Draft Water Resources Management Plan 2019

Contents

Summary of our plan 3

1 Introduction 17

2 Customer and stakeholder involvement 25

3 Our water supply system 34

4 Our baseline position 43

5 Identifying future options 81

6 Strategic choices for our region 94

7 Preferred plan and alternatives 109

8 Testing our plans 127

9 Assurance and board engagement 132

10 Conclusions 135

Appendix A - List of technical reports 138

Appendix B - References 139

Appendix C - Glossary 141

Topics of interest

1 What is a Water Resources Management Plan and how is it put together?
Page 17

2 How have we engaged with customers and stakeholders in preparing this Water Resources Management Plan?
Page 25

3 Where do we get our water from and how are the water supplies managed in our region?
Page 34

4 What is the supply-demand balance?

How resilient is our water supply system?
Page 43

4.2 What are we currently doing to reduce leakage and conserve water?
Page 44

4.3 What are the demands for water and how will it change in the future?
Page 51

4.4 What is the supply from our water sources and how will it change in the future?

How has the impact of climate change been taken into account?
Page 59

4.5 How are forecasting uncertainties taken into account in this plan?
Page 65

4.6 If no further action is taken what would the supply-demand balance be?
Page 67

4.7 How have we assessed water supply resilience to different hazards?

What level of water supply resilience do we have, before taking further action?
Page 71

5 What types of options have been considered, and how have they been compared?

How have we sought innovative solutions and identified options from outside the company?

What are the environmental implications of the options?
Page 81

6 What are our future proposed plans for:
- Further leakage reductions
- Customer levels of service
- Improving water supply resilience
- Enabling a future water trade

Page 94

7 What alternative plans have we considered and what is our proposal?
Page 109

8 How have we tested our proposed plans to ensure that they are robust?
Page 127

9 What steps have we taken to assure the robustness of the plan?
Page 132

10 What are the key findings of this document?
Page 135

Summary of our plan

United Utilities is committed to delivering reliable, safe, clean and resilient water supplies to three million household customers and around 200,000 non-household customers in the North West of England at a fair price. This document is our draft Water Resources Management Plan 2019 that defines our strategy to achieve a long-term, best-value and sustainable plan for water supplies in the North West. It ensures that we have an adequate supply to meet demand over the 25 years from 2020 to 2045. We have put processes in place to ensure that Board Assurance of this plan, including a statement to the Drinking Water Inspectorate that drinking water quality is fully protected under this plan.

Key points

- **Our dry year supply-demand forecasts show a surplus over the 25 years from 2020 to 2045, accounting for future economic and population growth, and climate change**
- **Our demand management plans offset upward pressures on demand. We are proposing leakage reductions of 18% over the 25 years, whilst also continuing to achieve current levels of water efficiency savings**
- **These demand management activities allow us to unlock further benefits, in particular a halving of our stated risk of requiring drought permits to augment supply by 2025**
- **We have also tested our plan to a range of hazards other than drought to ensure our supply system is resilient and in the process identified some key areas for improvement**
- **We've explored what a future water trade from the North West to other parts of the UK would mean. We outline plans for consultation on these proposals, which protect existing resilience, water quality and the environment**

Legacy of the 2015 Water Resources Management Plan

We produce a new Water Resources Management Plan every five years. In our last plan, published in 2015 and covering the period 2015-2040, we identified a future supply shortfall in our West Cumbria Resource Zone[1]. The Thirlmere Transfer scheme was selected to meet this shortfall by using some of the water available in our neighbouring Integrated Resource Zone. We are in the process of building a new water treatment works and a pipeline from Thirlmere Reservoir into West Cumbria. Once finished by 2022, West Cumbria will be in one of the UK's largest water resource zones. To protect the environment prior to delivery of this solution, a range of interim measures were also identified

[1] A water resource zone is an area within which water sources can be shared effectively. Customers within a resource zone should experience broadly the same risk of supply failure from a resource shortfall and therefore the same level of service.

