benefits for other drivers, such as where we have either strong customer and stakeholder views to do so, or where there are clear links to other strategies.

6.2.Decision Making Process

To obtain a preferred set of solutions that resolves the supply demand imbalances in the Tywyn Aberdyfi and Pembrokeshire zones, we are following a robust process that is compliant with regulatory guidance and best practice, is thorough in its appraisal of possible options, and takes full account of external and internal engagement. The key principles of our decision making process are:

- Conduct detailed customer and stakeholder engagement to understand their views and preferences for our options
- Undertake a detailed options appraisal process, including SEA/HRA and WFD assessment, to generate a set of costed, feasible supply side and demand side options
- Utilise the UKWIR Industry Standard "Economics of Balancing Supply and Demand" (EBSD) methodology to generate the 'least cost' plan
- Review against Welsh Government objectives as set out in the Environment (Wales) Act, Water Strategy for Wales and Future Generations Act
- Ensure our options are aligned with Welsh Water's PR19 priorities, our 2050 vision and our Biodiversity Plan

Our approach to decision making is outlined in Figure 66.

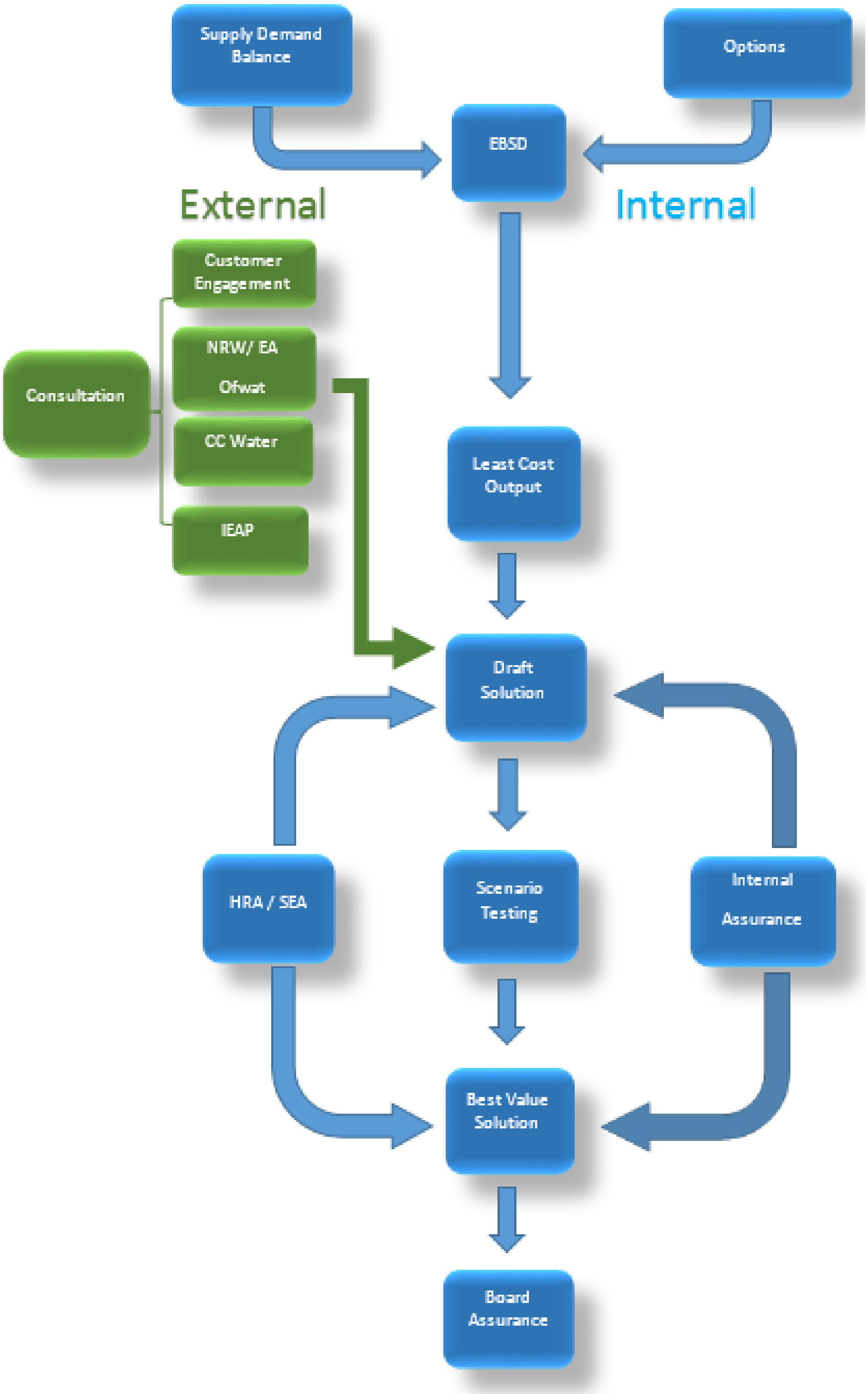


Figure 66 - Decision making approach

6.3. Supply Side Options

The starting point for the development of our feasible supply side options was to undertake a detailed review of those presented at WRMP14. With tighter water quality standards, a continued drive to reduce the 'cost to serve' our customers and the greater focus on resilience; options which were previously assumed to be feasible may no longer be.

Together with our consultants we produced new lists of supply side options (Appendix 32 – Technical note 1 – Unconstrained List of Resource Options (AmecFW)) during technical workshops to ensure that all potential technically feasible options were identified, and that any previous options containing unfeasible elements were either redefined, or removed from the process. This initial list of options was shared with NRW to provide opportunity to further challenge and refine. No significant changes to the initial list were required. A total of 38 supply side options were identified for the two forecast deficit zones (12 for Tywyn Aberdyfi and 26 for Pembrokeshire), see Appendix 24 and 25 which describes the process used to develop the options to a level of detail that is sufficient for costing. During this engineering phase further discussions with our Operational staff helped refine the options. Within this iterative process all options were subject to the same screening assessments.

6.3.1. Screening

Options have been screened using the Multi-Criteria Assessment (MCA), which is an approach that enhances the links between option appraisal and environmental assessment while remaining consistent with the evaluation of options undertaken during previous Plans. The MCA process was updated for this Plan to account for any new legislation, regulatory standards and guidance, and expanded to include the wider environmental considerations identified by HRA, WFD, and SEA assessments.

The MCA is consistent with best practice guidance and regulatory expectations and ensures objectivity and consistency to prevent bias towards any particular option or option type. Figure 67 summarises the two-stage coarse and fine screening process.

Utilising this approach has several benefits:

- It embeds environmental and resilience considerations into the option assessment process from the very outset;
- It identifies potential over-riding constraints that would result in an option being discounted early in the process, thereby helping to focus efforts on options that are promotable; and
- It enables early consideration of operational and engineering needs to address any identified adverse effects.

The same criteria were applied at the coarse and fine stages, with an increased level of scrutiny at fine screening.

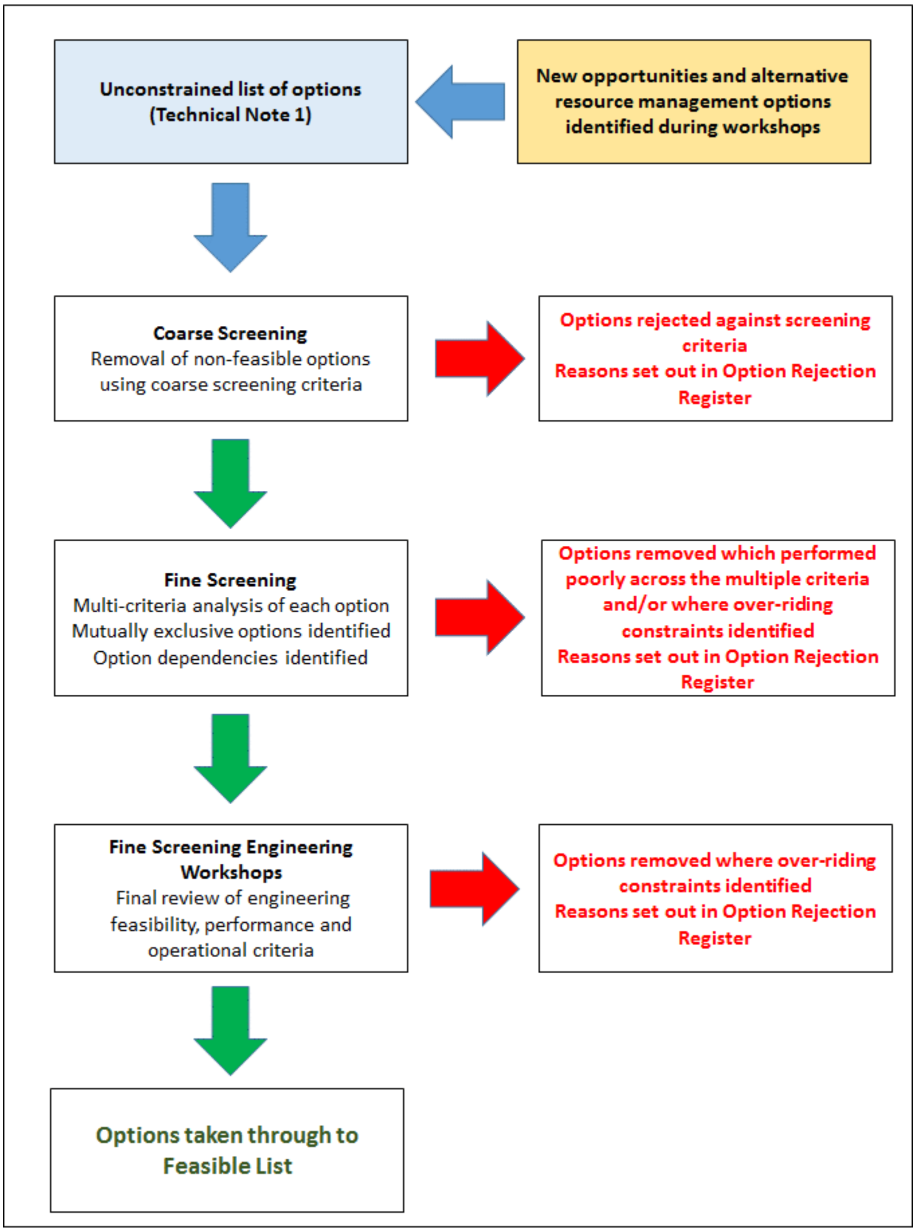


Figure 67 - Option screening process for WRMP19

6.3.2. Coarse Screening

All options were subject to a desk-based coarse screening assessment by operational, asset management, engineering, and environmental experts. Table 35 outlines the coarse screening undertaken on the unconstrained list of options, with the key considerations including any over-riding constraints to option promotion, development and implementation (e.g. legislation or policy, unacceptable risk or environmental impact). The coarse screening process also helped to rationalise options that were very similar.

Where options were assessed as having an over-riding constraint (i.e. against any single criteria) or which performed poorly against the majority of criteria, they were rejected at the coarse screening stage.

Of the 38 resource options that were put through the coarse screening process, 11 were rejected. Appendix 25 – Option Screening Methodology contains the 'Option Rejection Register' which details the rationale for each decision. The remaining 27 were taken forward for further scrutiny at the Fine Screening stage.

Assessment Category	Coarse Screening Key Considerations	Rationale for Rejecting Options at this Stage
Feasibility & Risk	Political acceptability and customer acceptability	The option directly contravenes either a stated policy or known customer preferences.
Engineering / Implementation	Engineering complexity and technological risks	The engineering or non-engineering implementation are either impossible or there are known insurmountable barrier.
Performance	Likely scale of supply benefit relative to the supply deficiency.	There is confidence that the resultant yield will be negligible and / or that an alternative option would serve this need better and more effectively.
Operational	Compliance risks	The option would cause a non-compliance issue (or increase the risk of non-compliance).
Environmental	Statutory risks to international and national designated sites	The option would have a major and unacceptable impact on a designated site, either during construction or longer-term operation.
	HRA and WFD compliance risks	The option would have a major and unacceptable impact on a HRA site or WFD waterbody, either during construction or longer-term operation.
	Planning risks including landscape, recreation and heritage	The option would have a major and unacceptable impact on landscape, recreation, and heritage at a strategic level/number. E.g. major disruption / change to landscape, eyesore, removal of recreation access/facility etc.
	Socio-economic risks (including consideration of the Well Being of Future Generations (Wales) Act)	The option would result in loss of jobs, would directly prevent job creation (that is otherwise expected), or otherwise have a major negative impact on society.

Table 35 - Coarse screening criteria

6.3.3. Fine Screening

The options taken through to the fine screening stage were subject to a more expansive and detailed two-step multi-criteria fine screening assessment, utilising the same assessment categories as those at the coarse screening stage. In deciding which options should be taken through to the Feasible List from the fine screening assessment outcome, the following factors were taken into consideration:

- The likely scale of the supply-demand deficit in the water resource zone over the planning period;
- The level of uncertainty and risk associated with the available options;
- The range of different option types to ensure an appropriate mix of alternative options;
- Those options identified as mutually exclusive or having a dependency on other options.

Fine screening was an involved process, commencing with initial assessments of risk (negligible, low, moderate, high), followed by facilitated technical workshops with relevant experts from across the company. These discussions further refined the assessment of the options and informed final decisions on those options to be rejected and those to be taken forward to the Feasible (or 'Constrained') List.

Appendix 25 – Option Screening Methodology summarises the main issues identified during fine screening and the rationale for inclusion and rejection at this stage.

6.3.4. Estimating the Option Yield

For each feasible supply side option we use our WRAPSim modelling software to calculate how much water the option will provide to the WRZ. The benefit each scheme provides is assessed as the gain in Deployable Output over and above our current baseline DO. We also assess the impacts of climate change upon each feasible option to confirm its vulnerability under more extreme events. This calculation of the options' yield is a critical element in the least cost scheme appraisal.

The assessment of supply-side option DO and climate change analysis is presented in Appendix 6 – Baseline Deployable Output assessment (AmecFW) and Appendix 10 – Impact of Climate Change on DO (AmecFW).

6.3.5. Estimating the CAPEX and OPEX

Utilising our company standard Unit Cost Database (UCD), the Whole Life Costs of the options have been calculated to enable cost benefit analysis and scheme optimisation. Whole Life Costs include construction and commissioning costs (CAPEX), periodic replacement of equipment costs (Recurring CAPEX) and the cost of subsequent ongoing operating & maintenance to allow the continued efficient operation of the scheme (OPEX). Carbon costs have also been calculated, corresponding to each of these cost components. All indirect costs have also been included such as insurance, management fees, design, investigation, overheads, project management and land compensation.

The scope of each option was detailed in standard templates which were then costed using the UCD's Project Estimating Forms (PEFs). The PEF utilises the UCD's CAPEX cost models that have been produced by the Engineering Estimating System from actual scheme cost information. The cost models are derived from a live Data Capture System that is embedded into our systems and updated on a six-monthly cycle. The PEF is embedded throughout Welsh Water as part of our 'Business As Usual' process and procedures for all costing activities and will inform the Business Plan for 2020-2025.

Where cost models are not available in the PEF, for unusual activities such as desalination and dam construction, standard industry models were used as an alternative. However, the percentage of external models is monitored to ensure that it remains low as a percentage of total costed works.

Quantities of chemical and power usage were estimated by Process Engineers. The unit cost of chemicals was obtained from our framework rates and an average power cost has been used to obtain the annual power costs.

The additional OPEX costs of labour, maintenance, 'Bought in Services' and 'other' (such as administration costs) were calculated by using a cost model based on chemical and power consumption. The cost model was derived from actual costs from our financial system 'SAP'.

6.3.6. Estimating carbon costs of feasible supply options

Separate carbon equivalent amounts have been calculated as follows:

Fixed CAPEX carbon quantities have been calculated for the initial implementation of the scheme option. These values have been taken from the Carbon Report worksheet that is part of our Solution Target Pricing Tool (STPT). This is based on the 'Cradle to Built Asset' embodied carbon boundary, so takes into account extraction and processing of raw materials, manufacture, transport to site, construction and disposal of waste. It does not take into account asset operation, maintenance, renewal and end of life disposal. The data used are taken from the Inventory of Carbon an7d Energy (also known as the ICE database) developed by Bath University.

Recurring CAPEX carbon quantities have been calculated for the recurring CAPEX expenditure for replacement of time expired equipment during the working life of the scheme option. These have been calculated on a pro rata basis from the fixed CAPEX.

Operational carbon quantities have been calculated based on the anticipated power usage of the scheme. These have been calculated by taking the anticipated power usage and applying a carbon conversion factor of 0.5 kg per kWh. The conversion factor is consistent with that used for our in house assessment of operational greenhouse gas emissions, which are reported as CO2 equivalents based on power imports from the national grid. Further details are available in Appendix 33 – Social and Environmental Evaluation Report for Option Appraisal (AmecFW).

6.4.Demand Side Schemes

Demand side options are ways in which we can reduce demand for water to improve the supply demand balance. As described in Chapter 4, the WRZ short-run Sustainable Economic Level of Leakage (SELL) profiles developed for this Plan have been incorporated into the baseline demand forecasts. For zones identified as being in deficit in the baseline supply-demand balance we identify a range of demand management options such as customer smart metering, water efficiency and leakage reduction options such as pressure management or asset renewal.

If leakage schemes are selected to resolve the forecast imbalances then the lower level of leakage resulting from implementation of the scheme is regarded as the long run SELL. Scheme options were provided as both discrete leakage increments derived from the cost relationships, and costs and expected savings for individual DMAs ranked by the Average Incremental Cost (AIC) from low to high.

The following sections provide an overview of the demand management schemes that we have appraised for this Plan.

6.4.1. Enhanced Active Leakage Control (ALC)

Enhanced ALC refers to additional leakage reduction beyond the level required in the WRZ to achieve the short-run SELL baseline leakage forecast. This option would increase the amount of proactive leakage detection and repair (“Find and Fix”) within the deficit zones and reduce the SELL. Schemes are defined at the District Meter Area (DMA) scale with costs based the relationships that were developed in the calculation of the SELL.

The approach used for the derivation of the ALC cost curves builds directly on the methodology used for PR09 and PR14, and continues to be based on the Method B approach to cost function assessment as originally set out in the ’Tripartite Report’ (2002) and, in the most recent ‘Managing Leakage’ (UKWIR, 2010) report.

Method B marginal cost relationships are empirically derived from actual DMA-level observations of the annual unit cost of moving from a starting level of distribution leakage (L0) to a lower level of distribution leakage (L1) where this cost also includes the cost of overcoming the annual NRR. DMA-level unit costs are plotted against average excess leakage levels (i.e., Annual Average distribution leakage less DMA-level background leakage). The fitted marginal cost relationship which results is then integrated to produce a total cost relationship which can be used to derive the composite transition and maintenance ALC costs for specified L0 and L1 values.

Annual Average leakage savings for each DMA were calculated as the difference between the sum of DMA weekly leakage multiplied by 7 (days in a week) and the average leakage level for April (for the relevant year) multiplied by the number of savings days (days with leakage different to zero, the saving can be positive or negative). The resulting leakage difference is added to the Annual Average leakage growth rate, i.e. NRR.

To reduce inter-group variability and associated statistical noise, DMAs were initially grouped not by zone but rather by operational areas and by strata (or ‘cohorts’) within each area. A number of alternative stratification methods were examined, the most appropriate of which was considered to be predominant pipe material type. Initially, three cohorts were defined for (i) Iron (ii) Plastic and (iii) 'other'.

Cost coefficients for material cohorts within each operating area were translated to zone coefficients using percentage contributions of the relevant pipe material in each zone. The resulting marginal cost relationships for each zone were then integrated to derive total cost relationships. The resulting total cost function coefficients can be used to estimate the annual cost of moving from one level of leakage to another.

8206						
6.54	Background Leakage	2.81				
Average Target Leakage (Ml/d)	Costs to Reduce Leakage & Combat NRR in 1 Year			Maintenance Cost of NRR in following Years		
	Detection Cost (£)	Detected Repair Cost (£)	Total Active Leakage Control Cost (£)	Detection Maintenance Cost (£)	Detected Repair Maintenance Cost (£)	Total NRR Maintenance Cost (£)
6.54	425,369	623,229	1,048,598	425,369	623,229	1,048,598
6.44	439,864	644,466	1,084,331	428,177	627,342	1,055,518
6.35	454,492	665,897	1,120,389	431,058	631,564	1,062,623
6.26	469,256	687,529	1,156,785	434,019	635,902	1,069,920

Figure 68 - Sample of Pembrokeshire Enhanced ALC schemes

6.4.2. Pressure Management

Analysis of pressure management schemes was undertaken at a Pressure Management Area (PMA) and WRZ level. The key fields of height (AOD (m)) at the average zonal pressure (AZP) and critical point pressure (CPP) were combined with the average zonal night pressure (AZNP) to derive inferred static and total head at the average and critical point locations. The average, maximum and minimum property pressures were then calculated by subtracting the ground level from the DMA average total head at night.

The threshold for assessing the scope for additional pressure management was set to ensure that pressures at the highest point in the DMA are greater than 25 metres (20 metres level of service + 5 metres head-loss allowance). The approach isolated those PMAs/DMAs that had an estimated possible scope for reduction applied to the CPP and corresponding revised AZNP.

A reduction in pressure will reduce the flow rate from all background leaks and bursts. The start levels of leakage for the PMAs were estimated using average 2015/16 DMA nightline data from LMARS. DMA leakage levels were then converted to PMA values based on PMA property counts. PMA leakage levels were then used to derive leakage savings based on the potential pressure reduction at the AZP.

A key element of the leakage savings calculation is the natural rate of rise (NRR). DMA NRR values derived as part of the SELL calculations were adjusted for the change in pressure resulting from the scheme implementation. The leakage and NRR savings combined give a total saving (Ml/d) per PMA for the reduction in pressure. This figure was then used to derive AICs for each proposed PMA scheme.

Existing cost data was used to reflect the cost of a new PMA installation or an optimised option in existing sites. The costs were used in the cost-benefit analysis and then converted to whole life costs including annual maintenance costs over the 80-year optimisation period. Net Present Value (NPV) costs were calculated using a discount rate of 3.6%. The resulting NPV costs for new and existing pressure management schemes are £36,267 and £23,928 respectively.

For each WRZ, scheme costs were assessed against the associated leakage and NRR benefits and schemes were ranked according to their cost effectiveness (AIC data – low to high). The data points for production of the WRZ-level cost relationships were established from the scheme rankings outputs.

The cost curve relationship was built up from an analysis of DMAs ranked in order of increasing AIC cost. A best fit trend line (exponential or polynomial) was then fitted to the cumulative DMA cost and savings values. Cumulative savings were expressed as % of WRZ leakage. Scheme options were provided as both discrete leakage increments derived from the cost relationships, and costs and expected savings for individual PMAs ranked by AIC from low to high. This gave alternative inputs for EBSD assessment and an additional level of granularity and transparency to potential additional savings.

Rank	Row	Scheme ID	DMA Name	WRZ	New PRV	Leakage Saving (exc NRR)	Total Saving	Property Metres	Cost per Property Metre	Scheme Cost	NPV Scheme Cost	PV Total Saving	Value of savings	AIC	Payback Period
						Ml/d	Ml/d	pm	£ per pm	£	£	Ml	£	(p/m3)	Years
1	1822	4062	Brandy Hill to Crosshands PRV	8206	No	0.007	0.178	4,178	0.88	£3,696	£23,928	1,693.63	£180,450	- 9.24	0.5
2	3378	13875	Newport - Mount View PRV (A)	8206	No	0.013	0.078	5,821	0.63	£3,696	£23,928	747.69	£79,663	- 7.45	1.2
3	3300	13509	Pendine Bottom of Hill PRV (A)	8206	No	0.015	0.055	2,639	1.40	£3,696	£23,928	522.87	£55,710	- 6.08	1.7

Figure 69 - Sample of Pembrokeshire Pressure Management schemes

6.4.3. Asset renewal (distribution infrastructure)

We have defined six policies for the renewal of our distribution assets, at the DMA level within our WRZs, with the aim of further reducing leakage levels.

- Policy 1 : Distribution mains only;
- Policy 2: All (distribution mains, communication pipes and customer service pipes);
- Policy 3 : Distribution mains and communication pipes;
- Policy 4: Communication and service pipes;
- Policy 5: Service pipes only;
- Policy 6: Communication pipes only.

For the purposes of this Plan, the AIC (£/Ml saved) of asset renewal has been defined as:

$$= \frac{Capex\ of\ AR\ (including\ external\ costs) - PC\ cost\ in\ savings\ in\ leak\ detection\ and\ repairs}{PV\ of\ volume\ savings\ in\ (current\ leakage + 0.5\ \times NRR)\ \times Effectiveness}$$

Where: PV is the Present Value of the future stream of costs or savings discounted at 3.6% over the 80-year optimisation period;

And NRR is the total Natural Rate of Rise in leakage

Effectiveness = proportion by which the leakage and NRR associated with a given asset type is assumed to be reduced following renewal.

The renewal policies are assumed to relate only to designated 'target assets' where the target assets were defined by material type. The cost of asset renewal was based on assessments of the overlying terrain and diameter of the asset being replaced. The present value of leakage and associated cost savings over the 80-year optimisation period were based on current detection and repair costs and water saved through leakage and NRR.

These were dependent on the assumed 'effectiveness' of asset renewal in reducing leakage. Effectiveness rates for service pipes, communication pipes and distribution mains renewal were assessed as being, respectively, 90%, 90%, and 70%, consistent with previous studies. WRZ-level AICs were calculated for each of the 6 policy options and these were used to prioritise the order of DMA selection, with those DMAs where asset renewal provides the greatest PV leakage saving per PV cost being selected first.

Cumulative renewal costs and cumulative leakage savings were plotted and a polynomial relationship fitted to produce WRZ-level cost-leakage savings relationship for each of the 6 policies. The same three functional cost relationships identified as being the most cost effective in PR14 were taken forward for application in PR19, these being:

- Policy 2: All (distribution mains, communication pipes and customer service pipes);
- Policy 3: Distribution mains and communication pipes;
- Policy 4: Communication and service pipes;

Scheme options were provided as both discrete leakage increments derived from the cost relationships, and costs and expected savings for individual DMAs ranked by AIC from low to high.

Rank	Row	DMA	DMA Name	WRZ	Leakage Saving (exc NRR)	Length of Main renewed	Scheme Cost	Cost Savings over 80 years	NPV Schmem Cost	AIC
					Ml/d	km	£	£	Ml	(p/m3)
1	1124	204P0405	TEMPLETON VILLAGE & BEGELLY THOMAS	8206	0.05	0.10	368,952.40	2,428,460.74	- 2,059,508.35	- 108.22
2	1129	204P0411	PENTELPOIR VILLAGE & RIDGEWAY	8206	0.07	0.33	780,623.11	2,265,859.73	- 1,485,236.63	- 66.95
3	1126	204P0408	BRANDY HILL TO WHITLAND	8206	0.27	3.15	2,172,705.62	5,314,981.22	- 3,142,275.60	- 37.32

Figure 70 - Sample of Pembrokeshire Asset Renewal schemes

6.4.4. Enhanced ALC (based on the current policy minimum team work)

Since 2015 we have employed a team to undertake 'policy minimum' type leakage detection. This has involved systematic concentrated leakage detection in DMAs with historically high leakage which has proved difficult to pinpoint and reduce. It has also at times included aspects of additional civil work to allow for further isolation of parts of the network.

Details of leakage detection activity for the sub-set of 'policy minimum' DMAs were extracted from our LMARS system and a standard cost rate applied to determine leakage detection costs. The cost of a Team Leader was pro-rated across all policy minimum DMAs. Leaks resulting from the policy minimum work were isolated within the full leak dataset. The costs of these resulting leak repairs were determined using standard unit repair costs. A contingency was added to this repair cost to account for any additional civils work or the installation of additional logging equipment that may be required to resolve long term 'leakage issues'.

Using these DMA costs and savings, relationships were developed for two cohorts, Iron and Other, which could be used to predict the costs and leakage savings in other DMAs for future policy minimum work. DMAs were ranked within WRZs by low to high AIC in order to provide policy minimum scheme options that could be used to drive leakage below the short run SELL. Leakage Management and Leakage Related Externalities were assumed to be consistent with those determined for standard ALC, and those relationships were used to determine the relevant costs.