in the plan to keep abstraction and impacts on the environment to a minimum. Further detail on West Cumbria can be in our *Draft WRMP19 Technical Report – West Cumbria legacy.*

We are continuing to deliver the outcomes of the previous plan and in developing this Water Resources Management Plan 2019 we reflect how our supply system will look once these are complete. Therefore, as a long-term 25 year strategic view, this plan now reflects the merging of the previous West Cumbria and Integrated Resource Zones. We are now calling this the Strategic Resource Zone to draw distinction with the previous zones. We've also for the first time included a new, smaller resource zone called Barepot to reflect supplies to commercial customers (non-potable in nature, i.e. not to drinking water standard) located in the West Cumbria area. Whilst we have other non-potable or commercial supplies, those at Barepot lack connectivity into an existing resource zone. The water resource zones assessed in this draft Water Resources Management Plan 2019 are shown in Figure 1.

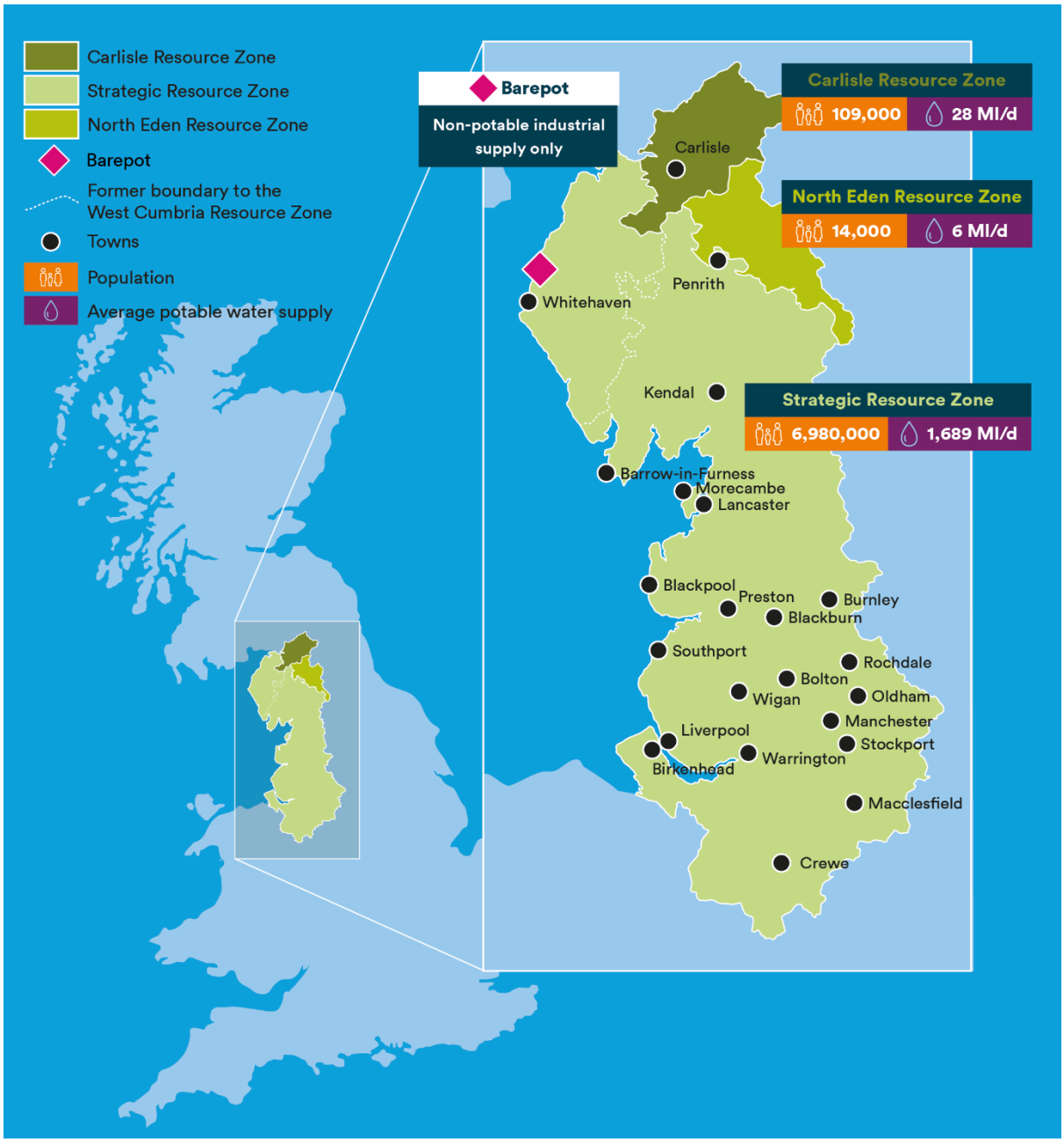


Figure 1 Resource zones in the North West from 2022/23

Our approach to building the draft 2019 plan

There are a number of changes in our approach to building this plan from previous ones, in part driven by new policy and guidelines, but also listening to and acting on what customers, stakeholders and regulators have told us.

We have completed extensive customer and stakeholder engagement following these key objectives:

- **Engaging early** – This has been important to ensure we can fully take feedback on board in developing our plan. For example, we completed an extensive pre-consultation activity with regulators and stakeholders in autumn 2016 before starting work on the plan.
- **Engaging widely** – We have sought collaboration and feedback on our plan as it evolves as broadly as practically possible and used different routes to discuss development of our plans. We have engaged the commercial markets to identify new and innovative potential third party solutions, as detailed in Section 5 of our plan.
- **Using different or innovative approaches** –
    - In engaging with customers in particular, we have sought to understand preferences and views based on a variety of research methods to support our decisions.
    - We have used a range of interactive techniques, including a 'build your own plan' game, to improve awareness on the choices that people are making.