An extract from the full list of Enhanced ALC schemes for our Pembrokeshire WRZ is given in Figure 71 below.

Rank	Row	DMA Ref	DMA Name	WRZ	Predicted Total Saving	Scheme Cost	NPV Scheme Cost	PV Total Saving	Value of savings	AIC
					Ml/d	£	£	Ml	£	(p/m3)
1	1146	205P0205	GOODWICK	8206	0.126	£34,696	£34,696	1,208	£128,740	- 7.78
2	1141	204PG152	Bolton Hill downstream Gap	8206	0.003	£1,321	£1,321	31	£3,255	- 6.33
3	1128	204P0410	NEYLAND SR OUTLETS	8206	0.056	£23,863	£23,863	535	£56,991	- 6.19

Figure 71 - Sample of Pembrokeshire Enhanced ALC schemes

6.4.5. Enhanced ALC (based on the installation of permanent correlating noise loggers)

A cost benefit relationship was developed for the installation of permanent correlating noise loggers termed ‘leakage automation’ schemes. From across our supply area, 100 DMAs were identified as being suitable for deployment of permanent correlating noise loggers.

Sample costs together with observed leakage savings from a recent trial of this technique that we undertook, were used to estimate the potential leakage savings and costs of any possible future schemes. It was assumed that the installation of the correlating noise loggers would cut leak detection costs by half. These costs were estimated using the standard ALC detection cost coefficients. The repair costs were assumed to be those to transition to the lower level of leakage, and these were estimated using the ALC repair cost coefficients.

The total installation cost of the schemes includes

- Logger Costs
- Detection costs (half standard ALC)
- Repair Costs (transition only)

Cost savings going forward were assumed to be gained from a reduction in the time taken to detect leaks in order to overcome NRR and maintain leakage at the same reduced level. It was again assumed that detection times would be half that of standard ALC due to the availability of information from the correlating noise loggers.

The sample costs and estimated leakage savings were applied to the 100 DMAs identified as suitable for deployment of the noise logging technology. DMAs were ranked within each WRZ by low to high AIC in order to provide ‘leakage automation’ scheme options that could be used to drive leakage below the short-run SELL.

Leakage Management and Leakage Related Externalities were assumed to be consistent with those determined for standard ALC, and those relationships were used to determine the relevant costs. However, it should be noted that the Leakage Managements carbon costs do not include the embedded carbon within the logger as the value was unavailable at the time of this study.

Scheme options were provided for only WRZ which contained DMAs that had been identified as being suitable for deployment of the correlating noise loggers. Of our two deficit zones, only Pembrokeshire contained suitable DMAs; these schemes are shown in Figure 72 below.

Rank	Row	DMA Ref	DMA Name	WRZ	Predicted Total Saving	Scheme Cost	NPV Scheme Cost	PV Total Saving	Value of savings	AIC
					Ml/d	£	£	Ml	£	(p/m3)
1	100	204P0410	NEYLAND SR OUTLETS	8206	0.033	£1,359,600	£1,292,859	312	£33,194	404.33
2	98	204P0110	Marble Hall	8206	0.022	£1,263,922	£1,211,360	209	£22,262	569.10
3	99	204P0112	ADMIRALTY SITE	8206	0.003	£734,845	£704,144	26	£2,811	2,657.87

Figure 72 - Sample of Pembrokeshire leakage automation schemes

6.4.6. Customer smart metering

Based on our existing information, we developed a cost benefit relationship for the installation of 'smart' customer meters that would provide the basis for the generation of options to increase our 'smart' meter penetration in WRZs with a forecast deficit. It was assumed that smart meters would be installed at all customer properties replacing existing 'dumb' meters where they were already present. Sample costs used are given in Table 36 below.

Item	Comment	Cost (£)
Smart meter installation	Unmetered property	579
Smart meter installation	Metered property	104
Installation contingency		13
Communication strategy		3
Meter replacement	Every 16 years 104	104
AMR fixed network system Base station / Concentrator Antennas & cables	Per 250 properties	20,000
Base station replacement	Every 10 years	2,700
SIM	Per annum per base station	30
Hosting & Support	Per annum per base station	866

Table 36 - Sample Smart Metering costs

Our requirement was for one base station for every 250 properties. The number of base stations required was determined from the DMA property counts (however in reality it would be possible to design schemes such that DMAs are not treated as discrete areas). Dependent upon geography, and topography, suitable sections of DMAs may be grouped together to produce schemes that require the minimum amount of base stations. An estimate of leakage savings that could be achieved was determined by reducing leak awareness times to 5 days in our customer side leakage model. Table 37 below shows the savings. It was assumed that upon installation of the smart meters, a number of leaks would be located, some of which would be on the customer supply pipe and some on the communication pipe. The cost of repairing these leaks was included in the scheme installation cost.

Bill Category Description	CSPL reduction following smart metering (l/p/d)
Assessed Measured, Household, Billed (Not-Void)	36.15
Assessed Measured, Household, Unbilled (Void)	32.88
Assessed Measured, Non Household, Billed (Not-Void)	43.73
Assessed Measured, Non Household, Unbilled (Void)	39.67
Measured, Household, Billed (Not-Void), External Meter	17.57

Measured, Household, Billed (Not-Void), Internal Meter	35.91
Measured, Household, Unbilled (Void), External Meter	32.88
Measured, Household, Unbilled (Void), Internal Meter	32.88
Measured, Non Household, Billed (Not-Void), External Meter	22.13
Measured, Non Household, Billed (Not-Void), Internal Meter	43.72
Measured, Non Household, Unbilled (Void), External Meter	39.67
Measured, Non Household, Unbilled (Void), Internal Meter	39.67
Unmeasured, Household, Billed (Not-Void)	36.15
Unmeasured, Household, Unbilled (Void)	32.88
Unmeasured, Non Household, Billed (Not-Void)	43.73
Unmeasured, Non Household, Unbilled (Void)	39.67

Table 37 - Estimated leakage savings due to Smart Metering

A number of additional assumptions were taken from our customer side leakage model, this included the number of undiscovered (continually running) leaks, estimated to be 3.96 leaks per 1000 properties; an assumed average leak size of 0.234 m3/h; and an assessment as to the number of leak repairs that would be undertaken per 1000 properties following installation of a blanket smart metering. Table 38 shows the number of leak repairs.

Category	No. of leak repairs per 1000 properties
Voids	5.82
Externally metered	6
Unmeasured	7.96
Internally metered	7.27

Table 38 - Number of leak repairs per 1000 properties following Smart Metering

The calculated total leakage savings from each 'Smart' meter scheme therefore includes three elements: a saving to leakage on the customer supply pipe, a saving of distribution leakage that would be found at meter installation; and an element of savings to NRR that relates to customer supply pipes occurring in the years after installation. Leakage savings were assumed to apply to both household and non-household properties. Consideration was also given to demand savings achieved by the installation of the meters, using information from our household consumption model. It was assumed that savings to demand would apply to households only.

DMAs were ranked within each WRZ from low to high AIC in order to provide 'smart metering' scheme options that could be used to reduce leakage below the short-run SELL. Leakage Related Externalities were assumed to be consistent with those determined for standard ALC. Leakage Management Externalities were assumed to be consistent with those determined for the repair of reported leaks since detection would not be required. Based on our existing data, we assume the embedded carbon within a meter to be 0.02 tonnes CO_2. This cost was added to the leakage management carbon cost.

Rank	Row	DMA Ref	DMA Name	WRZ	Predicted Leakage Saving	Predicted Demand Saving	Predicted Total Saving	Capex Costs	Opex Costs	Detection Saving	NPV Scheme Cost	PV Total Saving	Value of savings	AIC
					Ml/d	Ml/d	Ml/d	£	£	£	£	Ml	£	(p/m3)
1	1132	204P0504	STEPHENS GREEN SR OUT	8206	0.064	0.028	0.092	£650,952	£427,427	-£1,112	£1,077,267	1713.13	£182,527	52
2	1148	205P0301	PRESELI AND NEWBRIDGI	8206	0.057	0.031	0.088	£577,932	£363,013	-£997	£939,949	1305.11	£139,054	61
3	1139	204P0511	TENBY 7"	8206	0.036	0.014	0.050	£347,918	£287,062	-£412	£634,569	856.61	£91,268	63

Figure 73 - Sample of Pembrokeshire 'Smart Meter' schemes

6.4.7. Trunk main leakage options (repair and renewal)

Assessed WRZ trunk main leakage volumes were allocated to particular sections of the network using knowledge gained on pipe age and material type. This information was then used to produce predicted leakage values for groups of trunk main pipe sections within a WRZ, given their age, material and length.

Estimated leakage volumes along each group of trunk main sections were converted into an equivalent number of leaks. This was achieved using appropriately calibrated data for leak numbers and associated size estimates derived from a known set of trunk main leaks, found as part of the ongoing trunk main leakage detection programme.

The relevant costs and benefits of replacement and repair options were estimated for each group of trunk main sections or 'trunk main scheme' assessed to have non-zero leakage. An additional cost was included to account for the probability that pipe sections within a DMA may cross known intersections (motorways, rivers etc.). This was determined using GIS information on the number and type of known crossings in a WRZ and the application of typical WRZ crossing costs in £/metre.

Trunk main detection costs were assumed to be £190/km using repair cost data from a cost-benefit analysis study for the SEWCUS WRZ undertaken by our consultants RPS in 2011. For the 2011 study the data comprised a range of repair-related costs together with associated outcome probabilities. These were used to assign repair-related costs under a range of different circumstances relating, for example, to trunk mains shut-off, discolouration and flushing, customer notification and potential tankering requirements. A RPI increase was applied to the costs used in PR14 for use in this updated model.

Carbon and social costs associated with trunk main repair and replacement were assumed to be the same as those calculated for repair and replacement of the distribution asset. The leakage benefits of trunk main renewal and repair relate to the resulting leakage savings over the 80-year optimisation period. The AICs of renewal and repair schemes for each trunk main section within a WRZ were separately plotted in ascending order, and the ranking was used to determine cumulative costs and savings. This information was used to produce trunk mains replacement and leak repair scheme options.

Rank	Row	Scheme Ref	Supply Zone	Length m	Age Band	Material cohort	Leakage Saving	NPV Scheme Cost	PV Total Saving	Value of savings	AIC
			Nr.	Metres	Yr	Ref.	Ml/day	£	Ml/year	£	(p/m3)
1	454	8206 ST 80-90	8206	10908.6	80-90	ST	0.06	£ 2,852,342	743	£ 79,211	373
2	453	8206 ST 60-70	8206	13231.3	60-70	ST	0.06	£ 3,448,574	701	£ 74,726	481
3	455	8206 ST MORE	8206	240.4	>100	ST	0.00	£ 113,851	20	£ 2,133	558

Figure 74 - Sample of Pembrokeshire trunk main renewal schemes

6.4.8. Water efficiency options

For this Plan a more calculated approach to assessing water efficiency options has been undertaken (Appendix 34 – Water Efficiency Schemes) aligning with the framework of current Water Efficiency offering, and screening out schemes which were not practical, realistic or deliverable. Schemes considered within the analysis are shown in Figure 75. The scheme list is a selection of water efficiency products and services, developed in our water efficiency programme since AMP4 to present. Products are a basket of goods which has taken consideration of customer focus group feedback, accreditation criteria (WRAS), consumption savings and unit price.

Ref	Water Efficiency Scheme Type
WE001	Hippo (Solicited)
WE002	Hippo (Unsolicited)
WE003	Ecobeta (Solicited)
WE004	Ecobeta (Unsolicited)
WE005	Push Tap installation (Solicited)
WE006	Push Tap installation (Unsolicited)
WE007	Save A Flush (Solicited)
WE008	Save A Flush (Unsolicited)
WE009	Tap Inserts (Solicited)
WE010	Tap Inserts (Unsolicited)
WE011	Aerated Showerhead (Solicited)
WE012	Aerated Showerhead (Unsolicited)
WE013	Shower Timers (Solicited)
WE014	Shower Timers (Unsolicited)
WE015	Hose Trigger Gun (Solicited)
WE016	Hose Trigger Gun (Unsolicited)
WE017	Garden Crystals (Solicited)
WE018	Garden Crystals (Unsolicited)
WE019	Non-Domestic Audits
WE020	Domestic Audit*

Figure 75 - Water Efficiency scheme products

Each scheme is presented as a series of sub-schemes produced at the DMA level within each WRZ. Therefore under a specific WRZ there maybe 100 individual (DMA specific) Water Efficiency schemes ranked by lowest to highest AIC. The outputs of each scheme are a series of incremental steps of savings ranked by AIC (p/m3) against which the cumulative NPV Scheme Costs (£), cumulative PV Savings (ML), and where applicable the Externality cost (£) (Carbon & Social), are expressed.

Water Efficiency schemes are a function of specific scheme costs and savings scaled up by the property counts and demand data available with the specific DMAs (Sub-Schemes) of a given WRZ. Scheme costs, savings and assumptions around take up and installation rates are based upon a range of data sources including:

- 'Future Water Efficiency Targets – A Consultation' (Ofwat, 2008). Product costs are from DCWW's framework contract with Aqualogic. (Contract Ref: 308/2012);
- 'Water Efficiency Evidence Base Statistical Analysis' (Artesia, July 2015, Report No.1096);
- 'Future Water Efficiency Targets – A Consultation' (Ofwat, 2008).

The scheme analysis has also considered the level of water efficiency product saturation within the existing property base drawing on the number of products previously sent to our customers under the current service offering and assumptions around the water efficiency of new builds and renovations.

Carbon costs have been produced for both domestic and non-domestic audits using costs of travel to and from sites, however no embedded carbon quantities for products could be obtained so these have been set to zero.

The result of the process is a suite of product and audit schemes specific to the DMAs within each zone. This gives options for demand schemes and an operational delivery model for the water efficiency programme.

Figure 76 below shows the resultant suite of water efficiency schemes for Tywyn Aberdyfi. Prior Water Efficiency activity has also been considered. In the case of Tywyn Aberdyfi, NHh audits were undertaken as a result of WRMP14, which means no further NHh audits can be selected.

WRZ	8021	WRZ Name	Tywyn / Aberdyfi								
Ref	Water Efficiency Scheme Type	Billed Hh Available For Products / Audits of Total	Billed nHh Available For Products / Audits of Total	NPV Scheme Cost	Yr 1 Savings	PV Savings	Value of savings	Carbon Costs	AIC	AIC	PV Savings
		No.	No.	£	Ml/d	ML	£	£	p/m3	Rank	Rank
WE001	Hippo (Solicited)	169		£6,988	0.005	10.177	£1,385	£0	£55.06	2	1
WE002	Hippo (Unsolicited)	169		£6,737	0.005	10.177	£1,385	£0	£52.60	1	1
WE003	Ecobeta (Solicited)	169		£12,472	0.004	7.803	£1,062	£0	£146.24	6	7
WE004	Ecobeta (Unsolicited)	169		£91,808	0.004	7.803	£1,062	£0	£1,163.03	15	7
WE005	Push Tap installation (Solicited)	169		£15,044	0.005	10.177	£1,385	£0	£134.21	5	1
WE006	Push Tap installation (Unsolicited)	169		£131,709	0.005	10.177	£1,385	£0	£1,280.54	16	1
WE007	Save A Flush (Solicited)	169		£7,032	0.002	4.071	£554	£0	£159.14	7	12
WE008	Save A Flush (Unsolicited)	169		£7,419	0.002	4.071	£554	£0	£168.64	8	12
WE009	Tap Inserts (Solicited)	169		£7,331	0.003	5.428	£739	£0	£121.46	4	10
WE010	Tap Inserts (Unsolicited)	169		£12,059	0.003	5.428	£739	£0	£208.57	9	10
WE011	Aerated Showerhead (Solicited)	169		£8,766	0.005	9.838	£1,339	£0	£75.50	3	5
WE012	Aerated Showerhead (Unsolicited)	169		£34,317	0.005	9.838	£1,339	£0	£335.21	11	5
WE013	Shower Timers (Solicited)	169		£7,019	0.001	1.696	£231	£0	£400.18	12	14
WE014	Shower Timers (Unsolicited)	169		£7,209	0.001	1.696	£231	£0	£411.42	13	14
WE015	Hose Trigger Gun (Solicited)	169		£7,870	0.000	0.678	£92	£0	£1,146.39	14	16
WE016	Hose Trigger Gun (Unsolicited)	169		£20,422	0.000	0.678	£92	£0	£2,996.36	17	16
WE017	Garden Crystals (Solicited)	169		£7,159	0.000	0.034	£5	£0	£21,089.15	18	18
WE018	Garden Crystals (Unsolicited)	169		£9,385	0.000	0.034	£5	£0	£27,651.83	19	18
WE019	Non-Domestic Audits		34	£21,188	0.000	0.000	£0	£991	£999,999,999.00	20	20
WE020	Domestic Audit*	169		£20,073	0.004	7.294	£992	£3,086	£261.60	10	9

Figure 76 - Example Water Efficiency option costs

6.5. Third party options and water trading

In our Water Trading Prospectus we make it clear that we are willing to trade with other water companies and with third parties – we already have more than 20 bulk water trades in place, the most significant of these by volume is the Elan Valley bulk supply, where we export more than 100,000 Ml per year to Severn Trent, for it to supply its customers in Birmingham.

We believe water trading can play a part in supporting the economy, as long as it is done in a sustainable way. We support the position set out by the Welsh Government that water trading must benefit Wales and the people of Wales, and not jeopardise our own business and the customers we serve.

As part of the 2014 Price Review, Ofwat introduced water trading incentives to encourage water trading between incumbent water companies. By allowing scarce resources to be optimised between company areas as well as within them, it can allow more expensive investment in developing new resources within a company's area to be deferred, reducing future upward pressures on bills. Companies can only receive these water trading incentives if they produce, and are compliant with, an approved trading and procurement code.

Welsh Water's Trading and Procurement Code was approved by Ofwat in February 2016. The code is intended to provide reassurance that any trades we conduct will be in accordance with the code and that in contracting for the provision of water resources we will purchase from the most economical sources available, having regard to the quality, quantity and other relevant aspects.

Our Plan shows that we are open and transparent when considering supplies of water to us from 3rd parties and support the use of competitive processes. For the 2019 Price Review we have published our Water Bid Assessment Framework as part of our overall Business Plan submission for AMP7. This Framework confirms that we are open to receipt and assessment of competitive bids for the provision of solutions for our deficit water resource zones as set out in this Plan. We intend to issue a regular call for competition in accordance with the Utility Contracts Regulations 2016 negotiated procedure on a frequency interval of no more than eighteen months from June 2019.

As part of the pre-consultation process, we published a view of the need and availability of water resources across our supply area on our website. A Prior Information Notice in the OJEU followed from the 17th May 2017 until the 18th August 2017 seeking either bulk raw or treated water supplies in the following zones at the indicative quantities stated below:

- Pembrokeshire (~1 - 10 Ml/d);
- Tywyn Aberdyfi (~ 0.1 - 0.5 Ml/d);
- North Eryri Ynys Mon (~1 - 10 Ml/d);
- SEWCUS (~2 - 30 Ml/d).

To date there have been no substantive responses to our publication on the website or the OJEU.

Whilst seeking economically efficient imports of water to deficit zones, the vast majority of our supply region has water surpluses making water exports more likely. Any potential export would need to comply with the following conditions:

- No water resource zones placed into deficit as a result of the export;
- No impact on our ability to supply water during periods of drought;
- No impact on our company's level of service;
- The environmental sustainability of supply (no deterioration of raw water source).

With the potential to benefit customers and the wider Welsh economy we have scrutinised the plans of neighbouring water companies and the potential for water exports. Discussions have taken place with United Utilities, Bristol Water, Severn Trent Water and Thames Water as well as the Canal and Rivers Trust. However, due to the location in West Wales of the deficit problem areas there are no suitable opportunities to pursue.

We discussed potential high level options for export to Severn Trent Water and Thames Water but we have not reached the stage of agreeing specific terms as this will need further detailed work. Once this work is complete and if there are options to be taken forward then we will discuss these with Welsh Government and Natural Resources Wales to confirm they align with their expectations and will present the details in future WRMPs/Annual Review reports.

We are also working with the Canal and Rivers Trust on a raw water export solution to support the Brecon & Monmouthshire canal during periods when their abstraction from the River Usk is restricted.

6.6. Selection of the Best Value Solutions

As detailed earlier in the Chapter, the way in which we assess the best value solutions in our deficit WRZs involves the initial application of a least cost water resource planning optimisation model. The approach is to firstly examine which programme of options is the most economical in terms of scheme costs against the benefit they provide. The benefit is defined as either the amount of additional water an option can provide, or the reduction in customer demand through water saved.

The model uses a mathematical optimisation to produce a least cost schedule of investments in these zones and is now an industry standard through guidance. We have applied the decisionLab model (Appendix 31 – EBSD Optimisation Method Statement (decisionLab)) which was developed in 2012/13 to implement the EBSD methodology while providing the required flexibility in usage. It has been used to support multiple water companies in WRMP14 as well as WRMP19, and is therefore at a good stage of maturity.

The model produces a least cost optimised programme of investments over the selected planning period to meet the defined planning challenge.

There are 3 types of decision variables within the formulation:

- **Which Options** should be selected;
- **In which year** should the Option be selected / activated;
- **What utilisation** should be made of the Option in each year of the Planning Period.

Figure 77 provides a high-level view of the model operation. The principal input data to the model is our supply demand balance information, all feasible supply and demand side options costs (CAPEX, OPEX, Carbon) and yields (expressed as Ml/d).

The assessment period is the number of years of costs that the model takes into account in the calculation of the NPV for a particular solution. This will be either equal to or longer than the planning period. A longer assessment period is recommended, and our model is set up to use an 80-year assessment period in line with the Water Resources Planning Guideline.

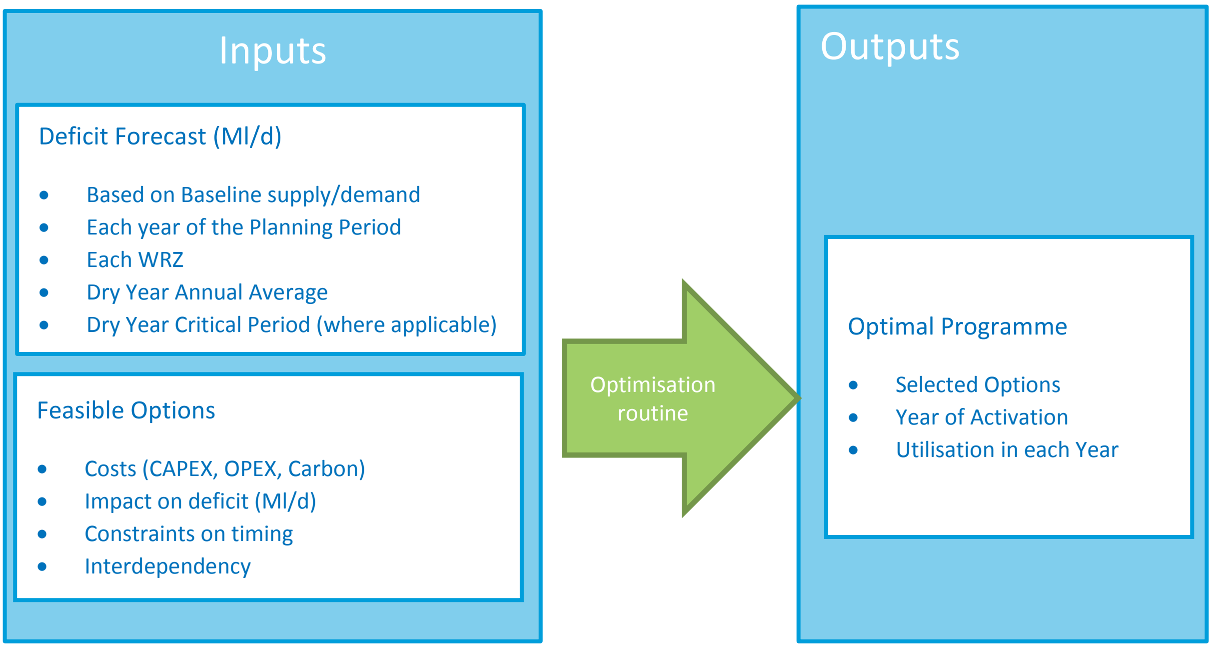


Figure 77 - Overview of the optimisation modelling approach

6.7.Customer Engagement

We are committed to understanding the needs and expectations of our customers as their views drive our day-to-day operations, and we act on rapid feedback on the service we provide from customer interactions right across our activities. It is essential that we maintain the involvement of customers when planning for the future, both in terms of our long-term vision, and prioritising our business planning for five-yearly regulatory reviews.

Our Customer Challenge Group (CCG) helps to direct Welsh Water in both engaging with customers and to challenge the robustness of our planning processes and our response to customer preferences. This group contains a number of stakeholders who work within the water sector, such as NRW and CCWater, and those who are independent such as Citizen Advice and Cardiff University.

All materials developed for the customer engagement projects (Qualitative and Quantitative preference surveys) were developed in conjunction with the CCG. The engagement materials were modified following comments received from the group and then peer reviewed independently by Ken Willis. The CCG raised a number of key points that we have incorporated within our Plan:

- The importance of catchment management approaches and nature based solutions.
- The need to effectively engage with land managers and reward contribution to improving water management.
- Engagement with planning authorities on future development plans.
- Critical role of demand management solutions.
- Strategic role of smart meters and cost effectiveness.
- The approach to dealing with customer side leaks and role of the company in supporting customers in reducing in house leakage through taps/cisterns etc.
- The importance of engaging with plumbers.
- Water as a key national natural asset in respect of any future water trading.
- Strategic importance of the plan as stewardship of a national asset.
- Therefore critical importance of the consultation on the plan both in engaging key stakeholders but also opportunity for the customer base.

Our PR19 customer involvement strategy uses a variety of engagement methods and aims to strike a balance between statistically robust customer research (commissioned from research agencies accredited by the Market Research Society) and giving all customers and stakeholders the ability to have their say (through mass consultation using innovative online methods such as a chatbot and online community).

6.7.1. “Have Your Say” consultation

Nearly 20,000 customers from a wide range of demographic groups and locations took part in the summer 2017 “Have Your Say” (HYS) Consultation. There was a strong response through a variety of channels, including nearly 3,000 customers completing the consultation through our world-first bilingual Welsh and English chatbot. Water resource issues were covered within the HYS consultation at a high level. The findings of the HYS surveys were as follows;

- ‘Cleaner rivers and beaches’, ‘working with nature for cleaner water’ and ‘better water quality for all’ are seen as most important – topping the list for all demographic groups
- ‘Making the water supply more reliable’ ranked 5th importance overall.

- The overall balance of opinion is slightly more towards increasing bills (39%) than decreasing them (27%), but opinions are split within this audience

6.7.2. WRMP Customer Preference Surveys

For this Plan we have completed qualitative and quantitative stated preference surveys including Computer Aided Telephone Interviews (CATI) and this has provided us with an understanding of customers' views on the various types of options available to us to maintain and improve our supply demand balance. The survey work also sought to understand our customers' preference on the level of resilience we should adopt to the implementation of extreme drought water use restrictions such as standpipes and rota cuts. The survey interviewed a number of Household (HH) and Non Household (NHH) customers with the methodology set out in Figure 78.

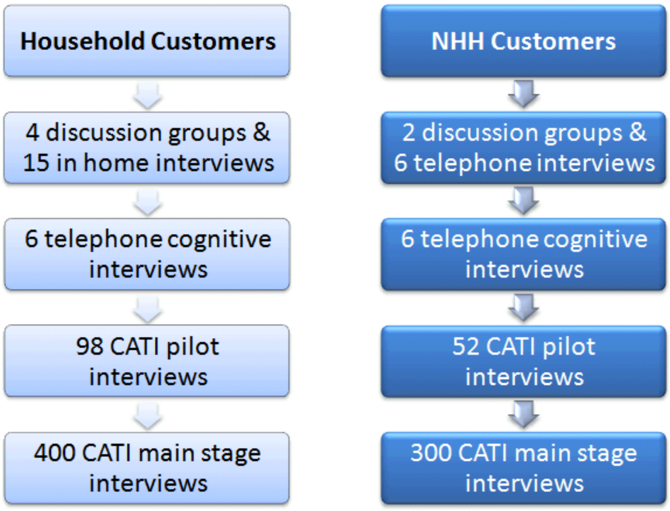


Figure 78 - Overview of the research programme

6.7.3. Willingness To Pay

Full details of the survey results are provided in Appendix 26 – Willingness to Pay Survey Results. Figure 79 presents the Willingness To Pay (WTP) results for measures to address supply demand shortfalls. In general, the WTP values are higher than expected based on PR14 results. However, this is driven by the fact that the value of an avoided temporary use ban was higher in the latest main WTP results (£228/HH) than was found at PR14 (£34). This means that every measure that is linked to it is likely to have a higher value.