Our plan is designed to meet the aspirations and requirements set out by Defra as defined in its *Guiding principles for water resources planning*. These guiding principles outline the key policy priorities the government expects Water Resources Management Plans to address, which we discuss in turn below:

Government policy

- We take into account local authority plans for growth to meet government economic and housing development ambitions.
- We ensure that our plan continues to meet drinking water quality standards now and in the long-term, whilst ensuring that there is no deterioration in the quality of the water which is supplied. This is in line with the latest Drinking Water Inspectorate guidance[2] to water companies.
- We have followed the latest regulatory guidelines and Defra Direction[3] in developing the plan.

Take a long term, strategic approach to protecting and enhancing resilient water supplies

- We have used new methods from recent industry research to test the plan under a wide range of possible future scenarios. We are one of a number of leading water companies implementing these techniques in this planning round.
- We have developed sophisticated new techniques to test the response of our water supply system to more severe and different patterns of drought than we have seen historically, and used the latest industry climate change approaches.
- Our approach helps us to see how plans might perform beyond the 25 year planning horizon out into the 2080s to ensure they are robust.

[2] Drinking Water Inspectorate long term planning for the quality of drinking water supplies, September 2017: http://www.dwi.gov.uk/stakeholders/guidance-and-codes-of-practice/ltpg.pdf
[3] The Water Resources Management Plan (England) Direction 2017.

- Our approach has been designed to test the 'value' of different solutions beyond meeting the supply-demand balance, but also to include performance related to resilience and the environment. This allows us to define the long-term 'best-value' (or cost effective) plan rather than just a traditional 'least-cost'.
- For the first time our plan looks at how resilient we are to a host of non-drought hazards to water supply, including flooding, freeze-thaw[4], contamination, asset failure and power failure. We also ensure no deterioration in resilience or water quality in our assessment of future water trading.

Consider every option to meet future public water supply needs

- We have collaborated closely with customers, regulators, stakeholders and other third parties, to co-create a plan, considering multiple options to meet future public water supply needs. This has included engagement with commercial markets to investigate different and innovative third party solutions, as detailed in the 'Identifying future options' section of our plan.
- In collaboration[5] with other water companies, we have considered water trading as a pathway[6] in our preferred plan. We have completed discussions with all neighbouring water companies to understand cross-boundary or joint options. Very recently, a Water Resources North group has been inaugurated to further promote collaborative working on water resources between organisations in the North of England in future.
- Competitive markets and innovation underpin this plan, from contractor and supplier selection through to delivery of Water Resources Management Plan options. Our preferred plan includes a sizeable contribution from third-party options.

Protect and enhance our environment, acting collaboratively

- Our plan seeks to ensure that we avoid deterioration of the condition of catchments and waterbodies under the terms of the Water Framework Directive in particular. Assessment of the impacts and benefits of the plan to the environment is fundamental to its development; we strive to enhance the environment through the delivery of our plan. Where risks are identified as part of our long-term plans, we will complete further investigation in the future to explore these and mitigate any impacts.
- We have worked with the environmental regulators to identify and account for sustainability changes *via* the Water Industry National Environment Programme (WINEP), which sets out measures needed to protect and improve the environment. We've identified the need for further investigations from 2020 onwards, and will continue to work with regulators and stakeholders (such as River Trusts) to protect against deterioration and, where possible, reverse it.

Promote efficient water use and reduce leakage

- We have considered options that seek to reduce demand and have fully assessed them as part of our options identification and appraisal.

[4] Freeze-thaw events relate to peak demands caused by rapidly increasing leakage levels. These normally occur during the winter months, when changes in temperature can cause the ground to freeze and then thaw relatively quickly. This can result in pipes or mains cracking or bursting.

[5] This is sometimes referred to as co-creation.

[6] Essentially, this is a plan within a plan, to show what our strategy for water resources in the North West might look like with or without a future water trading export from the region.

- We have explored the costs and benefits of different demand management solutions, and engaged with customers and stakeholders on future potential plans. This has informed our future strategy.
- We have explored how we can engage with customers differently to communicate water efficiency messages and are currently trialling new approaches to encourage customers to install water meters.
- Demand and consumption are still forecast to reduce through the 25 year planning horizon, as in our previous plan. There is inherent uncertainty in future forecasts such as around future economic or population growth, including the impact of the UK's decision to leave the European Union. We have therefore accounted for plausible uncertainty in our target headroom allocation and demand scenarios, and will track trends as part of the Annual Water Resources Management Plan review process.

Starting position – what our forecasts said

- **From our 2015 plan we forecast a surplus in all resource zones, except West Cumbria, where we identified a future supply shortfall**
- **We are in the process addressing this shortfall, with a new water treatment works and a pipeline from Thirlmere Reservoir into West Cumbria. This will create a new Strategic Resource Zone, which has been assessed in this plan**
- **In this 2019 plan we forecast that we will maintain a surplus in all of our resource zones. Our plan is therefore focussed on other key choices for the future such as further demand reductions, levels of service, water supply resilience and the potential for water trading**

In preparing this draft Water Resources Management Plan we have assessed our supply-demand balance again using the latest data, tools and methods. This includes the latest population and local authority growth forecasts, and accounts for the potential impacts of climate change. The outcomes of the assessment show that we have a surplus in all of our water resource zones in a dry year. This is a really positive result as it provides an opportunity for us to explore how we can improve and provide a better service for both customers and the environment in our plan.

Through our analysis we looked at the risk of drought impacts on our water supply system, and how often we would have to implement emergency drought orders. Our current performance in this area is better than the Defra reference level of service (which is no more than 1 in 200 years on average, or 0.5% annual average risk). However, we recognise the consequences of drought are still of concern to customers and other stakeholders and so have accounted for this in our plans (see below).