The results show that our customers would much prefer to see a reduction in leakage as a priority with a lowering of leakage rate from 22% to 20% having the greatest value to respondents. However, there appears to be a limit to customer support for leakage reduction given the potential cost of achieving lower levels. There is significant conflict between these survey results and that from the wider PR19 survey results which have also sought a view on our customer's preference for leakage reduction.

These showed a strong preference for our existing position based upon the sustainable economic level of leakage. However, the leakage attribute was described differently in each case and the context of the surveys was markedly different with the results shown below concluded from a comparison of water resource schemes rather than a preference of leakage reduction in comparison with wider company initiatives.

The use of existing assets is seen as preferential to the development of new water resources. The full breakdown of willingness to pay is shown in Figure 79.

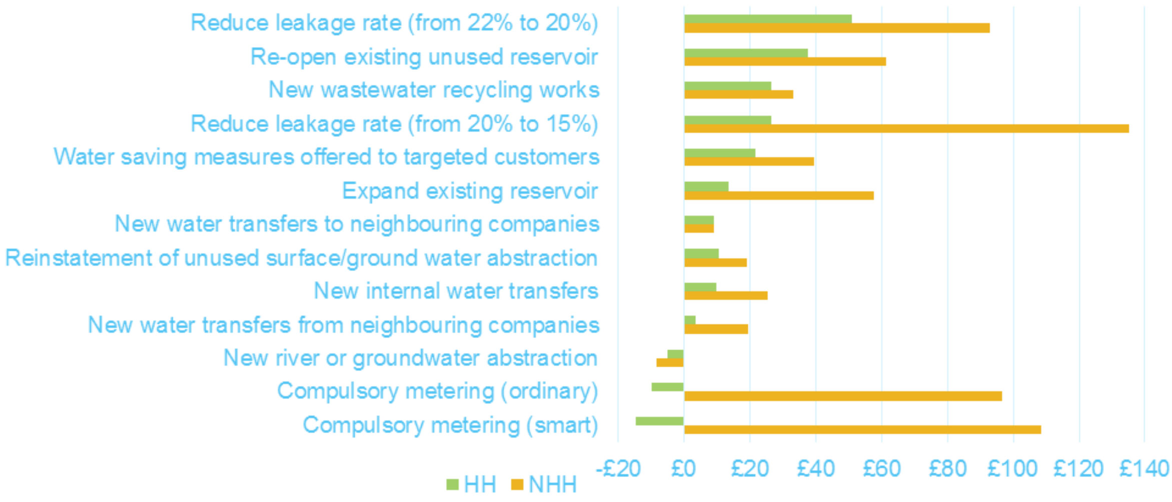


Figure 79 - Customer willingness to pay for supply and demand options

6.7.4. Resilience Valuation

Our analysis also indicated that our customers would like to see an improvement to our resilience to less frequently than 1:100 for the implementation of extreme drought measures - many customers attached a high value to the improvement in resilience from 1 in 100 to 1 in 200. However, the wider survey results gave a mixed view on the acceptability of higher bills and so these particular results must be viewed in this context.

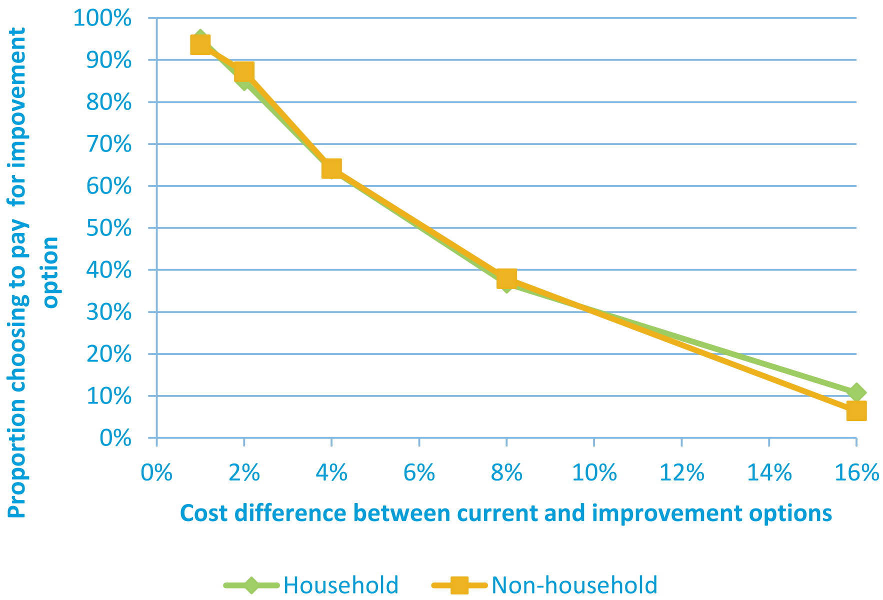


Figure 80 - Customer willingness to pay for improvements in resilience

6.7.5. Metering Options

Findings from this exercise indicated support amongst both households and non-households for the progressive metering policy option with household customers preferring the retention of optional metering, whereas non-households' next preferred option was compulsory metering. Again this view for non-households may be driven by the fact they are already metered. Households had a strong dislike for compulsory metering with negative WTP values.

6.8. Environmental Consultation

In our "Welsh Water 2050" vision document we have set out the long term context within which we will operate in the years ahead. This includes a number of planned actions which will directly support biodiversity and ecosystem resilience. In this way, our "Welsh Water 2050" vision aligns very well with the priorities of the Welsh Government as set out in the Environment (Wales) Act 2016

We know from our on-going customer engagement surveys that customers across our supply area expect us to enhance biodiversity and the environment in general, not least as this contributes to the well-being of the communities we serve. We are also mindful of the environmental legacy we will leave for future generations, as demonstrated in Welsh Water 2050. For our Plan it is therefore vitally important that any planned schemes do not negatively impact upon the environment in which we operate. Early and full consultation together with detailed assessment is key to ensuring this objective is met.

6.8.1. Environmental Assessment

WRPG requires us to assess whether our Plan options are subject to Strategic Environmental Assessment (SEA) and Habitats Regulations Assessment (HRA). Welsh Government's "Strategic Environmental Assessment in Wales" states that the Regulations require a responsible authority to:

- Determine, where necessary in consultation with the Consultation Bodies (Natural Resources Wales, and Cadw) whether any plan or programme is subject to the Regulations and whether an environmental assessment is required;
- Ensure (if required) that an environmental assessment is conducted and that an Environmental Report is produced, covering the proposals in the plan or programme and realistic alternatives;
- Consult the 'Consultation Bodies' Natural Resources Wales and Cadw on the scope of the Environmental Report;
- Consult those bodies and the public on the plan or programme and the Environmental Report;
- Take account of the Environmental Report and the responses to the consultation before adopting the plan or programme;
- Publish information about the adoption of the plan or programme, including how the Environmental Report and responses to the consultation have been taken into account;
- Monitor the environmental effects of implementing the plan or programme.

SEA has been integrated into this Plan from the outset. We have used the SEA from our WRMP14 as the starting point given that both Tywyn Aberdyfi and Pembrokeshire were forecast deficit zones in that Plan. Our 'SEA Scoping Report' and 'HRA Approach' documents were published for a consultation period of six weeks ending 21 April 2017. We received responses from Welsh Government, Natural Resources Wales and Cadw that have been used to amend the baseline information and assessment framework. NRW also attended a meeting on the 5th April 2017 to discuss in detail our approach to the SEA. As part of the overall Plan consultation we have received responses on our HRA and SEA and so have updated these accordingly.

Full details of our SEA and HRA are provided in Appendix 27 - SEA and Appendix 28 - HRA. We also completed a Water Framework Directive (WFD) assessment (Appendix 29 – Water Framework Directive Assessments of feasible options (AmecFW) to demonstrate that the WRMP is compliant with the objectives of the WFD. The WFD assessments undertaken for this Plan were based on the best available information at the time and as we take our preferred options forward to delivery, we will update these to ensure they take account of the latest water body status information from NRW and the EA. It is worth noting that when we obtain the latest waterbody status data, it will not affect the outcomes of our exiting assessments as these have indicated there will be no impact to WFD status from the construction and operation of our proposed schemes.

6.8.2. External Environmental Review

To provide further environmental scrutiny of our Plan, we have consulted with our Independent Environment Advisory Panel (IEAP) to seek their views on the development of this Plan and its outputs. The IEAP has been established to support Welsh Water to (i) maximise the value of its investment programme for customers and the environment, and (ii) to secure a safe and sustainable future for our environment; one that is able to support the economy and quality of life for generations to come. Table 39 outlines the membership of the IEAP.

The IEAP has provided good challenge during presentations and is broadly supportive of our Plan. The following key points were made at the presentation of outputs on 23 October 2017:

- There was no support for Welsh Water to drive leakage below the economic level;
- There was limited support for Welsh Water to invest to provide a level of service of 1:200 for implementation of extreme drought management measures. It was felt this should be uniform for all Companies – and be there to facilitate trading only;
- There was support for Welsh Water to consider options to trade surplus water trading if it builds on what we are doing for customers and brings benefit to Wales.

IEAP essentially questioned the value of driving leakage below the SELL and improving our resilience further above options such as moving to nature based solutions.

Following consultation on the draft Plan, one of the key themes that emerged was our stakeholders and customers expected us to do more on demand management and to be ambitious in setting our leakage targets. As set out in Chapters 4 and 7 of this Plan, we are aiming to achieve a 15% reduction in leakage levels by 2025 and by 2050 to have leakage at no more than 10% of current DI. This will bring benefit to the environment by reducing the volume of water 'lost' and hence lowering the rates of abstraction needed from our raw water sources.

Organisation	IEAP status	Organisation	IEAP status
Cynnal Cymru	Member	**Keep Wales Tidy**	Member
The Coal Authority	Member	**Country Land & Business Association**	Member
Business in the Community	Observer	**National Farmers Union Cymru**	Member
Marine Conservation Society	Member	**Elan Valley Trust**	Member
The Canal & Rivers Trust	Member	**RSPB Cymru**	Member

Organisation	IEAP status	Organisation	IEAP status
Confor	Member	**National Parks Wales**	Member
Independent Advisor to QEC	Observer	**Afonydd Cymru**	Member
Aberystwyth University	Member	**Natural England**	Member
Centre of Ecology & Hydrology	Member	**WRAP Cymru**	Observer
Natural Resources Wales	Member	**Cardiff University**	Member and Chair
Coed Cymru	Member	**DWI**	Observer
		Welsh Local Government Association	Member
Wye & Usk Foundation	Member	**Wildlife Trust Wales**	Member
Consumer Council for Water Wales	Observer	**The National Trust**	Member
Farmer's Union of Wales	Member	**Welsh Government**	Observer

Table 39 - IEAP Membership

6.8.3. The principles of an ecosystem approach

We understand that we serve many differing groups of customers, with individual wants, needs and expectations of our services. From our extensive customer research and continued tracking of customer sentiment, we have developed six customer promises to reflect the service we should provide to all of our customers; the first two of which state:

- Safe, clean water for all;
- Safeguard our environment for future generations.

Above all, customers place a particular emphasis on the reliability of essential services – the provision of safe drinking water, and the protection of the environment. In line with WRMP guidance we have sought to integrate the ecosystem approach as far as possible within our options appraisal to ensure our preferred options fully consider any potential environmental effects.

The Ecosystem Services (ESS) Assessment undertaken as part of the Plan is a quantitative and qualitative assessment of:

- The ESS present within the zone of influence of each WRMP feasible supply option (baseline at 2017);
- How the ESS present may change within the timeframe of the assessment (by 2050) in the absence of the WRMP option – the future baseline;
- How the ESS may change after the implementation of the WRMP feasible supply option (in relation to the future baseline).

6.9.Derivation of the Best Value Solutions

The UKWIR WRMP19 Decision Making process seeks to provide water companies with a framework to produce robust and resilient plans that represents 'best value' investment. We need to demonstrate to our customers and regulators that our preferred solutions are appropriate to the scale of issue within the individual WRZs and represent the 'best value', rather than purely the least cost, solution.

To achieve this, the final stage in our decision making process enables this selection of the 'best value' solution by undertaking a broader evaluation of the benefits of the schemes over and above the least cost output from our optimisation model. We therefore balance these outputs against the requirements of the following:

- Customer surveys and other stakeholder feedback;
- Environmental impact;
- Our 2050 vision;
- Resilience to climate change;
- Resilience to 1 in 200 year drought;
- Specific sensitivities in the WRZ e.g. catchment water quality issues.

Detailed information on how each of these aspects is considered to inform the 'best value' solution for our Pembrokeshire and Tywyn Aberdyfi zones, is contained within Chapter 7 of this plan.

6.10. Testing the Plan

To ensure the Plan is robust over the 30 year planning horizon we have tested our supply demand balances and the preferred programme of schemes, against a range of various scenarios. This will demonstrate the Plan's resilience to a range of risks and ensure that we have chosen the best value solutions for our customers. Table 40 below sets out our proposals for scenario testing. We have removed the "Leakage convergence" and "15% reduction in leakage" scenarios that were presented in the draft Plan as these are now built into our baseline demand forecast for this Plan.

Scenario Reference	Narrative	Method
Resilience to Extreme Droughts	Assess impact of severe droughts on key zones using updated UKWIR decision making techniques	Extreme Value Analysis
2080s Climate Change Impact	Longer term look ahead at impact of 2080's climate change on SEWCUS zone	DO modelling using perturbed inflow time series
High household population growth	Assess short term impact of economic/revenue scenarios on supply demand balance	Alternative demand forecast produced

Development of the Wylfa Newydd power station	Assess impact on supply demand balance and solutions	Alternative demand forecast produced

Table 40 - Scenario testing

7. Our Plan

7.1. Introduction

Welsh Government's Water Strategy for Wales (2015) recognises the importance of water as a resource to Wales. Providing a reliable supply of water is essential to support and grow the Welsh economy and so in this Chapter, we present our overall Water Resources Plan that aims to ensure we achieve this out to 2050 but with greater emphasis on the period between 2020 and 2025.

We sought our customer's and stakeholders views on our draft WRMP19. The comments received were supportive of our approach and proposals to resolve the forecast supply demand deficits and improve resilience. They did however challenge us to be more ambitious in our demand management strategy and so as set out in Chapter 4 and this Chapter, we are proposing much greater reductions in leakage levels throughout the planning period to 2050 and have committed to a programme of schemes that will encourage our customers to take less water for their everyday use. Following delivery of these demand management activities, there remains two zones, namely Tywyn Aberdyfi and Pembrokeshire where the supply demand position is in deficit and needs to be addressed.

In addition, we have sought a view from our customers regarding the level of water resource service that they would prefer across our region. We are already meeting, or exceeding this in the majority of our WRZs for the frequency with which we would need to restrict demand through the use of hose pipe or non-essential use bans. However, our customer's preferences suggest that we should look to improve our level of resilience against severe drought in our identified deficit zones as well as the Vowchurch zone.

We have also sought our customers and stakeholders views on the types of solutions that they would like to see which resolve any supply shortfalls and more generally on their feelings around leakage and metering. We are very aware that stakeholders would prefer to see demand management solutions over supply side ones where these have similar costs. Our customers echo this view but with reservations on the impact that this might have on their bills and also in terms of where investment should be made to tackle other areas of customer service.

This Chapter describes the schemes we have developed to resolve the forecast deficits and improve the level of water resource resilience in the Vowchurch zone. It also describes how we have tested our solutions against a range of potential risks and uncertainties to provide confidence in our decision making process.

We have a wider duty to use the water that we abstract from the environment efficiently and we need to increase our demand management activity to meet our wider duty, to gain evidence to inform future plans and to meet our stakeholder and customer's expectations. This work will also be targeted on those zones where we have a marginal supply demand position to reduce risk and increase zonal resilience. This forms a twin track approach to meeting our resource challenges for the future across our supply area.

The resilience of our water supply systems is of particular concern to us and this is reflected from government policy through to our duties as water undertakers and in our stakeholders' views. We need to ensure that our water sources such as our reservoirs are maintained and improved to meet new safety legislation. We have therefore provided some detail around our work on Dam safety in this section.

In terms of water quality, we are advancing the way we engage with local communities and organisations to improve the quality of water in the catchments from which we take our water and we propose to continue to fund work in this area. We also need to invest in our water treatment works and network to improve the resilience of water supplies.

In this Chapter we show how our Water Resources Plan aligns with our Drought Plan and the Company's PR19 Business Plan. The Chapter concludes with a view on future water resource issues facing the water industry in the UK and our proposals for future innovation to meet these.

7.2. Our Leakage strategy

We know from our own research[17] that leakage is an emotive topic with views divided between those customers who recognise the significant financial aspects associated with finding and repairing our leaking pipes and those who feel strongly that leakage is unacceptable and we shouldn't be wasting any water at all. One quote from a customer who took part in our research sums up this position:

"*It's the perception of leakage actually more than anything, it's about the fact okay yes I understand they are saying its about the fact that it becomes uneconomic, however I think basically you want to try to get down to no leak, it's still wasted water*"

Our findings are similar to those reported by CCWater[18] which confirmed that leakage is a key concern for customers, and where companies are not felt to be doing enough to reduce leakage, this can impact on customer's behaviours in respect of their own efficient use of water. CCWater have stated they support Ofwat's proposal for companies to reduce leakage by a further 15% beyond the economic level, by the end of AMP7 (2025), subject to there being customer support.

Welsh Government expect companies to forecast a reduction in leakage over our planning period[19]. They expect us to maintain our leakage levels at the calculated economic level but that we need to continue to innovate to reduce the costs of leakage detection and repair which will ultimately lower the economic level and hence actual leakage rates.

7.2.1. Review of leakage targets

Our current strategy is based upon achieving what is known in the water industry as a 'sustainable economic level of leakage' (SELL). This measure is based on the principle that the cost of reducing leakage rises significantly as the level of leakage reduces and that there comes a point at which the production of water is cheaper than the additional effort and cost needed to reduce leakage further. In other words, it becomes much more costly to our customers to go below the sustainable economic leakage level.

Ofwat proposed in its second consultation[20] a new approach to leakage target-setting which comprises significant challenges to the water industry in England and Wales to encourage more stretching performance commitments for leakage reduction:

These proposed changes will require a step-change in our approach in order to meet future leakage targets over the AMP7 period. Making a step change in leakage reduction will take us below previously achieved levels and therefore there will inevitably be some uncertainty in the forecast costs and choice of techniques.

Our recent analysis based upon new evidence around leakage on customer properties and the potential for innovation indicates that the economic level of leakage lies around 15% to 20% below the level we aim to achieve by the end of AMP6. We consider that a 15% reduction over the course of AMP7 is the appropriate level we should aim for due to the need to make significant changes to working methods and technology

[17]Dŵr Cymru Welsh Water WRMP Research, Final Report, October 2017, Accent/PJM Economics
[18] Water, water everywhere? Delivering a resilient water system (2016-17) CCWater December 2017
[19] Water Strategy for Wales, Welsh Government, 2015
[20] Water 2020: Our regulatory approach for water and wastewater services in England and Wales. May 2016

(See Our PR19 Leakage Business Case[21]). We will use AMP7 to improve confidence in our cost – benefit analyses with a view to making further reductions in future. We will include a greater focus than ever before on customer side losses tackling leaking pipes and appliances within households through our Project Cartref programme described below.

7.2.32. Leakage– Strategic Ambition

We have developed and commenced the implementation of a long term strategy to guide our improvements in leakage reduction. During AMP6 we have undertaken a number of projects aimed at better accounting of flows within our water supply system and our understanding of the current leakage position.

We have embarked on a project to coordinate water efficiency and customer side leakage operations on an area by area basis which we have called Project Cartref (meaning 'home' in Welsh). This is our customer-side leakage reduction strategy for AMP7. It responds to the innovation, trials, and research that we have conducted during AMP6 to better understand losses on the part of the network that is owned and controlled by customers.

Utilising new technology that can detect very low flows even in unmetered properties, we have established that the volume of water 'lost' through in home leakage, such as through dripping taps and faulty toilet cisterns, is much higher than previously thought. This is both a challenge and an opportunity. If we can work with customers to tackle these 'plumbing losses' then we can reduce water usage and overall leakage, at a lower cost than seeking further leakage reductions from our mains and distribution networks, where we face diminishing returns.

We have piloted Project Cartref during AMP6 with trials in 20 areas. When a home has been identified as potentially having significant plumbing losses, a dedicated trained plumber follows up with the customer and offers to carry out a domestic water efficiency audit to understand the source of leakage and provide other water efficiency advice. We then offer repairs and water efficiency devices at our cost. The trials have been successful, in that they have been welcomed by customers and have reduced leakage and consumption in those areas. They have also provided useful learnings on how to make the approach successful when rolled out at scale.

In conjunction with Project Cartref we will continue with our policy of repairing leaking or damaged supply pipes for free and replacing lead supply pipes when they are found.

Project Cartref means providing a different kind of service to customers and will rely on our customers to trust us to work in their homes for mutual benefit. We believe that our high trust scores and our 'not for shareholder' model will help us to do so successfully. Project Cartref marks an important innovation in our approach to leakage; one that is based on active customer participation and behavioural change. Our existing 'find and fix' and 'upstream' leakage detection and prevention activities will also need to continue in order to deliver the significant overall leakage reduction target to which we are committing in AMP7.

Our three-pronged strategy for leakage reduction will involve tackling upstream losses on trunk mains, on the distribution system through innovative methods, and a new focus on customer side losses (both from external underground supply pipes, and internal plumbing) – see the below sections for further details

7.2.2. Trunk Main Leakage

Building on our work to estimate the level of real loss in zones and "tiles" in the upstream network, we have identified sections where there appears to be leakage to find. Utilising new technology such as trunk main

[21] PR19 Leakage Investment Case Ref.5.8J

leak noise correlators, satellites, drones, mobile survey systems and fixed monitoring systems we will put greater emphasis into locating leaks, and we will increase staff resources accordingly.

As part of our customer minutes lost programme we will be installing additional monitors on trunk mains, which will support in identifying leaks. We have also commenced a programme of monitoring service reservoirs for overflows and losses through the structure and on-site pipework. Our pilots have shown that it is possible to locate leaks in this way, as well as unaccounted for consumption. The forecast saving over AMP7 is based on our experience to date from our trunk mains team, which was established in 2015.

The configuration of our trunk main network makes isolating some sections of main difficult in order to effect repairs. We are planning to develop enabling measures for repairs alongside our increased detection focus.

7.2.3. DMA Distribution Leakage

We propose to improve the efficiency of our leakage detection activity in DMAs in order to free up staff to focus on upstream and customer side leakage. A key part of our strategy is to utilise fixed monitoring systems in areas with high natural rate of rise (NRR), including acoustic logging, but also other emerging technologies. We also propose to systemise leak detection surveys by using new hand-held devices that make use of noise and vibration analysis algorithms rather than relying on the human ear.

7.2.4. Customer side leakage and losses

A key element of our AMP7 leakage plan is to increase focus on customer side losses, both external underground supply pipe losses to meet our leakage target, and internal plumbing losses through our water efficiency programme. Our pilots have shown that the level of leakage beyond the customer boundary box may be higher than previously reported. Our Cartref project will determine the costs and practicality of identifying those properties with leaks, and then engaging with the customer to make the repairs.

Detection will be aided by the use of new technology such as Stop Watch, and repairs by the use of new no dig techniques such as Aquapea. The forecast savings are based on the results from our pilot projects in 20 of our per capita consumption (PCC) areas, and the Cartref project, using a projected cost curve for detection and repair.

7.2.5. Leakage estimation and targeting

We will retain our current process which is followed for each of the 24 water resource zones to give a forecast for leakage over the 30-year planning period, with the Sustainable Economic Level of Leakage (SELL) for each zone being aggregated into a total for the Company. The current model does not distinguish between the types of leaks found in DMAs and for the forthcoming review of SELL, on which work has started. Changes are being made to the methodology to better understand the options available to us to meet the Ofwat challenge. We will improve the SELL model such that:

- An estimate will be made for the cost – benefit relationship for all available options for reducing leakage on the three sections of the network referred to above, especially in light of the recent findings related to customer supply pipe leakage and night use;
- Consideration will be given to reducing the level of ALC on mains and communication pipes in DMAs in order to free up resources for other more cost effective activities;
- At a company level, the model will show transparently the high level relationship between investment in leakage reduction measures and the resulting level of leakage;
- Leakage reduction scenarios will be better integrated with other strategic aims and investment cases such as zonal studies, water quality, supply interruption and pressure transient impact of more mains repairs. The wider benefits of an increased customer side leakage focus will be explored.

- Rather than a single SALT model for each zone, there will be separate models for the three specific sections of the network – 1) trunk mains and service reservoir leakage, 2) DMA leakage on mains and communication pipes and 3) customer side leakage comprising underground supply pipe leakage and internal plumbing leaks;

7.3.Metering Strategy

Metering is another polarising issue for our customers with opinion divided between those who see it as the fairest way to pay for water and those who are concerned that moving to a meter would increase their bills.

"It's much fairer and makes people more conscious of their usage. Smart meters are a good step forward and it means no surprises" Domestic, Colwyn Bay

"I'm not sure I agree with metering as it can be unfair as some people pay more and it's not fair if they don't have a choice" Domestic, Colwyn Bay

For some customers, moving to a measured supply will reduce their water bill and we offer a free switching service for those domestic customers who are currently billed on the rateable value of their home. Following this switch, the customer can choose to revert back to the previous charging method within two years from the date of installation of the meter. We do not meter on change of occupancy and our policy is very much geared to encouraging the voluntary uptake by our customers. That said, we are predicting a meter penetration rate of 70% by 2050, up from its current level of around 40%.

Even though we are not in a 'water stressed' area, as Table 41 shows, based on data from a recent CCWater report[19] our current meter penetration rates are in line with other water and sewerage companies that have a similar resource position.

	2012-13	2013-14	2014-15	2015-16	2016-17
Anglian	73.1	74.7	76.8	78.2	79.7
Dwr Cymru	35.0	37.0	38.0	39.0	41.0
Northumbrian	27.8	27.8	31.4	33.1	35.0
Severn Trent	37.5	39.0	40.9	41.7	43.1
South West	75.4	79.9	78.1	79.1	80.8
Southern	64.5	75.2	82.5	85.6	86.7
Thames	32.5	33.8	34.9	36.1	37.7
United Utilities	35.0	37.0	38.4	40.0	41.0
Wessex	54.0	56.0	58.0	58.0	60.0
Yorkshire	50.8	45.2	47.1	49.0	50.8

Table 41 - Water and Sewerage Companies Percentage of Household Metering[19]

In its Water Strategy for Wales (2015), Welsh Government recognises that any proposed approach to metering needs to be aligned with a responsible charging and tariff structure to ensure that households with affordability issues are protected.

The general consensus amongst our customers is that we should encourage and promote metering but they do not like the idea of being forced to have a meter. Our research indicated customers were more interested in 'smart' metering given the prevalence of this technology in our lives already. The results of our research are in line with CCWater's findings[21] that the majority of customers support metering as a fair way to pay for their water but that many do not support universal metering given the uncertainty over the impact to their bill.

This greater public awareness of metering, in line with the work being undertaken by energy companies to promote their 'smart' metering technology, should help increase the uptake in metering by our customers as they become wholly accustomed to being billed for their utilities in this way.

In its 2016 Using Water Wisely report, CCWater found[22] that people in Wales are starting to voluntarily move to a measured supply with 40% of respondents stating they asked for a meter to be fitted, compared to 34% in England, during 2016. Of the 40% that chose to move to a measured supply, 81% did so to save money.

Our strategy going forward therefore is to collect sufficient evidence to allow us to understand the costs and benefits of metering which may support a change in our position post AMP7. We have gained some evidence already from the installation of 250 digital 'smart' meters in the Grangetown area of Cardiff as part of the wider EU funded "WISDOM" project. We are in the process of rolling out these 'smart' meters to all our household customers in the Tywyn Aberdyfi zone, thus providing evidence from a more rural location.

We will continue to look at further deployment of these innovative 'smart' meters in our deficit/marginal zones in AMP7 and target areas where we need to collect further evidence. We would look to have dialogue with Welsh Government and CCWater around the results of our metering research and any potential impact for our future metering policy.

7.4. Water Efficiency

In its Water Strategy for Wales (2015), Welsh Government sets out how it will look to work with water companies to drive action and engagement on water usage and to promote the benefits of water efficiency. One of the key messages we received from our customers during the engagement work for this Plan is that we should be doing more for our customers with respect to promoting water efficiency.

We recognise customers are at the heart of decision-making at Welsh Water. We will continue to build on our wide range of customer engagement activities in AMP6, and work with our customers to understand what is important to them and how we should prioritise our investments. We are currently trialling what we call our Water Resilient Communities approach in the Rhondda Fach Valley, through which we are building long-term relationships with communities where we are investing in infrastructure in their areas. This provides an opportunity to further engage on water efficiency messaging.

7.4.1. Demand management and behaviour change

We work with customers to improve understanding of the value of water and reduce their demand by offering advice on water-saving devices and water harvesting. We harness research to identify smart technologies to reduce water use for both domestic and business users, helping them to save money and improving the sustainability of our services.

For our domestic customers we have trialled Project Cartref to address customer-side leakage, as part of which we have worked to install new 'stop watch devices' on individual supply taps to understand water consumption and the likelihood of leakage within individual properties. This allows us to target our engagement activities at households most likely to be experiencing leakage and offer free water audits and repairs. We are also raising awareness of poor plumbing practices that increase the risk of lead in drinking water.

Communicating the right messages to our customers at the right time in the right way is important to building strong relationships to facilitate our collaborative projects. We underpin our engagement programmes with research to improve our understanding of relevant technological innovations, the behavioural economics

[22] Attitudes to Tap Water and Using Water Wisely Survey 2016 CCWater/BMG Research, August 2016

driving water use, and appropriate communication channels. This ensures we are well placed to advise our customers and build on our reputation as a trusted service provider.

7.4.2. Water Efficiency Programme

Table 42 below shows a summary of our estimated spend on water efficiency (excluding metering) in AMP7 in comparison to our previous spend (AMP5) and current spend (AMP6). A significant increase in spend is forecast as a direct result of much greater water efficiency activity we will undertake over the five years from 2020 – 2025.

Water Efficiency Spend	AMP5	AMP6	AMP7
	£2,200,000	£2,718,500	£4,548,000
		+ £518,500	+ £1,829,500

Table 42 - Comparison of our Water Efficiency budget AMP 5 to AMP7

The key areas being targeted by this investment are:

- To build water efficiency messaging and education into our Cartref leakage initiative. Through the Cartref project an estimated 18,000 customer properties will receive a home water efficiency audit which will include the targeted installation of water saving devices and information encouraging conscientious and efficient use. The results from this work stream will inform and assist in delivery of our AMP7 performance commitment for PCC.

- Increase our Domestic Audit Programme – supporting c.30,000 customers across AMP7 compared to c.5,500 across AMP6;

- We will continue to deliver, and improve upon, our award winning schools outreach programme. Working in collaboration with our Education team, Welsh Government and Local Authorities we will aim to introduce water efficiency to children between the ages of 5-10 (c.210,000 individuals) over the AMP7 period, promoting water saving behaviours and encouraging the use of water efficient devices and practices through links to the educational curriculum.

- To engage with and support our most vulnerable communities. As part of our current 'Zonal Studies' programme of work we are looking to support c.10,000 customers within the Rhondda Fach Valley, an area of considerable water debt and vulnerable customer groups. This will set the basis for further 'community' support programmes going forward;

- We will work collaboratively with developers and planners to ensure that water efficient fixtures and fittings are installed in an effort to limit maximum use to 125 litres per person, per day in line with the Building Regulations 2010, (with consideration given to the amendments due in November 2018). We also plan to investigate ways of incentivising water efficiency measures into new builds.

- We will ensure our own premises are water efficient through the implementation of the Waterwise Checkmark at all key sites.

- Provide a targeted approach to Water Efficiency within our deficit zones utilising data and information from related work streams (Cartref, Community Support, SELL etc.) to implement solutions which achieve quantified demand saving results. This includes assessment of demand savings achievable from implementation of SMART metering solutions.

7.4.3. Per Capita Consumption

We estimate per capita consumption in un-measured households by monitoring flows in small leakage control areas averaging around 100 properties each. Applying our standard night consumption allowances, an estimate is made of leakage in each area from which the remaining flow is taken as consumption. Surveys of 10 of these areas using new logging technology have shown that night consumption is higher than currently estimated, comprising higher use and higher plumbing losses. Consequently network leakage is lower and average daily consumption is higher.

We will continually improve our night consumption allowances through further survey work to improve our estimates of night use, average daily use, internal plumbing loss and external supply pipe leakage. We will also generate some statistical relationships to be applied to the water balance generally and to understand the volatility in DI over summer periods. Although these areas are more actively managed than other LCAs, a common theme coming out of the surveys to date is that more could be done to maintain stop tap chambers, to facilitate leakage control.

We have set ourselves challenging targets in the reduction of PCC which we will meet through the initiatives described above. The target is to reduce average PCC from 145 l/hd/day to 138 l/hd/day by the end of AMP7, and a longer term aspiration to achieve an average PCC of 100 l/hd/day by 2050.

7.5. The Plan for Tywyn Aberdyfi

As described in Chapter 5, our improved understanding of the hydrology of our river sources in this zone has confirmed their vulnerability to dry weather. During severe drought events it is unlikely they will be able to provide enough water for us to meet our customer’s demand, a situation that will only worsen under the effects of climate change. We are therefore forecasting the zone to have a small supply demand deficit from the start of the planning period in 2020.

The demand forecast is based upon achieving a companywide leakage saving of 15% across the AMP7 period and a reduction in PCC, as outlined in chapter 4. The proportion of the additional leakage saving is smaller than in other zones given the good level of current leakage performance. Taking account of headroom including the growing uncertainties of achieving PCC targets in the long term, a maximum shortfall of 1.97 Ml/d is reached by the end of the period in 2050 under the Annual Average scenario, as shown in Figure 81, and a maximum shortfall of 2.79 Ml/d under the Critical Period scenario. This section describes how we have developed the Best Value solution for the Tywyn Aberdyfi zone which will be resilient, sustainable and meet our customer’s needs.

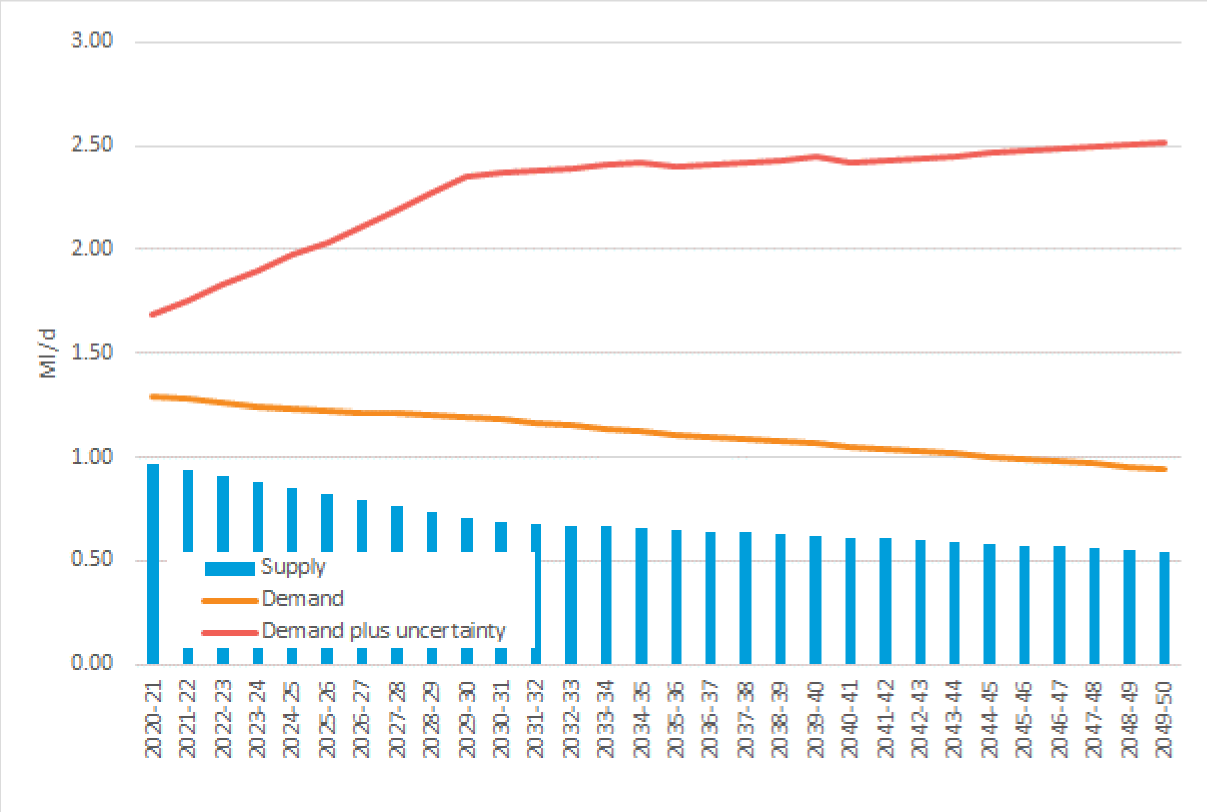


Figure 81 - Tywyn Aberdyfi Dry Year Annual Average baseline supply demand balance

7.5.1. Feasible Options

Following the process set out in Chapter 6, starting from an initial long list, various feasible supply side and demand management schemes have been considered in greater detail. A high level description of these options is provided below:

1. Water efficiency – this involves the installation of various water saving devices such as Hippo bags and aerated showerheads to help our domestic customers use less water. The total estimated savings, if all such measures were to be implemented, is 0.009 Ml/d at a projected cost of approximately £44,300 and an estimated 348,376,036 kgCO_2e;
2. Leakage – we have a number of schemes to reduce leakage below the economic level in the Tywyn Aberdyfi zone; the principal ones are:
    a. Trunk mains repair/renewal – these are our large diameter, high pressure water pipes that deliver treated water from our works to the areas of demand. The total estimated savings were we to successfully repair all the identified leaks, is 0.025 Ml/d at a cost of approximately £442,000 and an estimated 18,158 kgCO_2e. If we were to replace all the existing trunk mains in the zone with new pipes that don't leak, we estimate this would save 0.035 Ml/d at a cost of approximately £1.8 million and an estimated 517,406 kgCO_2e;
    b. Distribution mains renewal – these are the smaller pipes that deliver the water to our customers. The total estimated savings from replacing these existing pipes so that they don't leak is 0.017 Ml/d at a forecast cost of approximately £8.7 million and an estimated 1,064,508 kgCO_2e;

c. Enhanced Active leakage Control – this would increase our rates of leakage detection and repair activity over and above the calculated economic level. The total savings from full scheme implementation are estimated as 0.005 Ml/d at a cost of approximately £60,000 and an estimated 3,295 kgCO_2e;

3. 'Smart' metering – we are installing smart meters to our household customers during AMP6. Under our current policy, we do not have the powers to compulsorily charge our customers on a metered basis and our customers do not wish us to do this. However, this metering will provide good information to help reduce leakage on our customers pipes, on our customers usage behaviour and so improve our understanding of the costs and benefits of 'SMART' metering;
4. Install a new abstraction from the Afon Dysynni and transfer this raw water in to the Afon Fathew to be subsequently re-abstracted at our existing intake. The benefit of this option is a shorter pipeline from the Afon Dysynni to the Afon Fathew. This option would deliver up to 2.6 Ml/d with an estimated CAPEX of £2.4 million and an estimated 584,987 kgCO_2e;
5. Install a new abstraction from the Afon Dysynni and transfer this water directly to Penybont water treatment works. This would involve a longer pipeline than option 4 but would avoid any environmental risks from transferring raw water from one catchment into another. This option would deliver up to 2.6 Ml/d with an estimated CAPEX of £3.5 million and an estimated 715,650 kgCO_2e;
6. We would construct a storage reservoir, capable of holding up to 8 Ml, and fill it using the existing Afon Fathew intake. The water would then be transferred directly from the reservoir to Penybont water treatment works to provide additional raw water supplies, when available resource in the Afon Fathew during the summer is less than that required to meet customer demand. This option would deliver up to an additional 1 Ml/d at an estimated CAPEX of £410,000 and an estimated 186,501 kgCO_2e;
7. We would construct a storage reservoir, capable of holding up to 35 Ml, and fill it using the existing Afon Fathew intake. The water would then be transferred directly from the reservoir to Penybont water treatment works to provide additional raw water supplies, when available resource in the Afon Fathew during the summer is less than that required to meet customer demand. This option would deliver up to an additional 1 Ml/d but for longer than option 6 and hence provide resilience to more extreme droughts and climate change, at an estimated CAPEX of £830,000 and an estimated 378,516 kgCO_2e.

NRW were consulted on the supply side options and have advised that they are unlikely to consent to an abstraction that would involve water being transferred between catchments as this could impact on fish migration and increase the risk of inter catchment transfer of Invasive Non Native Species. Option 4 to transfer water from the Afon Dysynni to the Afon Fathew has therefore been discounted.

Essentially we have only three feasible options which provide sufficient water to resolve the challenge we face to shortfalls in supply in this zone. Its remote location and small population make transfers of water particularly challenging to develop and build, whilst other solutions, such as developing an impounding reservoir, are not commensurate with the scale of the problem and it would be difficult to design one that would not negatively impact the environment.

7.6.Tywyn Aberdyfi – Least Cost Solution

Given the size and scale of the deficit in this zone and the options available, the decision on a solution is relatively straight forward. Following the process outlined in Chapter 6, the least cost solution identified using our EBSD model is Option 5; install a new abstraction point on the Afon Dysynni and abstract additional water to Penybont water treatment works. To futureproof the scheme we will apply for an abstraction licence of

3.2 Ml/d, greater than the maximum throughput of the Penybont WTW so that if required, we could meet the whole demand for the zone from this source alone. Our environmental assessments of this option have been based upon this higher abstraction rate of 3.2 Ml/d; when we come to deliver the scheme in AMP7 we may design for this larger volume as it would allow us to potentially supply areas outside of the Tywyn Aberdyfi zone, in line with our Water 2050 strategy.

In addition we need to make sure that our water supplies from Penybont WTW are resilient. The installation of bankside storage at Penybont would both provide additional supply to meet short term peaks in demand when river flows are low but also storage that could be used when the water quality in the rivers becomes turbid and difficult to treat, usually after periods of heavy rainfall.

Given our awareness of our customers and stakeholder wishes in terms of demand management, we are taking forward a programme of work during the remainder of AMP6 to install 'smart' meters in all the households we supply. Although we cannot reduce demand low enough to resolve the forecast imbalance; it is important to manage it as low as possible to reduce the water we will need to abstract from the stream sources into the future. This metering programme will help in achieving this.

7.7. Tywyn Aberdyfi - Testing the Solution

To ensure that we have chosen a robust programme that delivers the best value for customers, we have undertaken a number of sensitivity and scenario assessments on a wide range of measures that could affect our supply demand balance for this zone.

7.7.1. Testing Against our Future Demand Strategy

The Ofwat PR19 consultation has challenged companies to go further in their leakage efforts and has set the industry a target of an additional 15% reduction in leakage over and above the SELL we had included in the draft Plan. As a business we will meet this target and have included this within our updated demand forecast for this Revised Plan along with our longer term target to reduce company leakage to c80 Ml/d by 2050, equivalent to 10% of current total demand. Within our updated demand forecast we have also included the impact of achieving our 2050 target of 100 l/hd/d for average PCC.

For Tywyn Aberdyfi there would only be a very minor reduction in the forecast demand following incorporation of the new leakage targets as we are already at a low level by the beginning of AMP7 even with reductions in PCC and so the zone remains in deficit and the solutions chosen are still required.

7.7.2. Scheme Resilience Testing

Although the exact location of the abstraction point on the Afon Dysynni has not been finalised, it is anticipated it will be in the vicinity of Pont y Garth (SH 6357 0710). The assessment below has therefore been based on modelled flows at this point. The Dysynni has a much bigger catchment than the Afon Fathew and so is able to support the required abstraction even during a drought. To investigate how resilient the intake would be to extreme droughts we have extended the range of annual minimum rivers flows in our supply models, using extreme value analysis. From this we can estimate the annual minimum river flow for the 1:100and 1:200 year type of drought events.

Table 43 and Figure 82 below shows that the driest year on record (1984) with a minimum river flow of 8.9 Ml/d, had an estimated return period of ~1:86. For the 1:200 year event, the annual minimum river flow has been estimated to be approximately 4.75 Ml/d. This is above the maximum potential abstraction of 2.6 Ml/d and well in excess of the peak week demand for the zone (1.74 Ml/d) and so we can conclude that the zone would be resilient to a 1:200 year drought if we invested in a new abstraction from the Afon Dysynni.

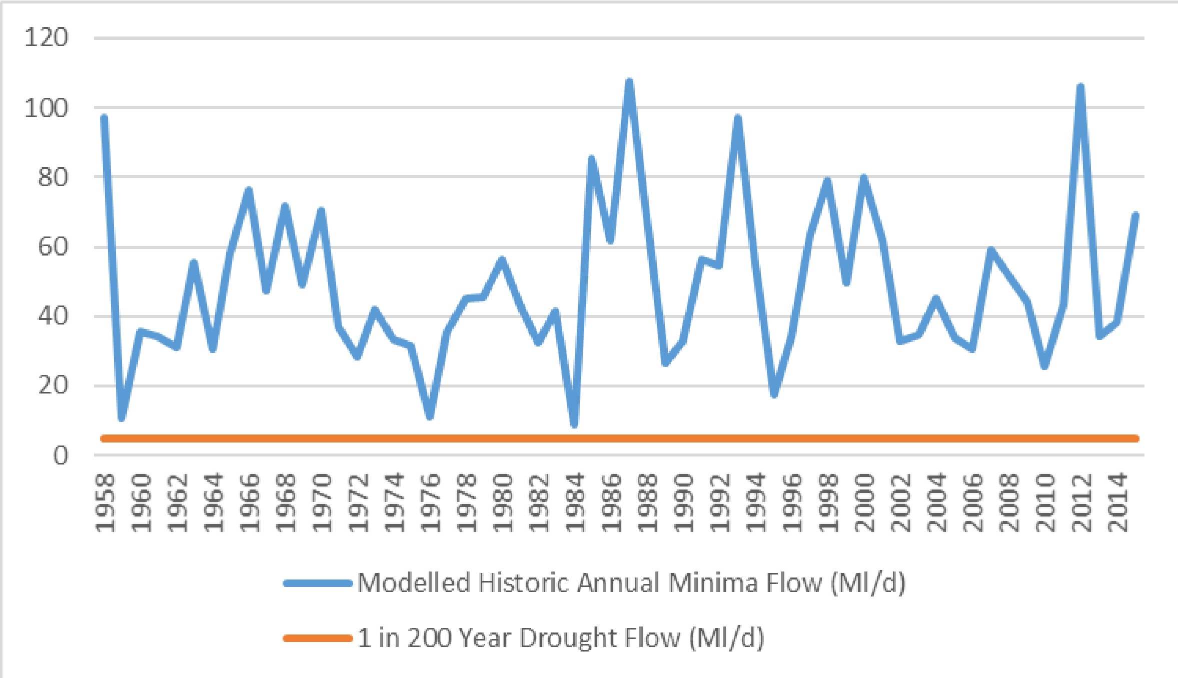


Figure 82- Afon Dysynni - Historic annual river flow analysis

River Flow (Ml/d)	Drought Return Period	Drought Probability
8.9 (Worst Historic –1984)	1/86	0.012
8.14	1/100	0.01
4.75	1/200	0.005
0.92	1/500	0.002

Table 43 - Afon Dysynni minimum modelled flows assessment

7.7.3. Climate Change Testing

Modelling of river flows in the Afon Fathew have shown them to be extremely sensitive to the 'dry' climate change scenarios that we have tested them against. Figure 83 illustrates how river flows are forecast to decline from our current ('baseline') position when the effects of climate change are taken into account. With a forecast peak demand of around 1.7 Ml/d these scenarios show that the Afon Fathew is unlikely to provide a secure long term source of water.

The Afon Dysynni has a much larger catchment than our existing sources and so we are confident that it is much less vulnerable to climate change. We have undertaken modelling of the impact of climate change on our modelled river flows in the Afon Dysynni using the 2030's climate change factors and can confirm that no reduction in deployable output occurs under either the Annual Average or Critical Period scenarios

This negligible climate change impact allows us to reduce the amount of uncertainty needed in our long term planning, which is illustrated in Figure 85 whereby the difference between the 'Demand' and the 'Demand plus uncertainty' lines is very small, in contrast with the much larger uncertainty allowance presented in Figure 83 for the baseline scenario.

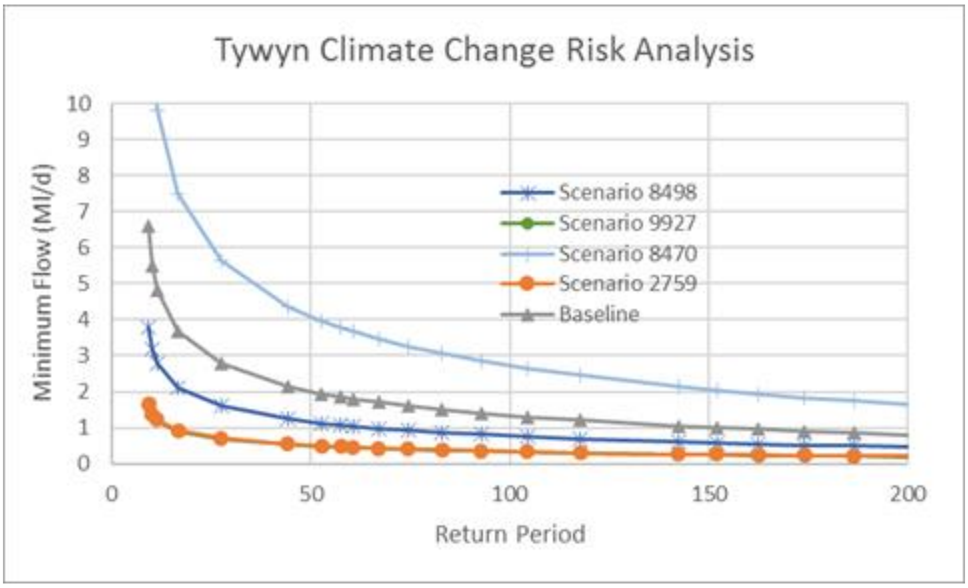


Figure 83 - Impact of climate change upon flows in the Afon Fathew

7.7.4. Testing Against Our Environmental Objectives

We have considered the likely environmental impacts of both the construction and operation of the proposed new intake on the Dysynni. These are presented in the SEA, HRA and WFD reports in Appendices 27, 28, 29.

NRW's 2015 Meirionnydd CAMS document states that there is sufficient water available in this catchment to be licensed without constraint. The intake, pumping station and pipeline are not within any nationally or internationally important ecological sites. The Craig yr Aderyn (Bird's Rock) SPA and SSSI is just above the pipeline route so we will ensure the timings of construction are sensitive to the needs of the red-billed chough. The Afon Dysynni flows into the Broadwater SSSI and the Lleyn Peninsula and Sarnau SAC. The abstraction would reduce flows in the river draining into these areas.

The scheme is within the Snowdonia National Park and so has the potential for an adverse landscape and visual effect on the designated landscape. The above ground works e.g. a new pumping station and WTW intake tanks will be designed sympathetically.

The bankside storage at Penybont WTW would be filled via the abstraction from the Afon Fathew under the existing licence. Although the Lleyn Peninsula and Sarnau SAC is downstream it is not anticipated there would be any adverse ecological impacts as the Afon Fathew licence has already been through the Habitats Directive Review of Consents process which considers full licensed abstraction volumes.

The Water Framework directive assessment (Appendix 29) concluded "No or minimal Impact Expected" from both the operation and construction of the bankside storage reservoir and "Minor level of impacts" from the construction and operation of the abstraction point on the Afon Dysynni.

The SEA has identified some minor negative effects primarily associated with the construction of the scheme but with appropriate mitigation (e.g. adopt best practice techniques and avoid activity during environmentally sensitive periods) these can be lessened.

7.7.5. Testing Against a High Population Growth Scenario

We have tested the impact of utilising a higher population growth projection for households within our supply demand balance. With the new Afon Dysynni scheme in place, Tywyn Aberdyfi is forecast to remain in surplus for both the Annual Average and Critical Period. This provides us with confidence that our preferred solution gives resilience for the long term against any significant increases in demand that we have not currently accounted for.

7.8.Tywyn Aberdyfi - Best Value Solution

The initial least cost assessment identified the new abstraction from the Afon Dysynni as the most cost beneficial scheme that resolves the forecast deficit in Tywyn Aberdyfi. No demand side measures could fully resolve the imbalance given the already low level of leakage. To confirm that this solution is the best value we have tested it further against other measures, such as drought risk, climate change and environmental impact; the results of which show

- It is resilient to climate change;
- It is resilient to more extreme droughts than we have experienced historically;
- It is resilient to potential uncertainties such as future rates of population growth;
- It has a minimal impact upon the environment.

Pumping water from the Dysynni (~6km to Penybont WTW) will be more expensive than abstracting from our current sources and so under normal conditions we will continue to abstract from the Fathew and Nant Braich y Rhiw to meet customer demand. The Dysynni would then be used in dry summers when there is a risk of the Fathew having insufficient resource to meet demand. The scheme provides the most resilient option to ensure sufficient water is available during severe drought events.

Figure 84 shows how the proposed new schemes will interact with the existing infrastructure. The supply demand balance in Figure 85 illustrates how the deficit will be resolved once the new Dysynni intake is in place.