Our testing of freeze-thaw (peak demand) resilience demonstrated that our system is resilient to repeats of historic freeze-thaw events and can cope with peak demands significantly higher than those previously experienced.

Through our water supply resilience risk assessment process we have also identified other resilience needs across our Strategic, Carlisle and North Eden Resource Zones. These risks can broadly be grouped into three categories of resilience risk at our water treatment works, regional aqueduct system, and trunk mains. The dominant hazards are contamination of raw water and asset failure.

We recognise the significance of these risks and have started to make improvements in this area, with around £200 million being spent on targeted resilience improvements by 2020.

What are our proposed plans for the period 2020-2045?

Drought resilience

In this 2019 plan we have tested our system to droughts that are more severe or extreme than historically experienced. These demonstrate a good level of resilience to drought in our region and our "design drought" remains unchanged.

- **What are we proposing?** – Our strategy is to, as a minimum, protect the existing levels of resilience we have and seek to enhance this where possible when we are completing activities to meet other drivers (e.g. leakage reduction, resilience enhancements, water trading).

- **Why are we proposing this?** – Our assessments show a good level of resilience to severe and extreme droughts relative to other hazards, and there is little evidence that customers would support further investment in this area to make the system more resilient. However, customers frequently state having reliable water supplies as a priority and do not want to see deterioration in service levels under future water trading or other proposals.

Enhanced demand management and leakage

In our 2015 plan, regional leakage was not forecast to reduce over the 25 year planning period from the target of 463 Ml/d. We've outperformed this target in the last few years, giving us a baseline position of 448 Ml/d for our 2019 plan. In this plan, we propose to reduce leakage by 80 Ml/d (or 18%) by the year 2045, at a pace that ensures cost effectiveness and affordability for customers.

- **What are we proposing?** – Whilst our leakage is already below the sustainable economic level, we propose to reduce leakage further by a total of 80 million litres per day (Ml/d) over the 25 year period until 2045. This is an 18% reduction from the baseline position of 448 Ml/d; 30 Ml/d of this reduction will be achieved by 2025 and the associated bill impact is expected to be no greater than a 55 pence increase per annum for every household. We are planning to achieve this initially by increasing our leakage detection and repair resources. However, over the course of the planning horizon we will seek to apply innovations and involve specialist third parties to achieve our long-term leakage aspirations as affordable for customers as possible. For example, we are currently exploring using satellite imagery to detect leaks, in-pipe assessment techniques and approaches to better monitor customer supply pipe leakage. We will also strive to maintain the rate of water efficiency savings we've seen historically, and continue to explore different approaches so that around 75% of customers will be on a water meter by 2045.

- **Why are we proposing this?** – Customers are willing to pay more on their bills to see some leakage reductions, however there are also affordability considerations as to how far we can go. Our programme aims to balance shorter-term affordability with our aspirations to reduce leakage. This customer and stakeholder feedback complements the strong policy aspirations

set by regulators in this area. Our water efficiency activities also help to offset the impacts of an increasing population on water demand.

Levels of service – frequency of drought permits or orders[7]

Our 2015 plan retained the existing levels of service, but committed to explore the potential for improvement in the next plan. In our 2019 plan we propose improving levels of service for drought permits and orders (to augment supplies during drought). This will reduce the stated level of service from 1 in 20 years to 1 in 40 years on average (or from 5% to 2.5% annual average risk) by 2025.

- **What are we proposing?** – To retain the level of service for the frequency of temporary use bans (aka hosepipe bans) at no more than once every 20 years on average (5% annual average risk). However, we propose moving the frequency of drought permits/orders to a better level; no more than once every 40 years (2.5% annual average risk) on average as part of this plan.

- **Why are we proposing this?** – Whilst our drought resilience is high, we recognise that the consequences of drought are still of concern to stakeholders. This is because drought permits and orders have the potential to have socio-economic (e.g. tourism) or environmental impacts, which was a key theme raised during pre-consultation. Whilst customers did typically see existing levels to be acceptable, they placed some value on service improvements in this area. This can be achieved following initial leakage reduction activities in 2025.