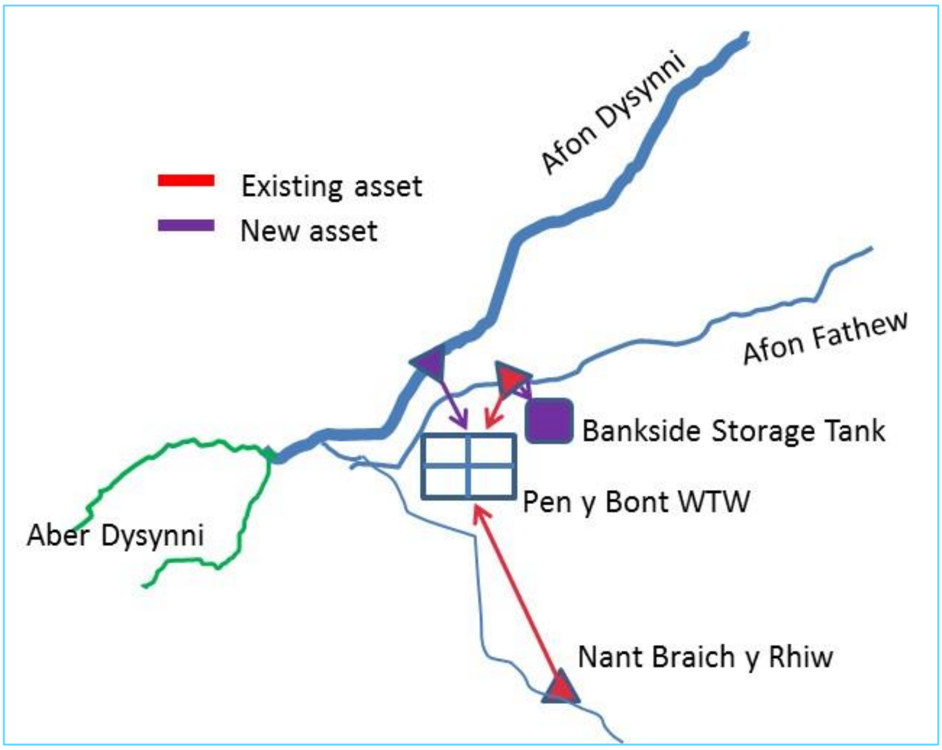


Figure 84 - Schematic of the Tywyn Aberdyfi zone showing existing and new assets from the preferred solution

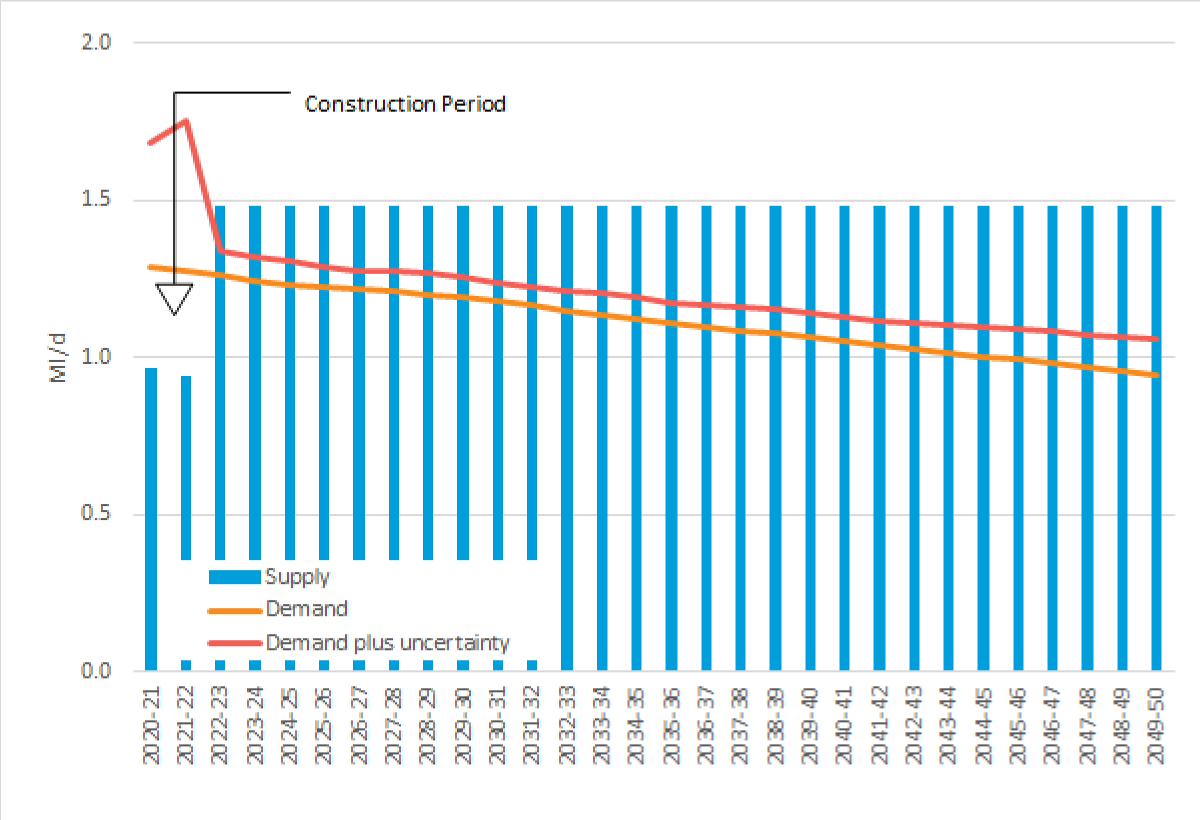


Figure 85 - Tywyn Aberdyfi Annual Average supply demand balance with the Dysynni scheme in place

Although Figure 85 shows a forecast shortfall until 2022-23 when the Afon Dysynni abstraction becomes operational, we are now progressing the scheme investigations to allow detailed design progress during the remainder of AMP6. This will allow us to 'early start' the scheme as soon as possible in AMP7. We are confident that we can fully support our customers' water supply needs in the zone in the short term through tankering of water supplies in from neighbouring zones should we encounter a severe drought event before the scheme is operational. We accept that this is not ideal from a resilience perspective which is why we have proposed the Dysynni scheme, however, our confidence is built upon our response to the drought of 2018 when we were able to mobilise significant tankering support in North Wales.

7.9.The Plan for Pembrokeshire

The Pembrokeshire WRZ is forecast to fall into deficit in both the annual average and critical period scenarios before the end of the planning period. The deficit grows from around 4 Ml/d by the end of the AMP7 period to around 6.5 Ml/d by 2049/50 (Figure 86). Without intervention, our customers could expect the imposition of drought restrictions more often than our policy level of service.

This section describes how we have developed the best value solution that resolves the expected dry year deficit in Pembrokeshire and delivers a resilient and sustainable water resource system that meets our customer's needs.

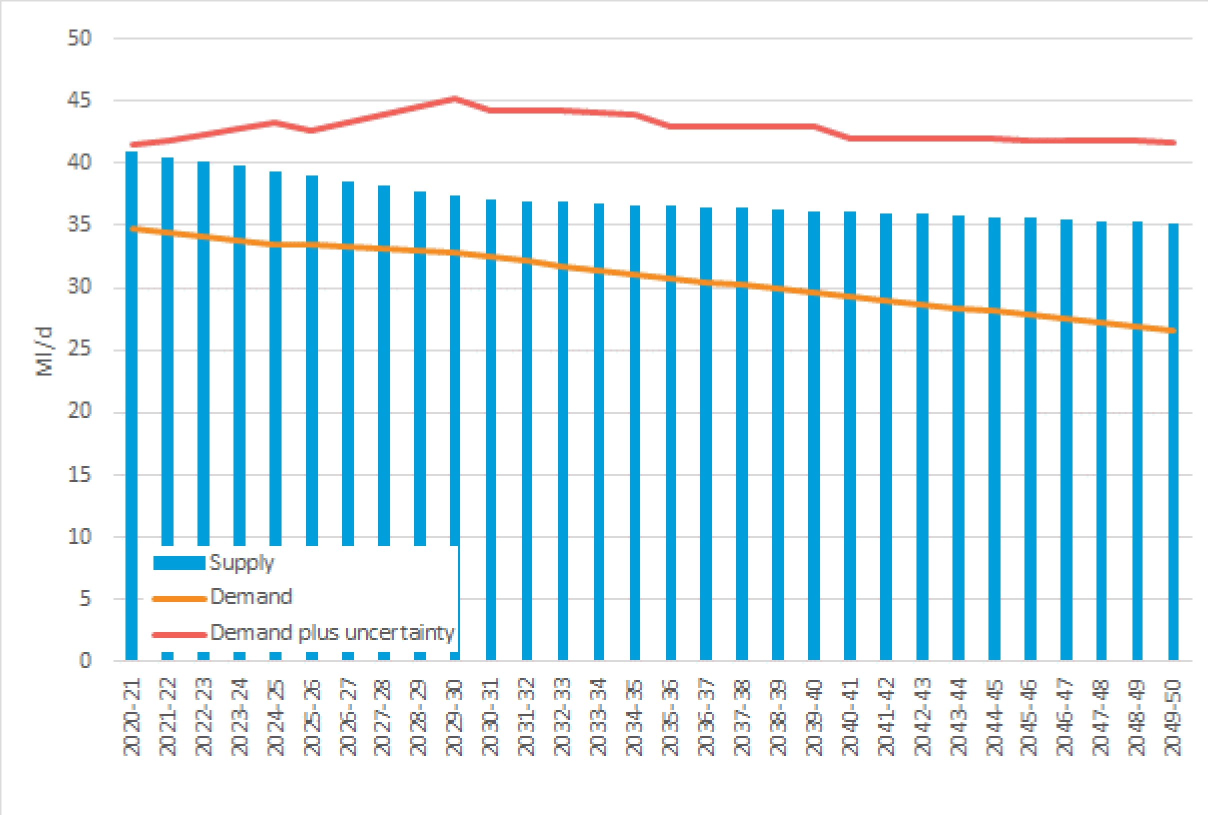


Figure 86 - Pembrokeshire Annual Average supply demand balance

7.9.1. Feasible Options

As in the Tywyn zone, starting from an initial long list, various feasible supply side and demand management schemes have been considered in greater detail. The cost of options are given in Appendix 30. A high level description of these options are:

1. Water efficiency - the total estimated savings, if all such measures were to be implemented, is 0.67 Ml/d at a projected cost of approximately £5.4 million and an estimated 682,010 $kgCO_2e$;
2. Leakage – we have a number of schemes to reduce leakage below the economic level in the Pembrokeshire zone; the principal ones are:
    a. Trunk mains repair/renewal –The total estimated savings were we to successfully repair all the identified leaks, is 0.1 Ml/d at a cost of approximately £1.53 million and an estimated 1,230,738 $kgCO_2e$. If we were to replace all the existing trunk mains in the zone we estimate this would save 0.14 Ml/d at a cost of approximately £48 million and an estimated 7,911,354 $kgCO_2e$;
    b. Distribution mains renewal – the total estimated savings from replacing these existing pipes is 5.26 Ml/d at a forecast cost of approximately £96.1 million and an estimated 52,784,070 $kgCO_2e$;
    c. Enhanced Active leakage Control – the total savings from full scheme implementation are estimated as 0.06 Ml/d at a cost of approximately £3.4 million and an estimated 3,226 $kgCO_2e$;

3. 'Smart' metering – rolling this out to all our domestic customers in the zone is estimated to deliver savings of 2.86 Ml/d at a forecast cost of £45.8 million and an estimated 1,518,339 kgCO_2e;
4. Raising the height of Llysyfran reservoir to increase storage to deliver 14 Ml/d at a cost of £16.3 million and an estimated 5,844,092 kgCO_2e;
5. Re-instating our Milton boreholes to provide water to industrial customers. This would reduce how much water we need to take out of the Eastern Cleddau River at Canaston for our industrial customers and deliver 2-4 Ml/d at a cost of £1.25 million and an estimated 58,692 kgCO_2e. However, there is significant uncertainty around the yield of this scheme during a drought year. In addition, the industrial users on the Haven have some concerns over the quality of the groundwater compared to the surface water that they currently receive;
6. Transferring water from our Tywi CUS zone into Pembrokeshire. This would bring 4.5 Ml/d of treated water into Pembrokeshire using surplus capacity from the Felindre system at a cost of £24 million and an estimated 11,717,513 kgCO_2e;
7. Upgrade our Canaston pumping station to enable full variability of rate at which we take water from the river to deliver 14 Ml/d at a cost of £13 million and an estimated 4,546,617 kgCO_2e;
8. Desalination for industrial use. This would reduce how much water we need to take out of the Eastern Cleddau at Canaston for our industrial customers and would deliver 15 Ml/d at a cost of £23.6 million and an estimated 12,325,135 kgCO_2e;
9. Taking 5 Ml/d raw water from the Afon Taf to be treated at Bolton Hill WTW at a cost of £6.3 million and an estimated 2,448,990 kgCO_2e.

7.10. Pembrokeshire - Least Cost Solution

7.10.1. Least cost solution

Following the process outlined in Chapter 6, we have used the EBSD methodology to identify the least cost programme of schemes to resolve the deficit throughout the planning period and this shows that the development of the Canaston Bridge pumping station upgrade on its own, is most cost effective.

Although the Milton scheme is cost effective at the top end of its estimated yield benefit, at the lower end the scheme cannot be combined with other cost effective schemes to create an overall cost effective programme to meet the zonal deficit, whereas the Canaston Bridge scheme meets the deficit in full.

This Canaston scheme is designed to resolve the over-release of water from the Llysyfran reservoir when it is regulating water to supply the abstraction from the Eastern Cleddau River at Canaston Bridge. An enhanced version of the scheme also increases the size of the bankside storage at the Canaston pumping station to better mitigate against poor water quality on the Cleddau. Further detailed work is needed to understand the benefit that this would provide but this has been included in the scheme put forward so that the potential environmental impact can be examined through the SEA and HRA process.

Figure 87 shows a schematic of the Bolton Hill water supply system. The over-release occurs as there is an environmental requirement, through the abstraction licence, to discharge water from the Llysyfran reservoir at the maximum rate at which water is abstracted at Canaston Bridge. The demand for water from Bolton Hill WTW fluctuates diurnally and daily in response to customer demand. The current pumps have a limited number of fixed flow rates and this means that to match demand, they are turned on for a period at a rate above the average demand from the works and then turned off again. The release from Llysyfran is set to the highest pumped value to be compliant with the abstraction licence. We therefore 'waste' water by, for example, releasing from Llysyfran 24 hrs a day but only abstracting for 16 hrs a day.

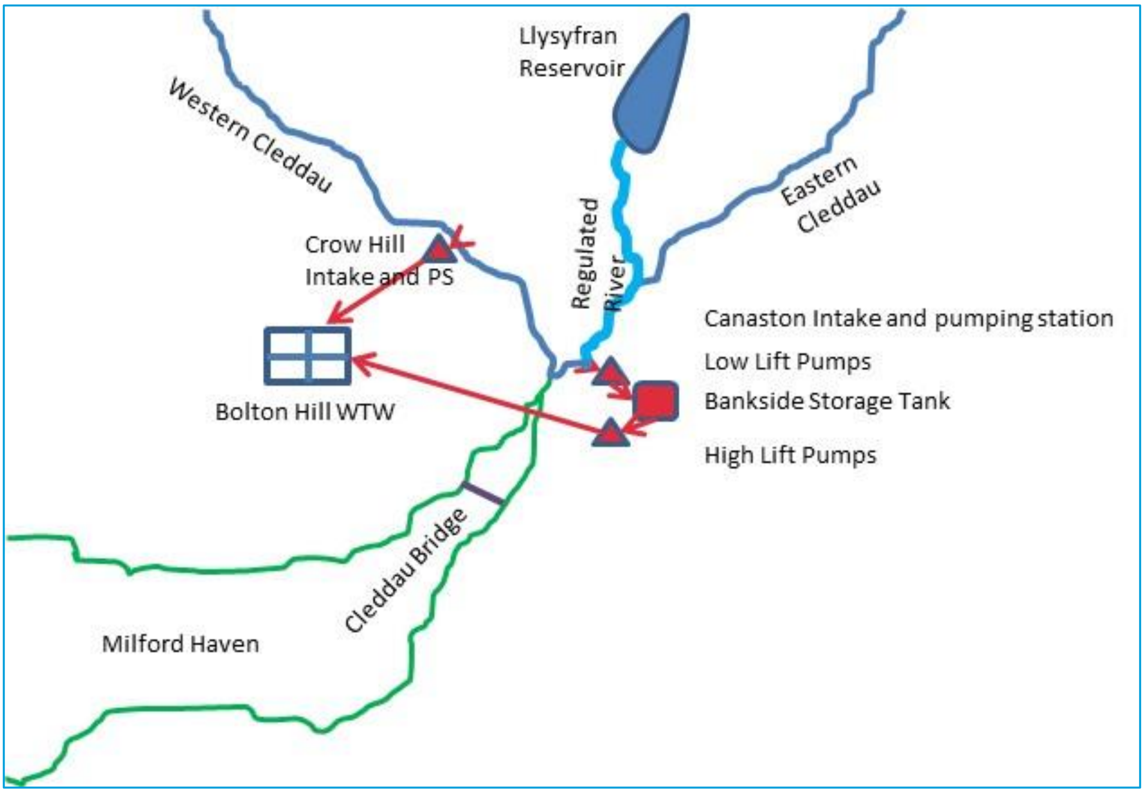


Figure 87 - Schematic of the Cleddau and Bolton Hill system

If we can vary the pump rate at Canaston then we can abstract from the river at a lower rate for a longer period, closer to 24 hrs, and reduce the rate at which we release water from Llysyfran. An example of the benefit of this proposed scheme is shown in Figure 88.

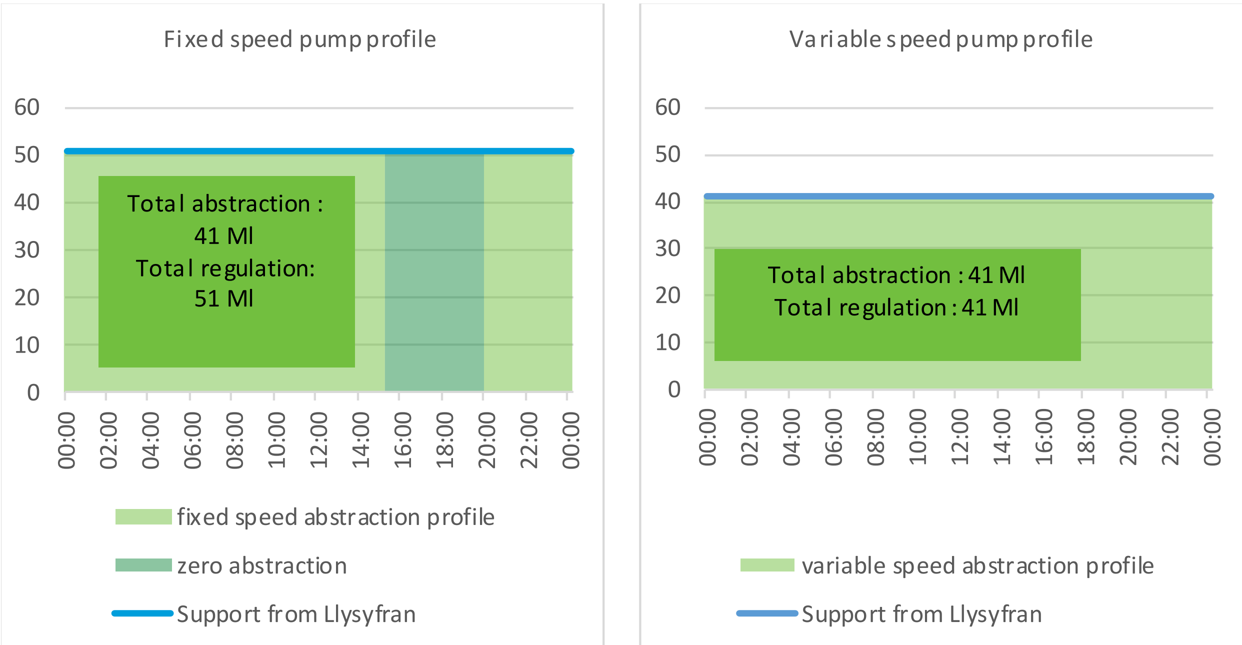


Figure 88 - Example of Canaston pumping station operation pre and post scheme implementation

Releasing less water from Llysyfran to support the Eastern Cleddau protects storage volumes from over-release. In a dry year the amount of additional water which can be saved by this change in operation is significant. The impact of this option on storage in a drought year is shown for modelled output of 1984 in Figure 89.

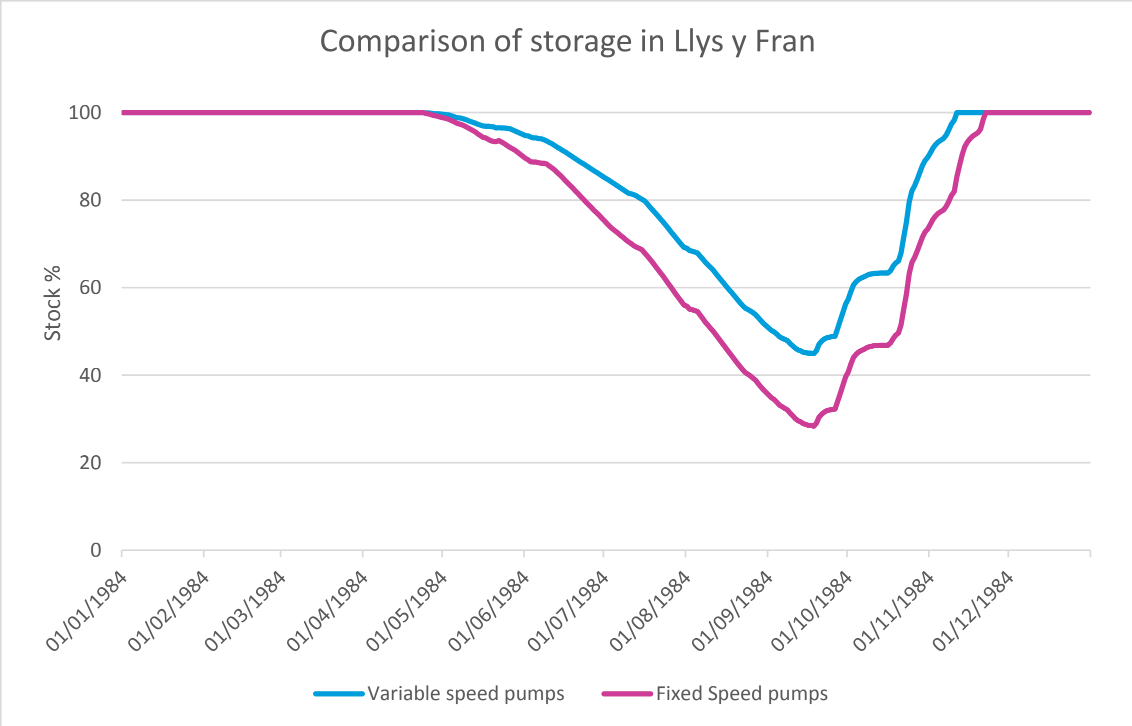


Figure 89 - Llysyfran storage levels pre and post scheme implementation

The ability of the supply system to meet demand in a normal, non-drought year, is limited by the capacity of Bolton Hill WTW. However, as the scheme preserves water resource, it ensures that there is always enough resource to supply the works. This provides significant climate change and extreme drought resilience benefit to the system when water resource would be the constraining factor. The scheme, therefore, reduces both the allowance made to DO for climate change impact and to the uncertainty within the Target Headroom calculation. The zonal supply demand position with the Canaston scheme in place is shown in Figure 90.

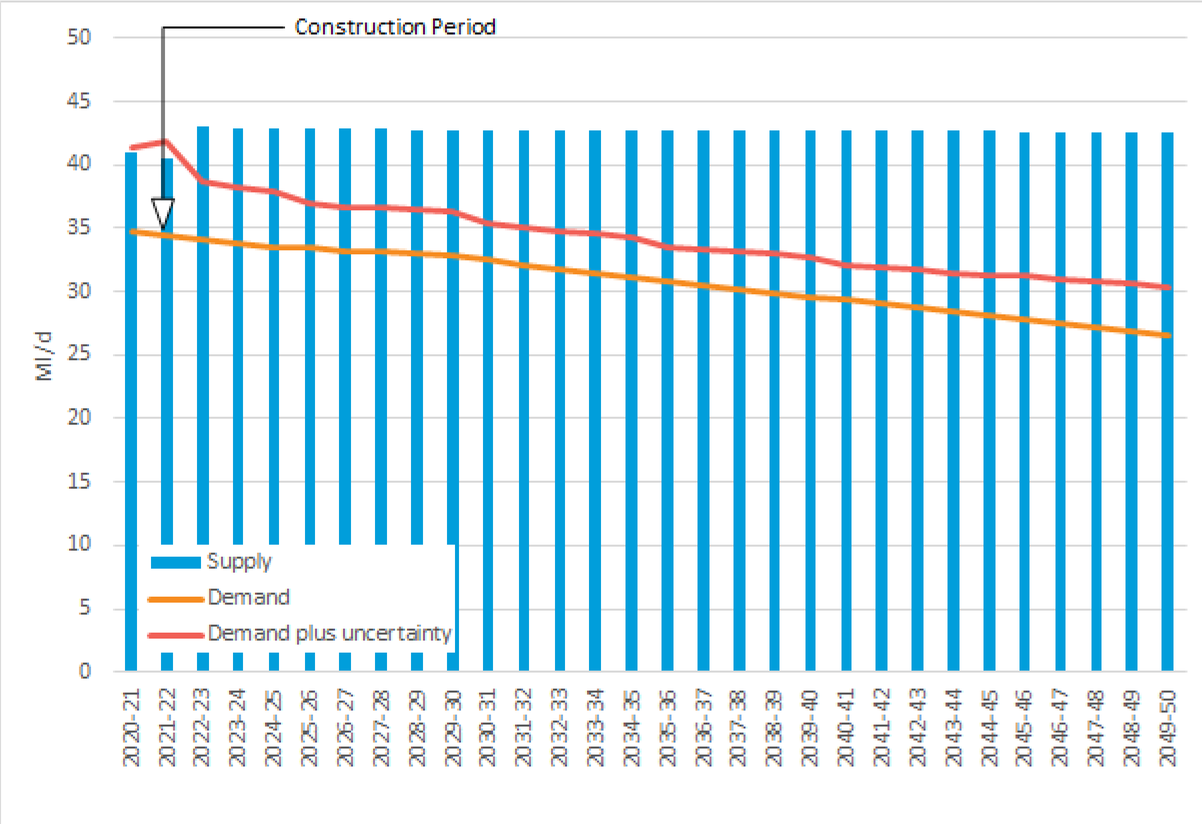


Figure 90 – Pembrokeshire Annual Average supply demand balance post scheme implementation

7.11. Pembrokeshire - Testing the solution

To ensure we have chosen a robust solution that delivers the best value for customers, we have undertaken a number of sensitivity and scenario assessments on a wide range of measures in the Pembrokeshire WRZ.

7.11.1. Testing Against our Leakage Strategy

In line with Ofwat's PR19 methodology consultation, we have assessed the impact of an additional 15% of leakage reduction from our target and have included this within our updated demand forecast for this Plan along with our longer term target to reduce company leakage to c80 Ml/d by 2050, equivalent to 10% of current total demand. Within our updated demand forecast we have also included the impact of achieving our 2050 target of 100 l/hd/d for average PCC.

For Pembrokeshire, even with this reduction in demand in place, the zone still falls in to deficit in year 2020/21 and so we still require the delivery of the upgrades to Canaston pumping station to resolve this imbalance early within the AMP7 period.

7.11.2. Scheme Resilience Testing

As described in Chapter 5, our testing indicates that we are not currently resilient to a drought event more severe than around a 1 in 100 return period. A key output of our preferred solution is to improve our resilience to above this value in line with our customer engagement findings. With the preferred scheme in place, we have re-run our water supply models against different and more extreme droughts than those in our historic record. This testing shows that the scheme should significantly increase the resilience of the zone to cope with a drought event beyond a 1 in 200 year return period without the need to implement extreme customer side measures.

Figure 91 and Figure 92 show the results of the testing of our preferred solution against extreme droughts. In Figure 91 it can be seen that our simulated minimum reservoir storage (dotted blue curve representing Llysyfran and Rosebush combined) with our current system setup would breach the emergency storage (vertical orange line) at a return period of less than 1 in 100 i.e. 0.01. With the preferred scheme in place to improve the variability of Canaston pumping station, our resilience to extreme droughts is greatly increased to beyond the 1 in 200 year event (Figure 92). Beyond this level of drought event, the assessment using these new techniques does become more uncertain and so there is further work we plan to undertake during the AMP7 period to better understand our level of resilience with the preferred scheme in place.

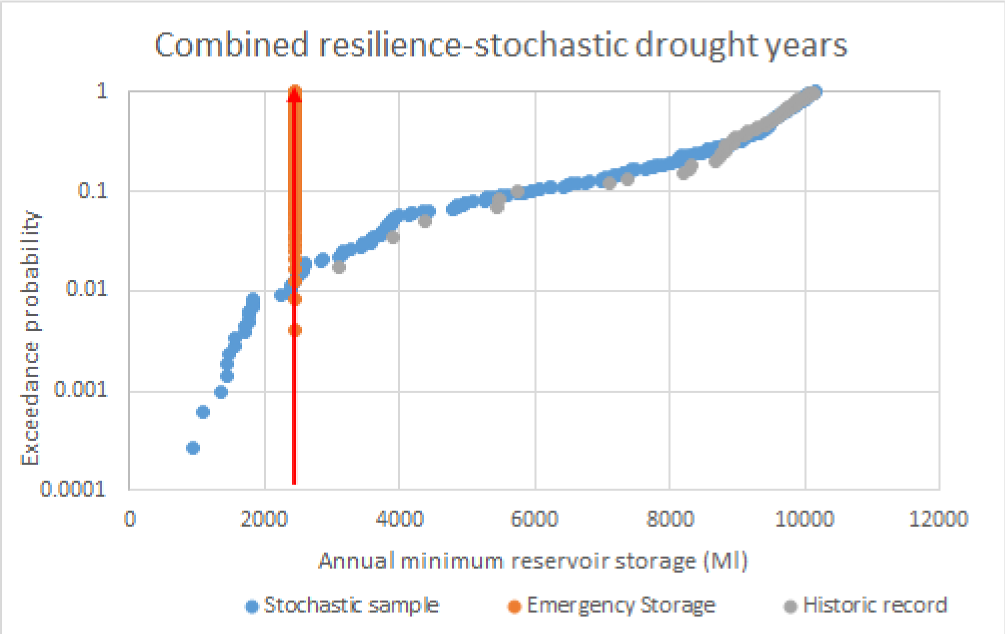


Figure 91 - Modelled minimum reservoir storage without Canaston upgrades

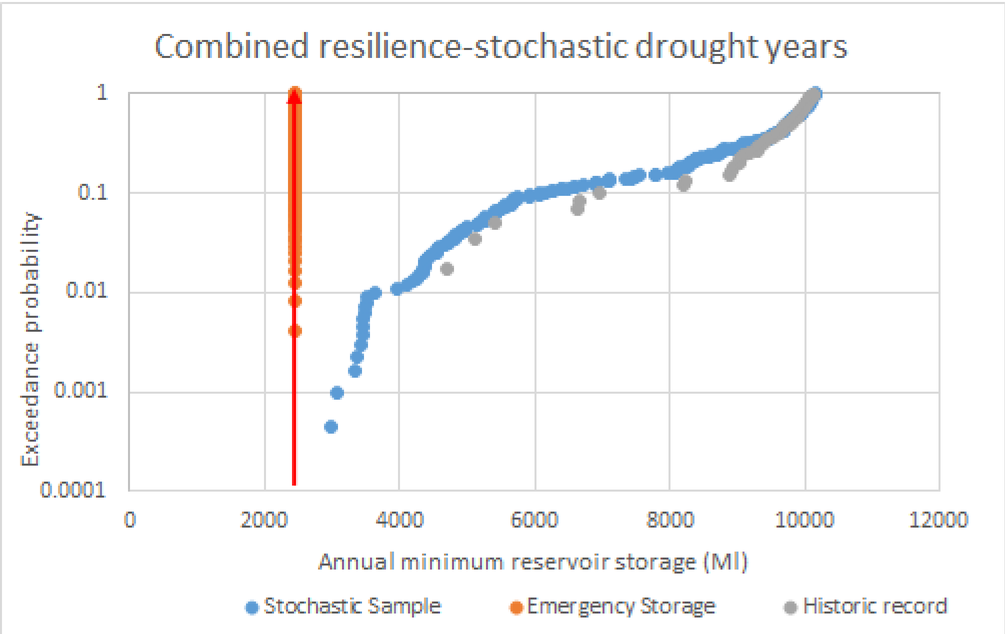


Figure 92 - Modelled minimum reservoir storage with Canaston upgrades

7.11.3. Testing against Climate Change

We have undertaken modelling of the impact of climate change on the preferred scheme using the 2030s climate change factors. This demonstrated that the effects of climate change on deployable output in the baseline scenario is mitigated for both the annual average and critical period scenarios. This is because the scheme enables us to maintain storage in Llysyfran which provides resilience to the lower inflows that we see in the climate change scenarios.

The extra benefit of this is that it reduces the impact of uncertainty allowances. The combination therefore of an increased supply capability and a decreased uncertainty allowance for climate change brings the zone back into a surplus position throughout the planning period, as shown in Figure 90.

7.11.4. Testing Our Hydrological Modelling

The representation of the hydrology of catchments in our Pembrokeshire zone holds a number of uncertainties mainly due to concerns over the quality and length of local flow records which are used in the Deployable Output assessment. Historically we have applied methods whereby we adjust flows from similar catchments to try and represent those flows we would expect to see in our actual reservoir catchments. In this Plan we have continued to improve our hydrological representation of the catchments, but it is still some way short of being perfect.

As described in Chapter 3, WRMP guidance allows us to include a percentage of uncertainty for the risks of using imperfect hydrology within our Target Headroom assessment model, this is termed the “S6” component. Within our planning, we typically apply a 5% uncertainty allowance for “S6” based on expert judgement. However, to test our preferred scheme for Pembrokeshire against the risk of our hydrological understanding being even more inaccurate than what we currently believe, we have run a scenario whereby the hydrological uncertainty allowance is increased from 5% to 10%. The resultant supply demand balance is shown in Figure 93.

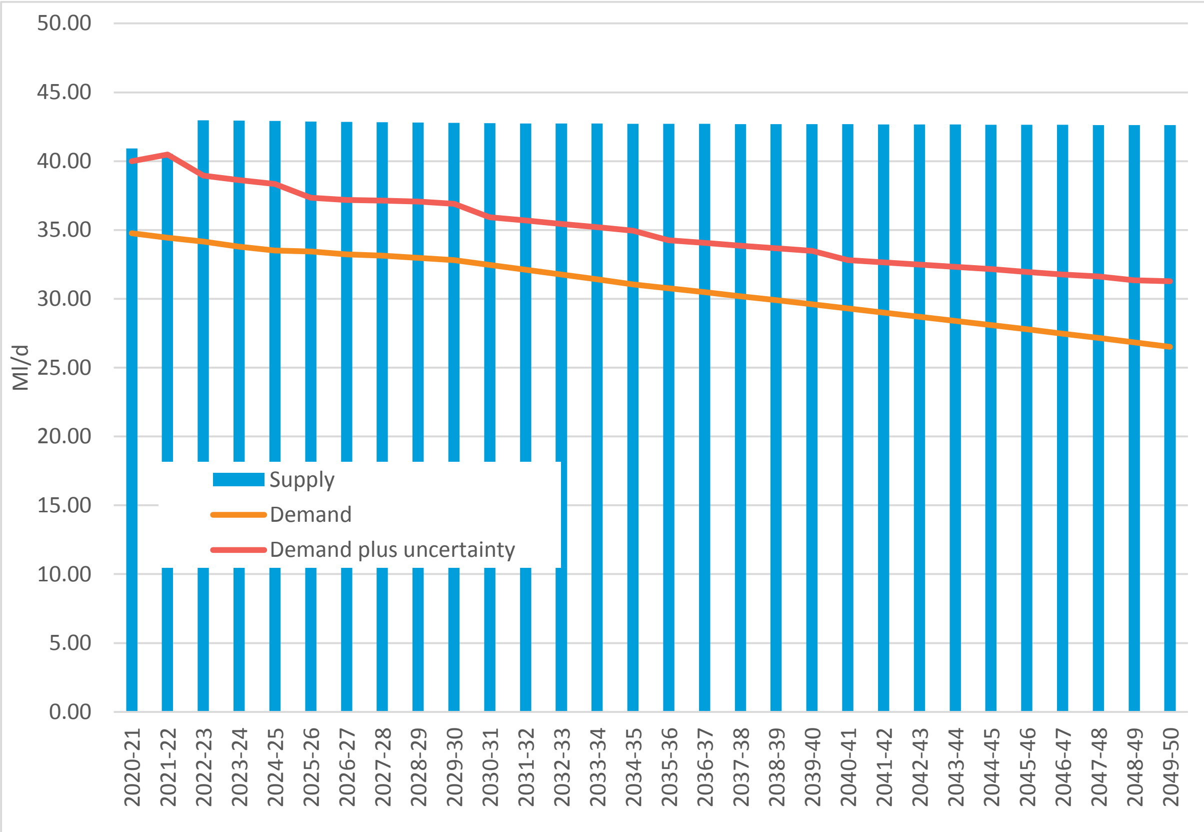


Figure 93 – Pembrokeshire Annual Average supply demand balance with 10% inflow uncertainty

When this result is compared to the SDB for the preferred option it can been seen that although the headroom allowance increases, i.e. the gap between the orange line and the red line, the zone still maintains a surplus position across the planning period. This confirms the benefit of the proposed investment in terms of the resilience it will provide should we have underestimated the amount of water there is within our reservoir and river catchments.

7.11.5. Testing Against Our Environmental Objectives

We have undertaken a Water Framework Directive assessment of the Canaston scheme on the nearby waterbodies 'Eastern Cleddau – confluence with Syfynwy to tidal limit' and 'Milford Haven Inner'. This concluded that 'With the use of standard best practice for construction, no significant impact on the ecology or water quality is predicted'[23] and that overall "no or minimal impact" is expected from the scheme during both construction and operation.

As our abstraction at Canaston takes water from the Eastern Cleddau SAC we have completed a Habitats Regulations Assessment of the scheme. This has concluded that the "option can be delivered with 'no adverse effect' and in practice it is likely that there will be 'no significant effects'''[24] .

We have also completed a Strategic Environmental Assessment (SEA) which concluded that the option could have a significant positive effect on economic and social wellbeing due to the level of spend on the scheme and the resultant benefit on the local labour market. The SEA also concluded that the scheme could have a negative effect on flood risk if additional bankside storage is constructed. However, potential mitigation measures have been identified for the design so that operation is possible without increasing flood risk

[23] WRMP19 – WFD Assessments of feasible options, Final report, Amec Foster Wheeler 2017
[24] WRMP19 – Habitats Regulations Assessment of the Consultation Draft WRMP, Amec Foster Wheeler 2017

elsewhere. All other effects in the SEA were minor or neutral. Further investigation into mitigation would be required at the time of planning.

7.11.6. Testing Against High Population Growth

We have tested the impact of utilising a higher population growth projection for households within our supply demand balance. With the Canaston pumping station upgrade in place, Pembrokeshire is forecast to remain in surplus for both the Annual Average and Critical Period scenarios, under this higher demand level, as shown in Figure 94 and Figure 95. This provides us with confidence that our preferred solution gives us resilience for the long term against any significant increases in demand that we have not currently accounted for.

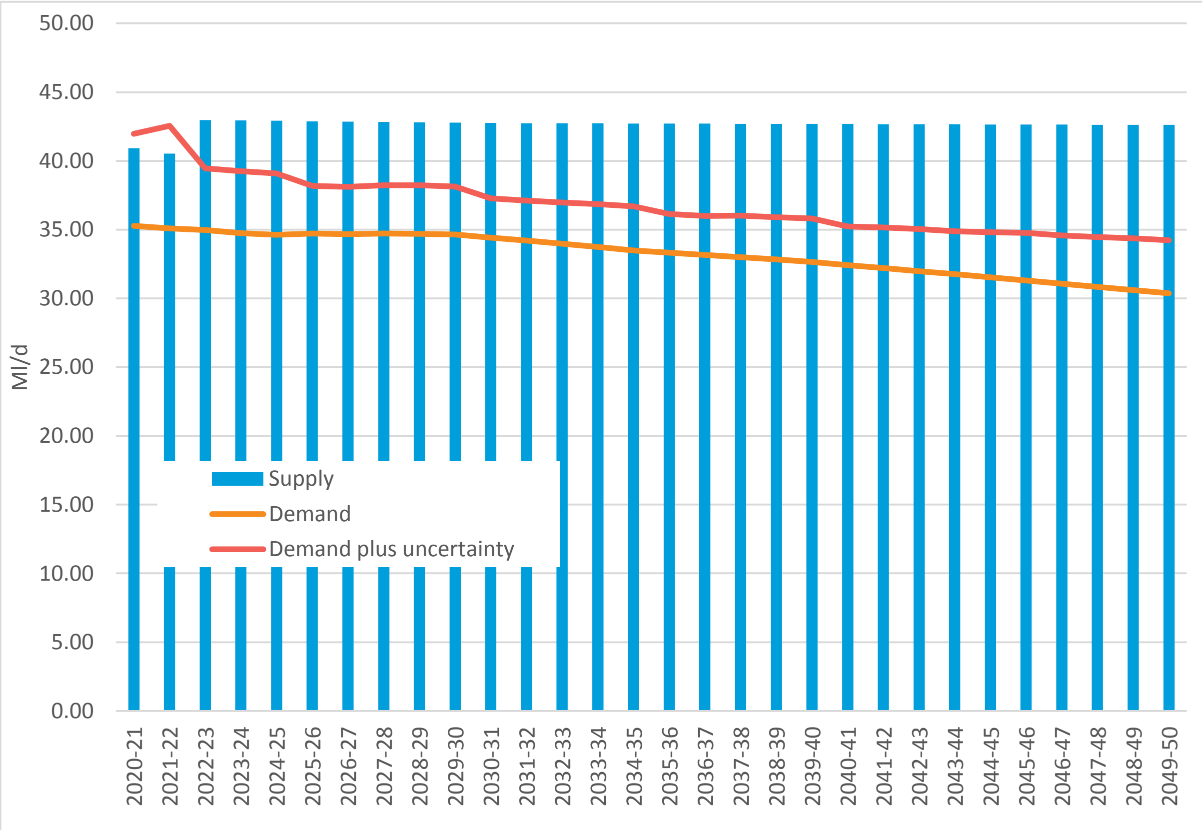


Figure 94 - Pembrokeshire Annual Average supply demand balance high population forecast

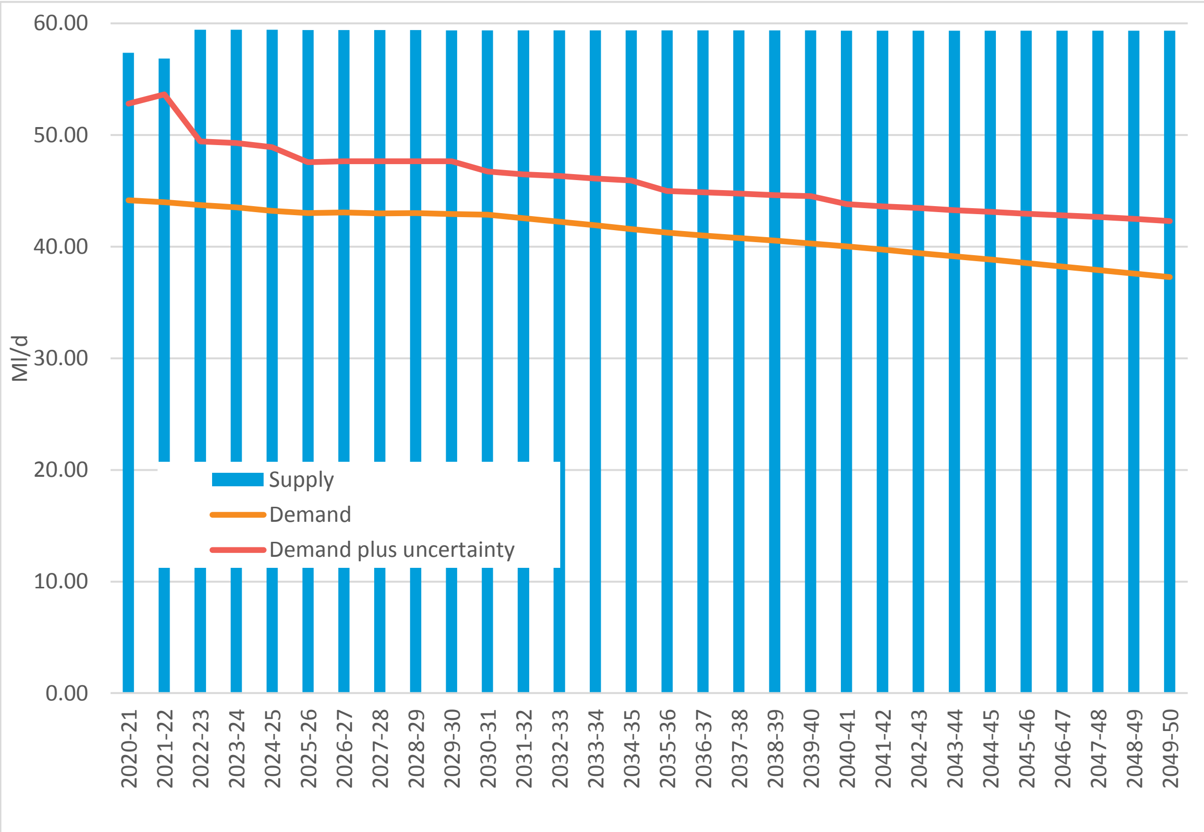


Figure 95 - Pembrokeshire Critical Period supply demand balance high population forecast

7.12. Pembrokeshire - Best Value Solution

The initial least cost assessment identified the Canaston Bridge upgrade as the most cost beneficial scheme that resolves the forecast deficit in Pembrokeshire. Although demand side measures cannot fully resolve the imbalance in the Pembrokeshire zone, as part of our wider strategy we are planning to increase our water efficiency activity in the zone and look to pilot further smart metering trials (Detailed later in this Chapter).

To confirm that this solution is the best value we have tested it further against other measures, such as drought risk, climate change and environmental impact; the results of which show

- It is resilient to climate change;
- It is resilient to more extreme droughts than we have experienced historically;
- It is resilient to potential uncertainties such as catchment hydrology and growth;
- It does not impact the environment.

Although Figure 90 shows a marginal shortfall until 2022, driven by climate change and headroom, given the relative magnitude of this the risk to customer supplies is low and we would actively respond with enhanced leakage activities in the zone to maintain resilient supplies.

7.13. Greenhouse Gas emissions of the Preferred Plan

We have calculated the increase in operational carbon from the implementation of the two supply side schemes proposed for our Tywyn Aberdyfi and Pembrokeshire WRZs. The new abstraction from the Afon

Dysynni for the Tywyn Aberdyfi zone is a pumped source compared to our existing 'gravity' sources so there will be increased energy usage. We have calculated that this would be around 0.085ktCo2 if used constantly, however, the scheme will only be used during exceptional dry summer periods and so its carbon impact is likely to be around 40 times less than this in the long term, which when compared with the Company's overall emissions will be insignificant. The Pembrokeshire scheme is at least carbon neutral as we are installing more modern pumps to abstract the same quantities of water more efficiently, hence reducing our energy usage.

Within our WRMP19 we have set challenging and ambitious targets to reduce the demand for water by 2050. Although not presented in Figure 96, our expectation therefore is that delivery of our Plan will lead to a significant reduction in greenhouse gas emissions as we put less water into supply; this is likely to more than outweigh the small increase due to additional pumping from the Afon Dysynni scheme. Figure 96 puts this into context showing the relative impact if the Afon Dysynni scheme were to be used all year every year compared with overall Welsh Water Co2 emissions. Although the plot is for the AMP7 period, with the Afon Dysynni scheme operational in 2022, there will be no increase beyond this period in relation to WRMP19 as no further schemes are proposed within the planning period.

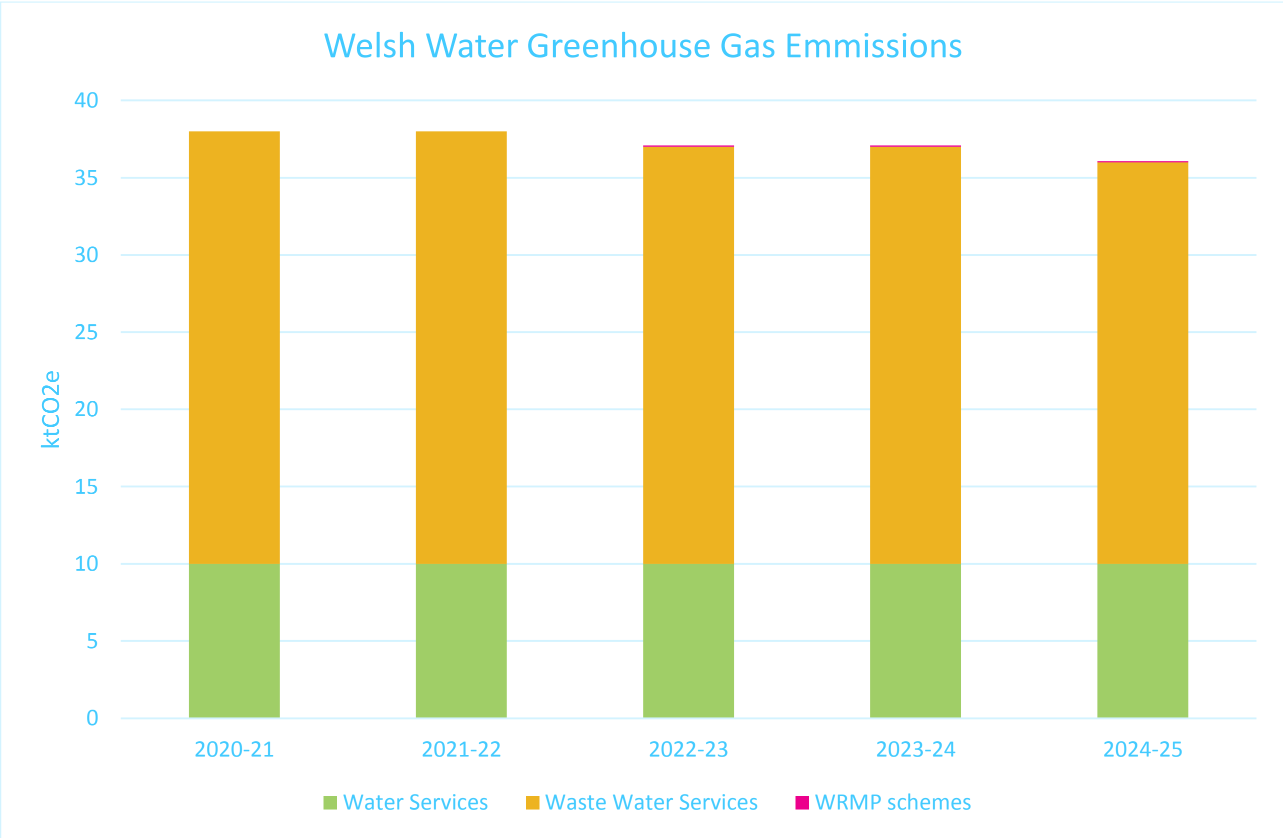


Figure 96 - Operational Carbon Impact of WRMP19 schemes compared to Welsh Water's PR19 submission

There are, of course uncertainties into the future, relating to the effects of population growth, climate change and environmental drivers that may impact our supply availability and the operation of existing sources. We already aim to take account of these in our planning but as time moves forward we may need to revise our plans. Any changes to our forecast greenhouse gas emissions arising from these will be addressed through subsequent WRMP submissions and if necessary, the Annual Review process. Proposals for any regional water transfers that may lead to increased emissions fall into this category and so the water supply benefits of these schemes will need to be assessed in this context.

7.14. Vowchurch

As described in Chapter 5, our Vowchurch zone is supplied from two operational boreholes; both of which suffer from poor raw water quality and deteriorating asset health given their age (both were drilled in 1981). We have recently drilled a new borehole that will go into supply in December 2017, and there is a potential need to drill an additional replacement borehole to enable the abandonment of the existing boreholes before they pose a risk to drinking water quality.

We have assessed the susceptibility of the Vowchurch zone to severe droughts using an 'extreme value' statistical analysis (Section 3.14 of Technical Appendix 19). Our initial resilience assessment has indicated that the River Dore and associated gravel aquifer may not provide the required yield to meet customer demands under drought events more extreme than we have seen historically, such as those experienced in 1976, 1984, 1989/90 and 1995. There is some uncertainty with this initial assessment and so to improve the confidence in our resilience assessment, we are generating a set of stochastic inflows for the River Dore to improve our understanding of drought risk for this zone, as required for our draft Drought Plan submission in March 2019.

This assessment indicated that the zone is not likely to be resilient to a drought event that might be seen in only 1 in every 200 years. The analysis suggested that the available yield from the boreholes and associated River Dore could be as low as 0.83 Ml/d compared to a licensed abstraction of 3 Ml/d. In such an event, we estimate that there is a possibility that we might need to resort to extreme demand management measures such as rota cuts but we would only undertake such actions in this relatively small zone if our tankering operations were found to be inadequate.

Although the risk is low the impact to our customers in the area is unacceptable. We have asked for our customers views on the level of resilience that might be acceptable and they would be willing to pay for an improved level of resilience to droughts more severe than would be seen in 1 in 100 years.

In addition, the Vowchurch site has been subject to environmental investigations and we aware that the current abstraction licence is viewed at its limit of sustainability by the Environment Agency. We will look to ensure that we have a limited impact on the site under severe drought conditions through this improvement plan.

There are limited options to resolve this issue in this area and demand management effort such as leakage reduction would not on its own resolve the situation. The Vowchurch boreholes site was subject to a Restoring Sustainable Abstraction (RSA) study in 2010/11 as required by the Environment Agency through the NEP for AMP 5. To inform the Cost Benefit element of the study, options appraisal work was completed which investigated alternative sources of supply to the Vowchurch boreholes. The only feasible option identified was to provide a potable supply of water from the neighbouring Hereford WRZ.

Given the water supply risks related to poor raw water quality and resilience to drought, our plan is therefore to lay a new potable water main between our Hereford and Vowchurch zones, capable of meeting the whole Vowchurch demand from Broomy Hill WTW when needed. Broomy Hill is fed by abstraction from the River Wye and is licensed for a maximum rate of 52 Ml/d. The initial resilience assessment of this river source (Section 3.10, Appendix 19) suggests there is no plausible drought severe enough to deplete flows in the River Wye to such an extent that they would be unable to provide 52 Ml/d for abstraction at Broomy Hill. We are therefore confident that this new supply of water to Vowchurch is fully drought resilient. This will cost around £6m.

7.15. Testing our Water Resources Plan

7.15.1. Background

We have derived supply demand balances for all of our 24 WRZs and where we have forecast shortfalls have identified the best value solutions for these zones. To ensure that our overall Plan is robust in all of our zones we need to test some of the assumptions used in our supply demand analysis through scenario analysis on specific zones and sensitivity analysis. In Chapter 5 we examined the impact of:

- Resilience to extreme drought of a 1 in 200 return period severity on all zones;
- The impact of climate change for our SEWCUS zone out to the 2080s in line with guidance for the English water companies;
- Development of the Wylfa power station on Anglesey.

These scenarios do not show that additional solutions are needed in response to these future factors beyond that described above for the Vowchurch zone. In this section we provide further results of scenario testing to understand:

- The sensitivity of the Plan to higher household population growth;
- The Impact of the new leakage convergence methodology;
- A 15% reduction in leakage.

7.15.2. Sensitivity to Population Growth

We have examined the sensitivity of our supply demand balances to population growth by recalculating our demand forecasts for all 24 WRZs utilising the upper quartile values from Welsh Government's projections (Figure 97).

These would increase demand across all of the zones to 2050, but unlike the position presented in the Draft Plan where six additional zones were forecast to fall into deficit by 2050, with a further two zones classed as 'marginal', the effects of our enhanced demand management strategy means that even under a high growth scenario, our supply demand balances remain robust with only Pembrokeshire and Tywyn Aberdyfi remaining as deficit zones.

We will resolve the deficit position in Pembrokeshire and Tywyn Aberdyfi through this Plan and we will continue to liaise closely with Local Authorities and Welsh Government to review population and growth projections as we have here to inform future plans.

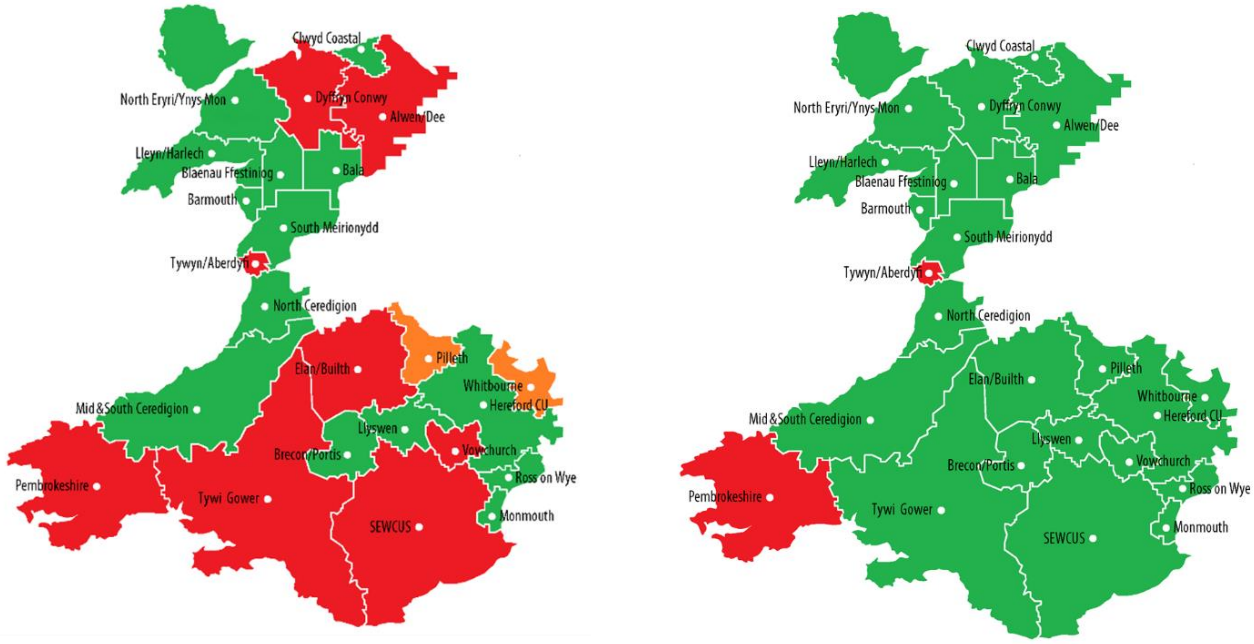


Figure 97- Forecast deficit zones in 2050 with upper quartile population growth projections for the Draft and Final Plans

7.15.3. Alternative Headroom Risk Profile

The purpose of this specific sensitivity assessment is to evaluate how the baseline supply demand balances across all our zones would respond to an alternative 'risk profile' specified in the Headroom allowance (described in Chapter 3). The baseline position (the level of risk we consider acceptable) is to reduce the risk allowance by 5% every 5 years of the planning period which is essentially taking a higher risk in our Plan uncertainty into the future; in this sensitivity assessment we have replaced this reduction in the profile with a constant risk profile which is a lower risk across the planning period (i.e. a greater 'Headroom' allowance than in the baseline supply demand balance).

The results show the following changes in the supply demand balance:

- In our Deficit zones (Pembrokeshire and Tywyn Aberdyfi) the position is a larger deficit as expected but would still be resolved with our preferred schemes in place;

In our other 'High Priority' zones from the Problem Characterisation (SEWCUS and North Eryri Ynys Mon) the impact of the alternative Headroom allowance is as follows:

- In North Eryri Ynys Mon the surplus position is reduced by 25% by the end of the planning period under Dry Year Annual Average scenarios;
- In SEWCUS the surplus position is reduced by 30% by the end of the planning period under Dry Year Annual Average scenarios (Figure 98)
- In the remainder of the our zones the more 'risk averse' Headroom allowance would not result in a deficit although an increase in required imports would be required to maintain the water balance in Barmouth, Vowchurch and Whitbourne.

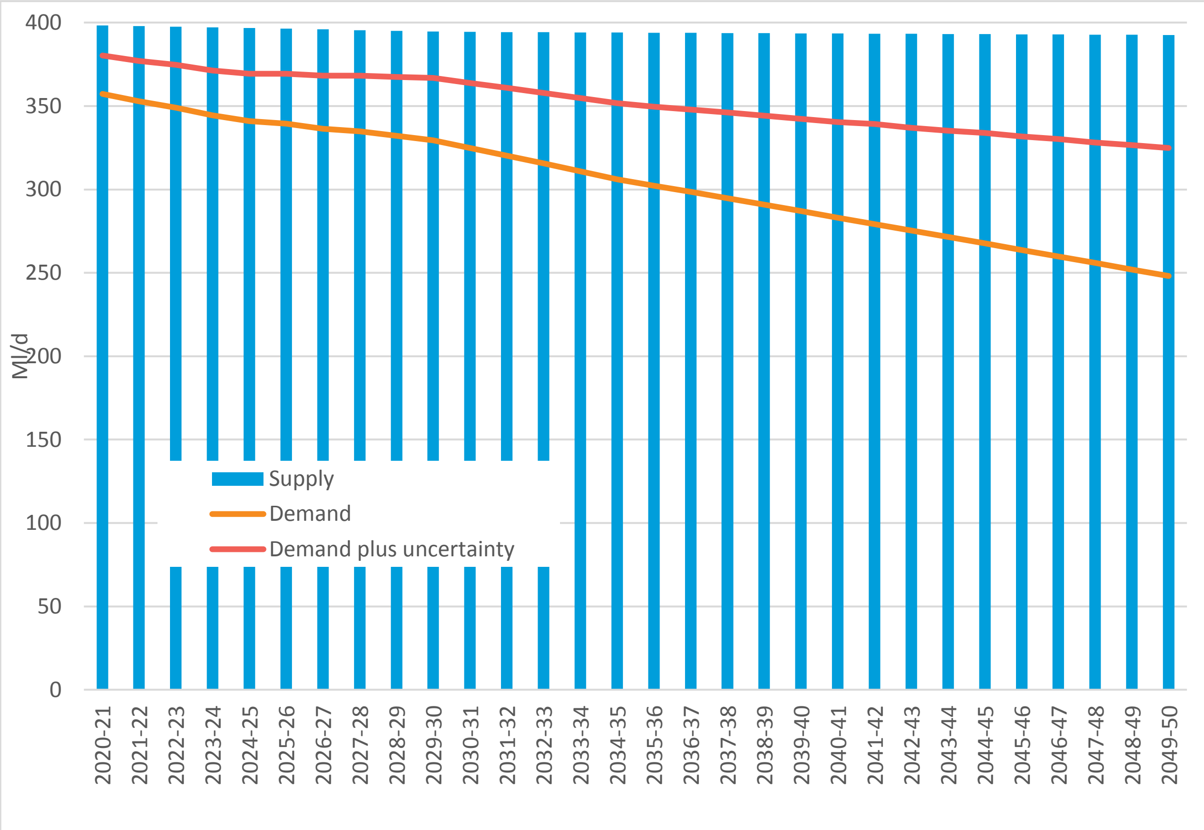


Figure 98 - SEWCUS supply demand balance under an alternative headroom profile

For the purpose of this Plan the company is not intending to adopt a different headroom profile but this exercise has helped confirm that our pragmatic approach to risk reduces the need for early investment that may not ultimately be required.

7.16. Key water resource system asset improvements in AMP7

This Plan has two principle ways in which it aligns with our Business Plan; directly through any investment required to resolve a supply demand shortfall and in our investment or studies related to our water resources assets or supply systems which are needed to ensure asset resilience.

7.16.1. Water Supply Resilience - Investment in our Dams

As highlighted in Chapter 5, our dams are key assets and an essential component of the water resource system in the majority of our zones. These dams function to store water when readily available during the wetter part of the year, which is then used to meet water demand during drier periods. The full use of our dam assets is critical during the driest years when we aim to maximise available storage to meet customer demand.

Many of our dams and the pipework and valves within them, are over 100 years old and require ongoing and significant investment to ensure they continue to meet changes in reservoir legislation, new best practice safety guidance and maintain water resource resilience.

In April 2016 Welsh Government introduced amendments to the Reservoir Act 1975, reducing the threshold volume of the Act from 25 million litres to 10 million litres for all reservoirs in Wales. These changes introduced additional dams and reservoirs to this regulatory framework and placed additional obligations on undertakers.

This is public safety legislation, designed to reduce the likelihood of dam failure and the sudden uncontrolled release of water. It does this through a rigorous process of registration, supervision, monitoring and periodic inspections by independent specialist engineers, appointed by Government Ministers. Reports produced by these specialist engineers contain actions to be completed in the interests of public safety that are legally enforceable by Natural Resources Wales and the Environment Agency in England.

The periodic inspections by independent specialist engineers are required at a maximum of 10 yearly intervals, but can be carried out earlier if the specialist engineers have any concerns about dam safety. Changes and improvements to industry guidance and best practice are considered at the time of these inspections with improvement works identified that have legally enforceable timescales.

In addition to the inspections required under the Act, we have used guidance provided by the Guide to Risk Assessment for Reservoirs Safety Management (RARS), published by Defra and Environment Agency in 2013 as the basis for establishing a 'Portfolio Risk Assessment' (PRA) for each Dam. The guidance combines the probability of failure and the risk to life in the event of an uncontrolled release of water to establish a site specific risk rating.

RARS focuses on the reservoir and dam's response to internal and external threats and loads and the release, direction and consequences of flood water from the reservoir. The threats and loads influence the assessment of the probability of failure and include factors such as structural integrity of spillways, the hydraulic capacity of chutes and spillways, slope stability and emergency draw down capacity.

The Dam Safety Portfolio Risk Assessment (PRA) is a structured process of risk assessment that has been carried out on our dams using current industry best practice. It more importantly provides a risk based tool for prioritising investment decisions, as well as capturing the benefit of this investment by demonstrating a reduction in risk. This ensures that we continue to target our investment to effectively reduce the risks at our dams, increase public safety and improve the resilience of the water resource system.

In response to the requirements of the amended legislation, plus continued advancements in new industry guidance and best practice, we need to make significant investments across Wales. This will include programmes of work;

- to repair or replace dam spillways to ensure they can safely pass the design flows in accordance with the 2015 guidance - 'Flood and Reservoirs Safety' 4th Edition, 2015;

- to refurbish and replace pipework and valves in dams to ensure we can continue to operate them safely – 'Measures in the interest of Maintenance' Reservoir Act amended April 2016;

- to increase the size of pipework and valves to ensure we satisfy the 2017 guidance on emergency drawdown capacity - 'Guide to drawdown capacity for reservoir safety and emergency planning': Published 11 August 2017.

Without this investment we can expect regulatory notices requiring us to undertake works to meet our legal duties in the interest of dam safety and in many circumstances we will need to lower the storage within our reservoirs prior to undertaking this work. Any reduction in reservoir storage within our WRZs has the impact of reducing our supply capability (DO). Given the overriding importance of the water resource gained from our reservoirs we would either fall into a supply demand deficit in zones or have significantly reduced resilience to drought without this investment programme.

All of our dams under the Reservoirs Act receive regular investment and work to maintain them. These are ongoing activities into AMP7 and beyond for as long as the dam remains under the scope of the Reservoirs Act. These activities include;

- Routine and regular inspection, monitoring and surveillance
- Studies and investigations
- Routine maintenance to fixed assets and surrounding grounds
- Small scale works e.g. fencing, signage and improvement to provide safe access and egress

Table 44 below contains a list of dam sites by WRZ and highlights where we anticipate the need for more significant dam safety works during the AMP7 period, above and beyond the regular activities identified. We estimate that the cost of this investment in AMP7 will be circa £110 million.

Water Resource Zone (WRZ)	Dam/Reservoir	Overview of the more significant works planned at sites across this WRZ in AMP7
North Eryri Ynys Môn	Cwellyn	Improvement works to pipework and valves at some sites. Potential for upsizing at some sites to increase capacity in order to satisfy the 2017 emergency drawdown guidance. The scope of these works is subject to further local studies and investigations. Improvement work to spillway to maintain its structural integrity and ensure it is able to safely pass the design flows required by the 2015 guidance. The scope of these works is subject to completion of further monitoring, investigations and analysis. Periodic maintenance and testing of rock anchors where required.
North Eryri Ynys Môn	Ffynnon Llugwy	
North Eryri Ynys Môn	Marchlyn Bach	
North Eryri Ynys Môn	Alaw	
North Eryri Ynys Môn	Cefni	
Clwyd Coastal	Plas Uchaf	Improvement works to pipework and valves at some sites. Potential for upsizing at some sites to increase capacity in order to satisfy the 2017 emergency drawdown guidance. The scope of these works is subject to further local studies and investigations. Grouting and works to improve slope stability where required and subject to further investigations and analysis.
Clwyd Coastal	Llyn Aled	
Clwyd Coastal	Llyn Aled Isaf	
Alwen Dee	Alwen	Major improvement and upgrading of pipework, valves and mechanical equipment at Llyn Celyn. Improvement work to Llyn Celyn to ensure it is able to safely pass the design flows required by the 2015 guidance. The scope of
Alwen Dee	Celyn	
Alwen Dee	Brenig	

Water Resource Zone (WRZ)	Dam/Reservoir	Overview of the more significant works planned at sites across this WRZ in AMP7
		these works is subject to completion of further investigations and analysis. Improvement works to the impermeable core at Alwen embankment dam. Subject to further investigations and analysis.
Barmouth	Bodlyn	Improvement works to pipework and valves at Llyn Bodlyn. Potential for upsizing to increase capacity in order to satisfy the 2017 emergency drawdown guidance. The scope of these works is subject to further local studies and investigations.
Lleyn Harlech	Cwmystradllyn	Improvement works to pipework and valves at some sites. Potential for upsizing at some sites to increase capacity in order to satisfy the 2017 emergency drawdown guidance. The scope of these works is subject to further local studies and investigations.
Lleyn Harlech	Cwm Dulyn	
Lleyn Harlech	Llyn Eiddew Mawr	
Lleyn Harlech	Llyn Tecwyn	
Dyffryn Conwy	Cowlyd	We will work with RWE Innogy as undertaker under Reservoirs Act to ensure that all new regulations are met. There is a potential under the next S10 in AMP7 Year 3 Q1 that draw down studies will be needed.
Tywi Conjunctive Use System (CUS)	Llyn Brianne	Improvement works to pipework and valves at some sites. Potential for upsizing at some sites to increase capacity in order to satisfy the 2017 emergency drawdown guidance. The scope of these works is subject to further local studies and investigations. Improvement work to a number of spillways to maintain their structural integrity and ensure they are able to safely pass the design flows required by the 2015 guidance. The scope of these works is subject to completion of further investigations and analysis. Improvement works to draw off towers and access bridges at some sites. Subject to further investigation and evaluation.
Tywi Conjunctive Use System (CUS)	Upper Lliw	
Tywi Conjunctive Use System (CUS)	Lower Lliw	
Tywi Conjunctive Use System (CUS)	Ystradfellte	
Tywi Conjunctive Use System (CUS)	Crai	
Mid & South Ceredigion	Teifi	Improvement works to pipework and valves at some sites. Potential for upsizing at some sites to increase capacity in order to satisfy the 2017 emergency drawdown guidance. The scope of these works is subject to further local studies and investigations. Improvement work to spillway to maintain its structural integrity and ensure it is able to safely pass the design flows required by the 2015 guidance. The scope of these works is subject to completion of further monitoring, investigations and analysis. Grouting and works to improve stability where required and subject to further investigations and analysis
Mid & South Ceredigion	Egnant	
Mid & South Ceredigion	Pond y Gwaith	

Water Resource Zone (WRZ)	Dam/Reservoir	Overview of the more significant works planned at sites across this WRZ in AMP7
North Ceredigion	Craig y Pystyll	Improvement works to pipework and valves at some sites. Potential for upsizing at some sites to increase capacity in order to satisfy the 2017 emergency drawdown guidance. The scope of these works is subject to further local studies and investigations. Grouting and works to improve stability where required and subject to further investigations and analysis. Improvement work to spillway to maintain its structural integrity and ensure it is able to safely pass the design flows required by the 2015 guidance. The scope of these works is subject to completion of further monitoring, investigations and analysis.
North Ceredigion	Llyn Llyghad Rheidol	
Pembrokeshire	Llys y Fran	Potential for structural improvement works at Rosebush subject to the completion of analysis and investigations in AMP6.
Pembrokeshire	Rosebush	
Pembrokeshire	Canaston Bridge	
Elan - Builth	Claerwen	Significant works at a number of sites to improve and refurbish towers, access ways and buildings. Including repair, replacement and upgrading of metal work, where required. Improvement works to pipework and valves at some sites. Potential for upsizing at some sites to increase capacity in order to satisfy the 2017 emergency drawdown guidance. The scope of these works is subject to further local studies and investigations.
Elan - Builth	Dol-y-Mynach	
Elan - Builth	Craig Goch	
Elan - Builth	Pen Y Garreg	
Elan - Builth	Garreg Ddu	
Elan - Builth	Caban Coch	
Brecon – Portis	Usk	Substantial capital works in AMP6 at Usk reservoir. This involves construction of a new spillway and replacement of sections of pipework. Potential for further work at Usk reservoir in order to satisfy the 2017 emergency drawdown guidance.
SEWCUS	Usk	Potential for significant improvement works needed at Llandegfedd subject to investigations and studies undertaken in AMP6. These works may include structural improvements to the tower superstructure and overflow weirs. Works to improve stability under seismic loading and improvements to emergency draw down capacity, as required by the 2017 guidance. Improvement work to a number of spillways to maintain their structural integrity and ensure they are able to safely pass the design flows required by the 2015 guidance. The scope of these works is subject to completion of further investigations and analysis. Significant improvement works to pipework and valves at Castell Nos including tower refurbishment. Potential for upsizing to
SEWCUS	Talybont	
SEWCUS	Llandegfedd	
SEWCUS	Llwynon	
SEWCUS	Cantref	
SEWCUS	Beacons	
SEWCUS	Pontsticill	
SEWCUS	Penderyn	
SEWCUS	Llyn Fawr	
SEWCUS	Castell Nos	
SEWCUS	Shon Sheffrey	
SEWCUS	Upper Carno	
SEWCUS	Lower Carno	
SEWCUS	Blaen-Y-Cwm	
SEWCUS	Rhymney Bridge 1	

Water Resource Zone (WRZ)	Dam/Reservoir	Overview of the more significant works planned at sites across this WRZ in AMP7
SEWCUS	Rhymney Bridge No 2	increase capacity in order to satisfy the 2017 emergency drawdown guidance. The scope of these works is subject to further local studies and investigations, and may be completed in AMP6.
SEWCUS	Nant Moel	Potential for significant structural stability improvement work required at Upper Carno subject to investigations and analysis carried out in AMP6. Potential for structural stability improvement work required at Lower Carno subject to further investigations and analysis.

Table 44 - Welsh Water Dams and Works required in AMP6 and AMP7

7.16.2. Water Supply Resilience – Investment in our Treatment Works

Modern land use with the use of chemicals presents an increasing risk to raw water quality and treatment challenges for our water treatment works. Our engagement with land owners is essential in our understanding of the risks we face but more importantly in the reduction of this risk through education and fostering of improved land management. We believe that a 'catchment as a first line of defence' approach is crucial to the future safeguarding of drinking water quality.

Our strategy is to maintain or improve the water quality in the catchments we rely on for our water supply so that our ability to supply water is not impacted. In response, we have instigated our 'WaterSource' initiative, the name given to our Catchment Management approach and are currently undertaking a number of schemes through co-creation partnering in line with Welsh Government's Well Being of Future Generations agenda. In AMP7 we will continue with this work including specific initiatives such as:

- Building Resilience into Catchment (BRICS – Eastern and Western Cleddau rivers)
- PestSmart – our pesticide disposal scheme and the Weed-wiper Partnership
- Tree planting to reduce landslip impact
- Promoting source 'Safeguard Zones' where appropriate
- Developing partnership working in the Brecon Beacons 'Mega Catchment'

Our investment in this area will increase in AMP7 to around £18m.

As well working to improve the water quality within the catchments from which we take water we need to ensure that our water treatment works are resilient in delivering wholesome water to our customers. As well as ensuring robust and resilient raw water resources, key to maintaining our supply capability is the health of our assets, namely the treatment works, pumping stations, service reservoirs and pipelines that deliver potable water to our customers. These assets require significant ongoing maintenance and investment so they can continue to provide the quantity of water needed to meet customer demands, whilst achieving ever higher drinking water quality standards. Any reduction in the performance of these assets will directly affect the deployable output of our zones and leave us vulnerable during periods of high customer demand.

Of particular note within the SEWCUS zone is our project to replace up to five of our existing treatment works with a new larger works in the Merthyr Tydfil area. The existing works were originally built in the early part of the 20thcentury, and these ageing assets have difficulty in providing a good service in the face of deteriorating raw water quality. The sites have been altered many times over the years and now have limited space for the additional treatment capability required to manage the emerging problems. The current configuration also provides limited resilience to manage supply in the event of problems with poor raw water quality or drought.

We are therefore proposing to construct a new treatment works capable of supplying 350,000 households and businesses with water. The new works would consist of comprehensive and advanced treatment processes capable of treating water to current quality standards as well as being capable of meeting potential future regulatory changes and emerging new risks to drinking water quality. We would also reconfigure the existing pipeline network to feed the new treatment works from existing reservoirs and ensure treated water is supplied to the areas currently served by the existing works. Successful completion of this project will hopefully achieve a much higher and more consistent water quality for our customers. The associated improvements to the network will help ensure a more resilient water supply for the future and support a wider South Wales network, which supplies water to almost 1 million people.

7.17. Alignment with our Drought Plan

As well as a Water Resources Management Plan, we are required to produce a statutory Drought Plan every five years that is also subject to public consultation. Although the Drought Plan is a short term, operational document that sets out the actions we would take to manage a drought across our supply area, they are complementary in a number of key aspects:

1) Level of Service – the frequency of imposition of Temporary Use Bans and Non-essential Use Bans is consistent between both Plans;

2) Our drought triggers for implementing customer side measures to restrict demand are consistent between both Plans;

3) Deployable Output modelling across both Plans utilises the same asset constraints, base demands and hydrological understanding.

Within this Plan we have undertaken a significant amount of work to understand what level of drought event that our water supply systems are resilient to. The results of this will feed in to the production of our 2020 Drought Plan (due for submission to Welsh Government in March 2019) and the review of whether our existing triggers and actions are still appropriate. Any improvements made to our water supply systems as a result of the outcomes of this Plan will be fed back in to our Drought Plan e.g. the Afon Dysynni is currently listed as a supply side drought option for the Tywyn Aberdyfi zone, but if we deliver this scheme in AMP7 then it will need to be removed as a drought option, although the drought resilience of this zone is greatly increased by this permanent solution.

Our current Drought Plan is available at: https://www.dwrcymru.com/en/My-Water/Water-Resources/Drought-Plan.aspx

7.17.1. Learning from the 2018 Dry Weather

Overview

Between April to July 2018 we experienced a very hot dry spell with rainfall around half of normal levels across most parts of our supply area (Table 45). Temperatures were above average for most of this period, with Wales experiencing the hottest June on record, culminating in levels of demand from our customers of over 1,000 Ml/d; approximately 20% higher than normal. Rainfall from the end of April to the end of July was lower than experienced during 1976 across Wales as a whole with parts of North and West Wales experiencing exceptionally low levels of rainfall.

Due to our robust water resource planning and the timely implementation of operational actions and capital schemes where required, we were able to manage this exceptional situation without the need for customer restrictions or additional impacts to the environment. This is in a year that arguably has been hotter and drier across our whole operating area than we have seen previously with Wales as a Country in developing drought for a prolonged period.

During this time we delivered 108 temporary capital schemes that have provided greater flexibility of our water supply systems, supported by a fleet of 40 tankers to both maintain supplies during peak demand periods but also latterly to preserve our supply side positions. There is a strong case for these infrastructure schemes to be made permanent to reduce the need for tankering and human intervention, which will enhance our drought resilience and this is proposed during the early part of our next investment period from 2020.

The benefits of these schemes will be incorporated into our next Drought Plan, due in March 2019 but the introduction of this new infrastructure will also support us to meet our 2050 strategy by reducing the number of water resource zones and providing greater flexibility in our conjunctive use within zones. This would result in the linking of the Barmouth and Lleyn Harlech zones to parts of the North Eyryi Ynys Mon zone, the Hereford and Vowchurch zones and the SEWCUS and Tywi zones.

The drought of 2018 has reinforced our understanding of the peaking in demand above normal levels during hot dry years and has provided additional data regarding reservoir and river inflows. Work now needs to be concluded to understand the context of the drought against other historical events. More importantly our drought plans need to take account of the raw water challenges we face against maintaining modern wholesome water quality standards as reservoirs empty.

We will undertake a review of the 2018 drought, using new modelling software and applying advanced statistical techniques, to understand how our supply systems performed and where there are any areas of risk. Our SEWCUS zone is a key area for review as we are mindful that when the new Habitats Directive abstraction licence conditions take effect, they will significantly reduce the amount of raw water resource available to us when compared to the volumes available this year.

This section provides an overview of the activities that we have undertaken to ensure minimum disruption to our customer service even if this dry weather had continued into August or later.

Rainfall

The period between early-May and mid-July 2018 was notably hot and dry in Wales. The combination of the two meant that we had very little effective rainfall for over 10 weeks.

- Following a relatively dry May (77% of long term average rainfall), June was extremely hot and dry.
- In Wales the mean temperature for June was provisionally 2.2°C above the long-term average, making it the warmest June since records began in 1910.
- With 22% of average rainfall, June was also drier than 1976. During this period the UK soil moisture deficits were the highest on record (in a series from 1961) and the highest for any month since August 1995.

This in turn led to river levels approaching the lowest ever recorded at many locations across Wales. The Afon Tywi registered its lowest June mean flow on record (in a series from 1958) and all rivers gauged by NRW in North Wales were ‘exceptionally low’ (except those used for river regulation).

North and West Wales were particularly dry with the June rainfall at around only 17% of LTA at Valley on Anglesey and Aberporth in Ceredigion.

The hot, dry weather continued into July. The mean temperature for July was provisionally 2.0 °C above the long-term average, provisionally the joint third warmest July in a series from 1910. Rainfall was 68% of average but most of this occurred in the last week. The June and July combined rainfall was 48% of the long term average and from May to July 57% (drier than 1976).

NRW Catchment	May-18	Jun-18	Jul-18	3 month average
Ynys Mon	67%	19%	84%	57%
Alwen	102%	23%	79%	68%
Dee	68%	41%	69%	59%
Clwyd	77%	20%	93%	63%
Valleys & Vale of Glamorgan	71%	18%	85%	58%
Usk	74%	15%	86%	58%
Pembrokeshire	80%	47%	108%	78%
North Ceredigion	62%	16%	72%	50%

Table 45 - May to July 2018 Rainfall as a % of Long Term Average[25]

Water Demand

During the drought event, the hottest weeks occurred between the 26th June and 11th July, just before the school summer holidays. As might be expected, the highest weekly demands coincided with this period with average customer demand increasing dramatically to nearly 1,000 Ml/d. The highest demands occurred earlier than we have seen in previous dry summers. Potentially therefore, demands could have been even greater if high temperatures had continued through late July into August when we normally expect peak demands. We will review the impact of this 'demand profile' upon our water resource modelling and confirm if any of our current assumptions need to be updated

North Eryri Ynys Mon

From the end of April to the middle of July there was very little effective rainfall in North West Wales meaning the rivers draining into our reservoirs were exceptionally low. Levels in our reservoirs draw down at different rates depending on the natural inflows but also the amount of water we abstract for public water supply and the amount of water we need to release into the river downstream for the ecology and fisheries (known as the compensation release). Llyn Cwellyn has considerably less storage compared with the demands placed on it and so draws down much quicker than the other reservoirs in the zone. Our main drought response therefore focussed on reducing our abstraction at Llyn Cwellyn as much as possible to minimise the risk of customer supply restrictions should the dry weather continue.

During the summer we produced regular forecasts of what the potential reservoir levels could be if the dry weather and high demands continued. We used these forecasts to take early action to balance the drawdown between the different reservoirs and maximise the water resources across the zone. This involved making numerous changes to our network operation and developing and implementing temporary infrastructure schemes which allowed us to reduce the demand from Llyn Cwellyn far lower than has ever been achieved in the past. These operational actions meant that rather than crossing into the 'Drought' action zone on the 16th July with storage at 1,000 Ml, by the 16th July storage was actually at 1,400 Ml, thus meaning we could maintain customer supplies for longer without the need for restrictions (Figure 99).

[25] https://naturalresources.wales/guidance-and-advice/environmental-topics/water-management-and-quality/resources/water-situation-report-2018/?lang=en

Temporary capital works included mains infrastructure to provide additional connectivity on Anglesey, a new pipeline to enable water from Anglesey to be pumped on to the mainland and other infrastructure which enabled our Ffynnon Llugwy reservoir and Mynydd Llandegai WTWs to serve the demands normally met by Cwellyn WTWs.

We plan to make these schemes permanent in AMP7 to increase operational flexibility and drought resilience to the zone for the future. We will include the benefits of these infrastructure developments within our drought plan assessments.

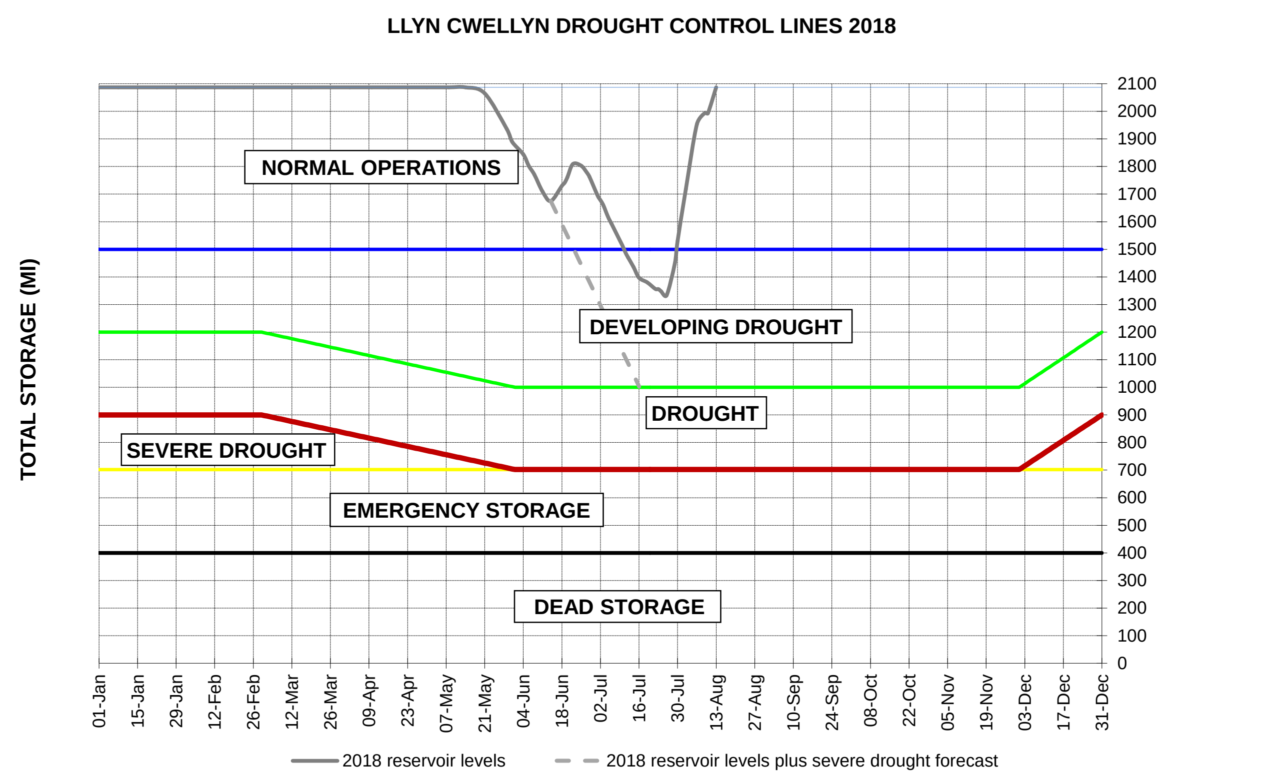


Figure 99 - Llyn Cwellyn 'actual' and 'forecast' reservoir levels 2018

Barmouth

Llyn Bodlyn, like Llyn Cwellyn, also draws down quickly and relies on intermittent rainfall during the spring and summer months to maintain the reservoir levels. Our early forecasts showed that if we encountered a prolonged dry weather event then there was a risk that we would need to implement customer supply restrictions by early August. During the first two weeks of July we installed two potable water links to support zonal demands; one from Rhiwgoch WTW and the other from Cilfor WTW in the neighbouring Lleyn Harlech zone. The abstraction from Llyn Bodlyn was then kept at an absolute minimum and the Eithinfynydd WTW in Barmouth was only used intermittently. This is shown in Figure 100 below where the actual reservoir level is maintained higher than the forecast level.

Being able to transfer water from Lleyn Harlech this summer helped us to avoid customer supply restrictions but has also significantly increased our drought resilience for the future in what is a single source zone. We again plan to make these transfers a permanent arrangement.

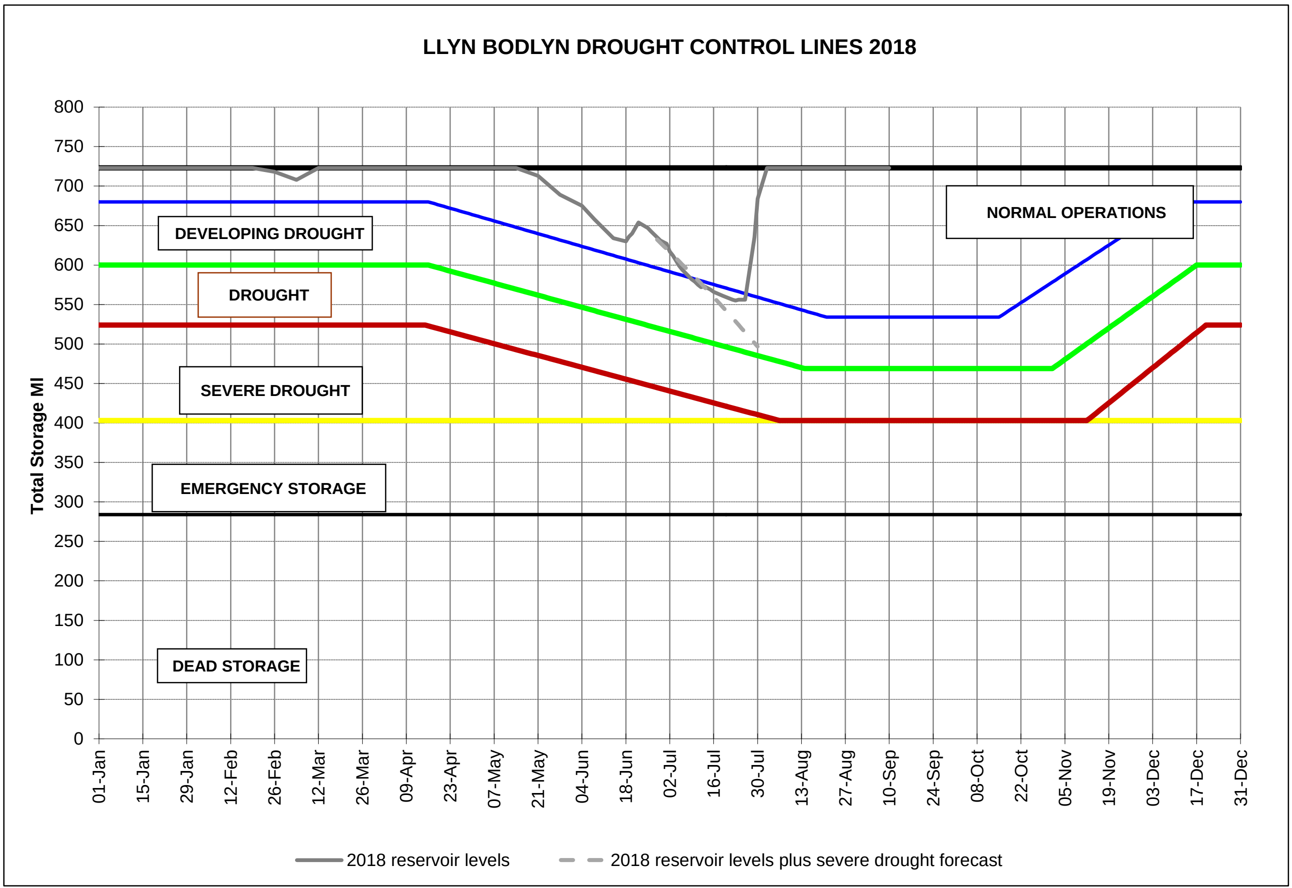


Figure 100 - Llyn Bodlyn 'actual' and 'forecast' reservoir levels 2018

Tywyn Aberdyfi

Of the two stream sources that supply Penybont WTW, we stopped abstracting from the Nant Braich y Rhiw on the 19th June when the hands off flow condition on the abstraction licence took effect. This meant that we were wholly reliant on the Afon Fathew to maintain customer supplies. This has confirmed the potential lack of resilience in the zone and the need for our preferred AMP7 to meet future supply deficit. This is the development of a new abstraction from the Afon Dysynni which would provide full drought resilience given the greater levels of flow in this river.

Pembrokeshire

In our Pembrokeshire zone, the pumpback scheme from Llysyfran reservoir to Preseli WTW that was identified in WRMP14, has been utilised extensively to help balance supplies in the zone. This dry period has also provided us with the opportunity to test the performance of our reservoir control rules to see how well they guided the management of our water resources. These will now be reviewed and updated as required in our next Drought Plan and future Water Resource Management Plans.

SEWCUS

The maintenance of water supplies across our most populous zone will always be a priority. From late April we have been working to balance the water resources within our 5 large reservoirs across the zone and to make best use of the lowland river sources to maximise the availability of water resources. Figure 101 provides a plot of the reservoir levels within the 'Big 5' reservoir group. This operation was only possible due to the benefit gained from the resilience schemes identified for SEWCUS in our WRMP14, which has reduced the risk to customer supplies this year.

For example we have reinstated our abstraction point at Manoravan on the River Tywi to provide an alternative source of supply to Usk reservoir for our Bryngwyn WTW. This enabled us to utilise Usk reservoir water in SEWCUS by regulating c1,900 Ml for subsequent re-abstraction at Prioress Mill into Llandegfedd reservoir. We have also fast tracked other SEWCUS resilience schemes including the recommissioning of the Llantrisant pumping station at our abstraction point on the lower River Usk and re-modelling of our Sor pumping station.

Figure 101 includes a forecast for a continued drought beyond that seen this summer. It can be seen that the effects of our drought actions along with some rainfall in August has resulted in no requirement for demand management action this year. However, without the August rainfall and with a continuation of dry weather into August and September, SEWCUS resilience would have been severely tested.

New abstraction licence conditions take effect at Prioress Mill and Llantrisant next year and this will mean that abstraction from the River Usk will be further restricted. Given our experience this year, we are undertaking a review of our system performance to confirm our level of our resilience to droughts within the SEWCUS zone. We are currently developing a water resource model for the zone along with new statistically based inflow series with which to test system performance. We will present these results in our forthcoming Drought Plan.

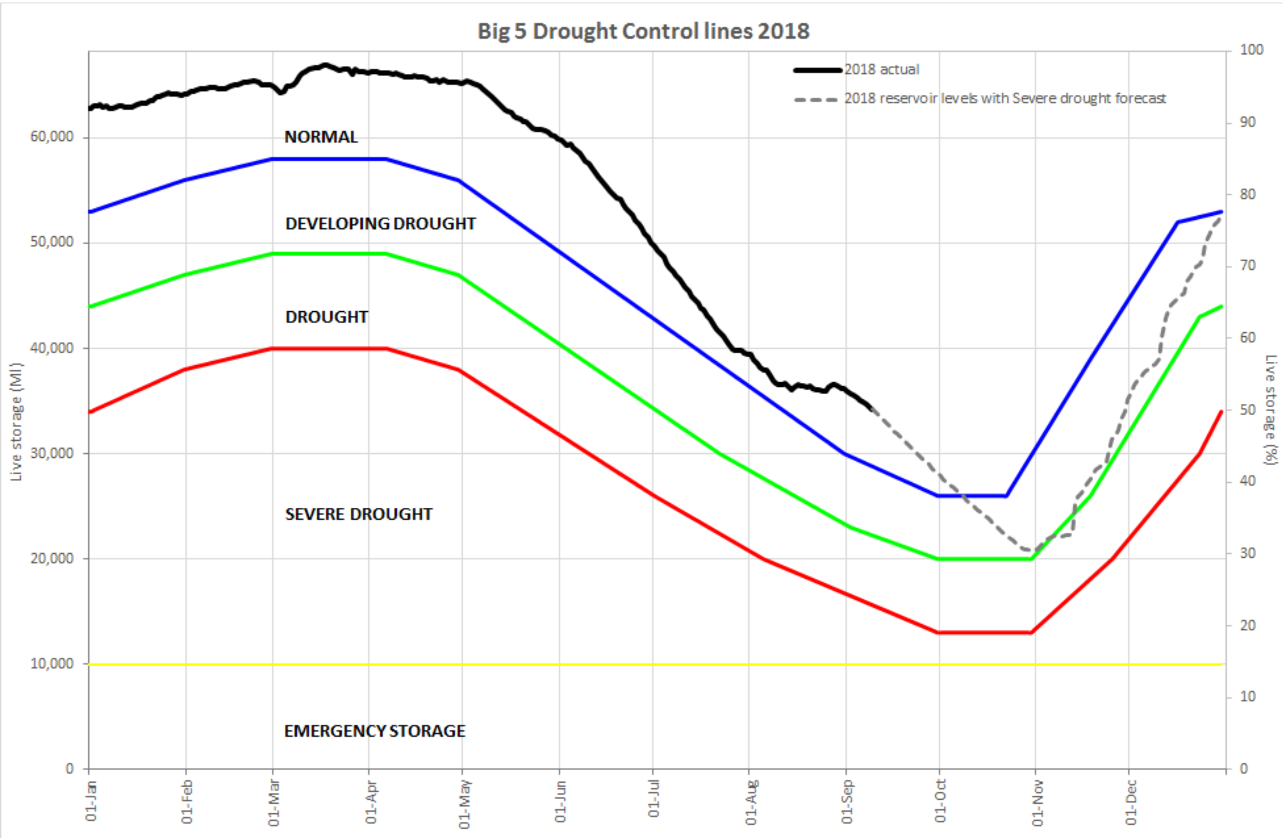


Figure 101 - Big 5 Combined Storage 'actual' and 'forecast' reservoir levels 2018

AMP7 improvements

In summary the drought of 2018 has reinforced our understanding of the peaking in demand by over 150 Ml/d above normal levels during hot dry years. The recent dry weather also provided additional data regarding reservoir inflows and work needs to be concluded to understand the context of the drought against other historical events. What can be concluded to date is that, in line with our Welsh Water 2050 plans, the additional connectivity temporarily employed during this summer has provided significant resilience benefits.

There is a strong case to make these schemes permanent by inclusion within our PR19 Business Plan submission. These may also impact upon zonal deployable outputs and we will include these within our updated system modelling and include the results within our WRMP Annual Review. Schemes will include:

- Connect permanently, for use bi-directionally, Anglesey with mainland North Eryri;
- Integrate Lleyn Harlech WRZ to Barmouth WRZ to enable the two zones to be considered as one conjunctive use zone;
- Increase the capacity and create a bi-directional connection between SEWCUS and Tywi CUS which provides an additional step to merging these WRZ as part of our aim under Welsh Water 2050.

Water Resource Model Improvements

Following a review of the dry weather, a number of work streams are set to commence to improve our management of future events:

- Updated water resource models, using the Aquator software, that take account of operational changes to our water supply networks and improved understanding of asset performance
- Review of the demand information used in these models and whether 2018 now provides a better representation of customers demand than 2006, which is our current 'baseline' dry year
- Review of our hydrological inflows, aligned with the advanced stochastic modelling being undertaken for the Drought Plan in order to complete the requirements of the Drought Vulnerability Framework
- Review of our reservoir operational and drought control curves to confirm that these are driving the efficient and sustainable management of our raw water sources.

The results of the stochastic analysis will aid in the understanding of the drought risk we face in each of our WRZs and allied to recent experience, will help us to produce a robust and responsive Drought Plan.

7.18. Future Water Resources Planning Challenges

In our Water 2050 vision we have set out a number of future challenges that the business will face. Specific to our Water Resources Plan we will need to consider the following in the AMP7 period:

- The Government Proposals on Abstraction Reform and changes to Regulation of the industry under the Water Act 2014 – Through discussions with NRW we have assumed that Abstraction Reform will not impact upon the deployable output of our supply systems and we will need to understand this fully as reform is put in place;

- The further development of water resources markets and trading and understanding the value of water resources in this context – As discussed in chapter 6, we have been working with the water industry which is looking at the long term need for water resource provision across England and Wales and the potential for transferring water between company areas. More specifically, we have been working to explore potential options, and cost benefits of sharing water resources with other water companies. These discussions have not to date led to any firm agreements. We will continue with this work;

- New climate change planning scenarios (UKCP18) – We will need to maintain awareness of the new UKCP18 work which will provide an improved evidence base for the potential impact of climate change into the future. In addition we are already involved in a number of UK water industry research projects that will use this data to better understand climate change and extreme drought risk;

- Further improvement in understanding our resilience to extreme drought events- We have undertaken detailed risk assessments using innovative techniques to understand our resilience to severe droughts in 4 of our water resource zones to date and used a simplified analysis in our remaining zones. We will be looking at the use of innovative flow and weather generation models to improve our confidence in water resource resilience across our region in AMP7;

- Manage and planning our water resources to ensure customer views and customer affordability objectives are met;

- Potential growth or new development that increases the demand for water – we will continue to track demand as a business as usual activity and where new evidence becomes available improve our demand forecasts. We will work with the local authorities in our area to maintain our understanding.

- The potential future use of Natural Capital Accounting (NCA) and its impact upon the options appraisal process for any future water resources schemes.

In response to these challenges we will continue to work closely with our regulators to continually improve our processes and understanding of the risks that we are presented with. We have invested in a new water resources modelling platform 'Aquator' which will provide us with a new application to support our water resources and drought plan development through improved deployable output modelling. We are also improving our catchment modelling capability so that we can improve the representation of the hydrological inflows within our reservoir and river catchments where needed.

We will continue to use the Annual Review process to report on any changes to our supply demand balances and to report on progress against this Plan.

REFERENCES

- Welsh Water 2050: Consultation Document. 2017
- Water Industry Act 1991 https://www.legislation.gov.uk/ukpga/1991/56/contents
- Water Act 2003 https://www.legislation.gov.uk/ukpga/2003/37/contents
- Reservoir Act, 1975 https://www.legislation.gov.uk/ukpga/1975/23/contents
- Water Act 2014 https://www.legislation.gov.uk/ukpga/2014/21/contents
- The Water Resources Management Plan (Wales) Directions 2016
- The Welsh Government Guiding Principles for Developing Water Resources Management Plans (WRMP's) for 2020, (April 2016)
- Welsh Government Water Strategy for Wales (2015) Supporting the sustainable management of our natural resources http://gov.wales/topics/environmentcountryside/epq/waterflooding/publications/water-strategy/?lang=en
- Welsh Government Environment (Wales) Act 2016 http://gov.wales/topics/environmentcountryside/consmanagement/natural-resources-management/environment-act/?lang=en
- Welsh Government Well-being of Future Generations (Wales) Act 2015 http://gov.wales/topics/people-and-communities/people/future-generations-act/?lang=en
- Demand Forecasting Methodology' (UKWIR/NRA 1995). Report ref 95/WR/01/1
- UKWIR (2016) WRMP 2019 Methods – Decision Making Process: Guidance. Report ref: 16/WR/02/10
- UKWIR (2016) WRMP 2019 Methods – Risk Based Planning. Report ref: 16/WR/02/11
- UKWIR (2002) Economics of Balancing Supply and Demand (EBSD). Report ref: 02/WR/27/3
- Environment Agency/Natural Resources Wales - Water Resources Planning Guideline: Interim update April 2017
- OFWAT (2016) our regulatory approach for water and wastewater services in England & Wales – overview
- OFWAT (2017) Delivering Water 2020 : Consulting on our methodology for the 2019 Price Review
- UKWIR (2014) Handbook of source yield methodologies. Report ref: 14/WR/27/7
- Heavily Modified Water Bodies: Guidance Document, UKWIR (2012), report ref: 12/WR/33/4
- Making the Most of Every Drop Consultation - Reforming the Water Abstraction Management System in Wales. January 2016.Welsh Government http://gov.wales/about/cabinet/decisions/previous-administration/2014/julsep/environment/ad2154/?lang=en
- Environment Agency (2017) WRMP19 supplementary information: Estimating impacts of climate change on water supply;
- Environment Agency (2013) Climate change approaches in water resources planning – Overview of new methods.
- Environment Agency (2016): Estimating impacts of climate change on water supply
- Enviroment Agency (2009) : Abstraction Metering Good Practice Manual
- UKIWR (2002): An Improved Methodology for Assessing Headroom
- UKIWR (2010): Managing Leakage 2011. Report ref: 10/WM/08/42
- UKWIR (2015): WRMP19 – Methods – Population, Household Property and Occupancy Forecasting. Report ref: 15/WR/02/8
- UKWIR (2015): WRMP19 Methods – Household Consumption Forecasting. Report ref: 15/WR/02/9
- UKWIR (2013): Impact of Climate Change on Water Demand – Main report. Report ref: 13/CL/04/12
- UKWIR (2017): Consistency of Reporting Performance Measures. Report ref: 17/RG/04/5
- UKWIR (1999): Estimating Legitimate Non-Household Night Use Allowances. Report ref: 99/WM/08/26

- UKWIR (2017): Future Estimation of Unmeasured Household Consumption. Report ref: 17/WR/01/16
- UKWIR (2017): Assessment of Key Parameters for Leakage Analysis. Report ref: 17/WM/08/59
- UKWIR (2006): Peak Water Demand Forecasting Methodology. Report ref: 06/WR/01/7
- United Kingdom Climate Projections 2009 (UKCP09)
- Swansea Local Development Plan, Deposit Plan, 2016
- Neath Port Talbot Local Development Plan, Adopted Plan, 2016
- Bridgend Local Development Plan, Adopted Plan, 2013
- Ceredigion Local Development Plan, Adopted Plan, 2013
- Pembrokeshire County Council Local Development Plan, Adopted Plan, 2013
- Future Water Efficiency Targets – A Consultation' (Ofwat, 2008).
- Water, water everywhere? Delivering a resilient water system (2016-17) CCWater December 2017
- Attitudes to Tap Water and Using Water Wisely Survey 2016 CCWater/BMG Research, August 2016
- Guide to Risk Assessment for Reservoirs Safety Management, Defra and the Enviroment Agency, 2013.
- https://naturalresources.wales/guidance-and-advice/environmental-topics/water-management-and-quality/resources/water-situation-report-2018/?lang=en
- Ref 5.8J PR19 Investment Case: Leakage Improvement (Dwr Cymru Welsh Water, September 2018).

GLOSSARY

Abstraction	The removal of water from any source, either permanently or temporarily.
Abstraction licence	The authorisation granted by Natural Resources Wales and the Environment Agency (in England) to allow the removal of water from a source.
Annual average	The total demand in a year, divided by the number of days in the year.
Available headroom	The difference (in Ml/d or percent) between water available for use (including imported water) and demand at any given point in time.
Average incremental social costs	The ratio of present social costs over present net value of additional water delivered or reduced demand
Consumption monitor	A sample of properties whose consumption is monitored in order to provide information on the consumption and behaviour of properties served by a company.
Demand management	The implementation of policies or measures which serve to control or influence the consumption or waste of water (this definition can be applied at any point along the chain of supply).
Deployable output	The output of a commissioned source or group of sources or of bulk supply as constrained by: • environment • Licence, if applicable • Pumping plant and/or well/aquifer properties • raw water mains and/or aquifers • treatment • water quality
Distribution input	The amount of water entering the distribution system at the point of production.
Distribution losses	Made up of losses on trunk mains, service reservoirs, distribution mains and communication pipes. Distribution losses are distribution input less water taken.
Drought order	An authorisation granted by the Secretary of State under drought conditions, which imposes restrictions upon the use of water and/or allows for abstraction/impoundment outside the schedule of existing licences on a temporary basis.

Drought permit	An authorisation granted by the Environment Agency under drought conditions, which allows for abstraction/impoundment outside the schedule of existing licences on a temporary basis.
Economic level of leakage (ELL)	The level of leakage at which it would cost more to make further reductions than to produce the water from another source
Final planning scenario	The scenario of water available for use and final planning demand forecast which constitute the company's best estimate for planning purposes, and which is consistent with information provided to Ofwat for the Periodic Review.
Habitats Regulations Assessment (HRA)	An assessment, required under the EU Habitats and Species Directive, of the potential effects of a proposed plan, programme or project on one or more Natura 2000 sites.
Level of Service	The frequency with which a hosepipe ban or a Drought Order/ Permit would be expected to be required in order to maintain water supplies
Meter optants	Properties in which a meter is voluntarily installed at the request of its occupants.
Meter programme	Properties, which are to be metered according to current company metering policy.
Net Present Value	The difference between the discounted sum of all of the benefits arising from a project and the discounted sum of all the costs arising from the project.
Non-households	Properties receiving potable supplies that are not occupied as domestic premises, for example, factories, offices and commercial premises.
Outage	A temporary loss of deployable output.
Point of consumption	The point where the supply pipe rises above ground level within the property, usually the inside stopcock or an internal meter.
Point of delivery	The point at which water is transferred from mains or pipes, which are vested in the water supplier into, pipes which are the responsibility of the customer. In practice this is usually the outside stopcock, boundary box or external meter.
Point of production	The point where treated water enters the distribution system.
Per Capita Consumption (PCC)	The current term which includes the metric used to quantify the amount of water consumed per person, in terms of domestic consumption for a household. Units can typically be in litres / day.

Risk	A measure of the probability and magnitude of an event and the consequences of its occurrence.
Source	A named input to a resource zone. A multiple well/spring source is a named place where water is abstracted from more than one operational well/spring.
Strategic Environmental Assessment (SEA)	A process of assessing the environmental opportunities and restrictions of a project, and identifying and managing its implications.
Supply-demand balance	The difference between water available for use (including imported water) and demand at any given point in time (c.f. available headroom).
Supply pipe losses	The sum of underground supply pipe losses and above ground supply pipe losses.
Sustainability reduction	Reductions in deployable output required by the Environment Agency to meet statutory and/or environmental requirements.
Target headroom	The threshold of minimum acceptable headroom, which would trigger the need for water management options to increase water available for use or decrease demand.
Total leakage	The sum of distribution losses arid underground supply pipe losses.
Treatment work operational use	Treatment process water i.e. net loss, which excludes water returned to source water.
Underground supply pipe losses	Losses between the point of delivery and the point of consumption.
Unrestricted demand	The demand for water when there are no restrictions in place.
Water available for use (WAFU)	The value calculated by deducting allowable outages and planning allowances from deployable output in a resource zone.
Water Resource zone (WRZ)	The largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which all customers experience the same risk failure from a resource shortfall of supply

APPENDICES

1. Appendix 1 – Assurance letter (Jacobs)
2. Appendix 2 – Security Statement
3. Appendix 3 – Analysis of Headroom Uncertainty (ATKINS)
4. Appendix 4 – Problem Characterisation (ATKINS)
5. Appendix 5 – dWRMP19 Method Statement
6. Appendix 6 – Baseline Deployable Output assessment (AmecFW)
7. Appendix 7 – Review and update of WRAPSim demand allocations (Artesia)
8. Appendix 8 – WRMP19 Inflows review and update (AmecFW)
9. Appendix 9 – Best Value Analysis hydrology update (ATKINS)
10. Appendix 10 – Impact of Climate Change on DO (AmecFW)
11. Appendix 11 – Climate Change Flow Factor (HRWallingford)
12. Appendix 12 – Basic Vulnerability Assessment (HRWallingford)
13. Appendix 13 – WRMP19 Assessment of outage (AmecFW)
14. Appendix 14 - Catchment Options Appraisal (AmecFW)
15. Appendix 15 – Demand Forecasting Technical Report
16. Appendix 16 – WRMP19 Household Consumption Forecast (Artesia)
17. Appendix 17 – AMP7 SELL Assessment (RPS)
18. Appendix 18 – Water Resource Zone Integrity Assessment
19. Appendix 19 – EVA resilience assessment (ATKINS)
20. Appendix 20 – NEYM resilience assessment (ATKINS)
21. Appendix 21 – Tywyn resilience assessment (ATKINS)
22. Appendix 22 – Pembrokeshire resilience assessment (ATKINS)
23. Appendix 23 – SEWCUS resilience assessment (ATKINS)
24. Appendix 24 - Engineering Assessment Methodology (AmecFW)
25. Appendix 25 – Options Screening Methodology and Outcomes (AmecFW)
26. Appendix 26 – Willingness to Pay Survey Results (Accent)
27. Appendix 27 - SEA
28. Appendix 28 - HRA
29. Appendix 29 – Water Framework Directive Assessments of feasible options (AmecFW)
30. Appendix 30 – Options costing proforma
31. Appendix 31 – EBSD Optimisation Method Statement (decisionLab)
32. Appendix 32 – Technical note 1 – Unconstrained List of Resource Options (AmecFW)
33. Appendix 33 – Social and Environmental Evaluation Report for Option Appraisal (AmecFW)
34. Appendix 34 – Water Efficiency Schemes