National water trading

In the last planning round the potential to export water from Lake Vyrnwy was identified as an option in other company plans. For this 2019 plan we explore the potential for a specific trade to the South East from Lake Vyrnwy (from 2035), whilst ensuring there is no deterioration to the service we provide. We recommend pursuing such a water trade in future, with further work to be completed to the next planning round to facilitate this.

- **What are we proposing?** – We have explored the potential to make the best use of markets for water resources. We've done this specifically with a proposed water export from Lake Vyrnwy to the South East of England. Whilst we have a supply-demand surplus, our strategy for water trading has looked beyond this, and started to develop a plan that will maintain a surplus to ensure no deterioration in levels of service, water quality, resilience or the environment. At this stage, our preferred plan recommends that we continue to explore water trading, and the options that may be required to address these needs are outlined in the next section. We expect that any movement of water under a trade would only be realised relatively infrequently from the mid-2030s (or later) onwards, and subject to further investigation and study.

- **Why are we proposing this?** – The North West has been identified as a potential water donor region in a recent national study lead by Water UK to meet acute long-term water resources

[7] These are temporary permits to allow us to take more water from the environment during drought than would normally be allowed under our licence conditions.

pressures elsewhere in the country. We believe that pursuing a water trade of this nature is in the best interests of customers in the North West and across the country as a whole and we are expected to explore this by regulators and government. Customers have indicated broad support for water trading, although like stakeholders they wish to see existing levels of service protected and expect that there will be benefits for the North West.

Water supply resilience to hazards other than drought

Our assessment of water supply resilience to hazards other than drought is new for this 2019 plan. From our resilience assessments, we identify a key risk to supplies in the Manchester and Pennines area. In this draft plan we put forward future plans to address this risk, and we propose five alternative solutions for consultation.

- **What are we proposing?** – Through our risk assessment process we have identified our largest resilience risks for priority investment. During the 2015-2020 period we are already investing around £200 million in targeted resilience improvements. Based on the impacts that customers experience during supply failures exceeding 12 hours duration, we have an ambition to ensure these events occur less frequently than at present. This is expected to take up to 20 years of future investment. Future investment will be targeted on addressing risks associated with our regional aqueduct system and some of our most vulnerable treatment works and major supply mains.

  To achieve our target level of resilience we are likely to need additional redundancy (spare capability and connectivity) for the largest risks, however this is a long term aspiration. In the more immediate future we will manage these risks to customer supplies through improved reliability and enhanced response and recovery capabilities. This will be coupled with targeted investment on the very largest risks to one of our aqueducts supplying water to Manchester and areas of the Pennines.

- **Why are we proposing this?** – We are working to define a programme of resilience investment in future at a pace customers support and can afford. We are currently undertaking further customer and stakeholder engagement, including through the consultation on this plan. In this draft Water Resources Management Plan we include a number of different potential solutions to our most pressing resilience risks and would like to hear the views of customers and stakeholders as we consult on this plan.

Summary of our preferred plan and options to deliver it

Our baseline supply-demand balance assessments show that we maintain a surplus in all four of our resource zones, but this is only part of the picture. We've also considered the opportunity to make some 'strategic choices' to protect and, where possible, benefit customers and the environment.

We believe the preferred plan:

- Demonstrates an emphasis on demand management in line with customer, regulator and stakeholder feedback regarding preference for these types of solutions;
- Represents a resilient balance of different options types, thus reducing future risk given customers have indicated that reliability of options is of high importance;

- Delivers the best-value for customers by improving the service that we provide whilst maintaining an affordable bill; and
- Represents a resilient and flexible long-term solution, demonstrated by testing the plan under alternative future scenarios.

In combination our strategic choices form our preferred plan, which is summarised in Figure 2:

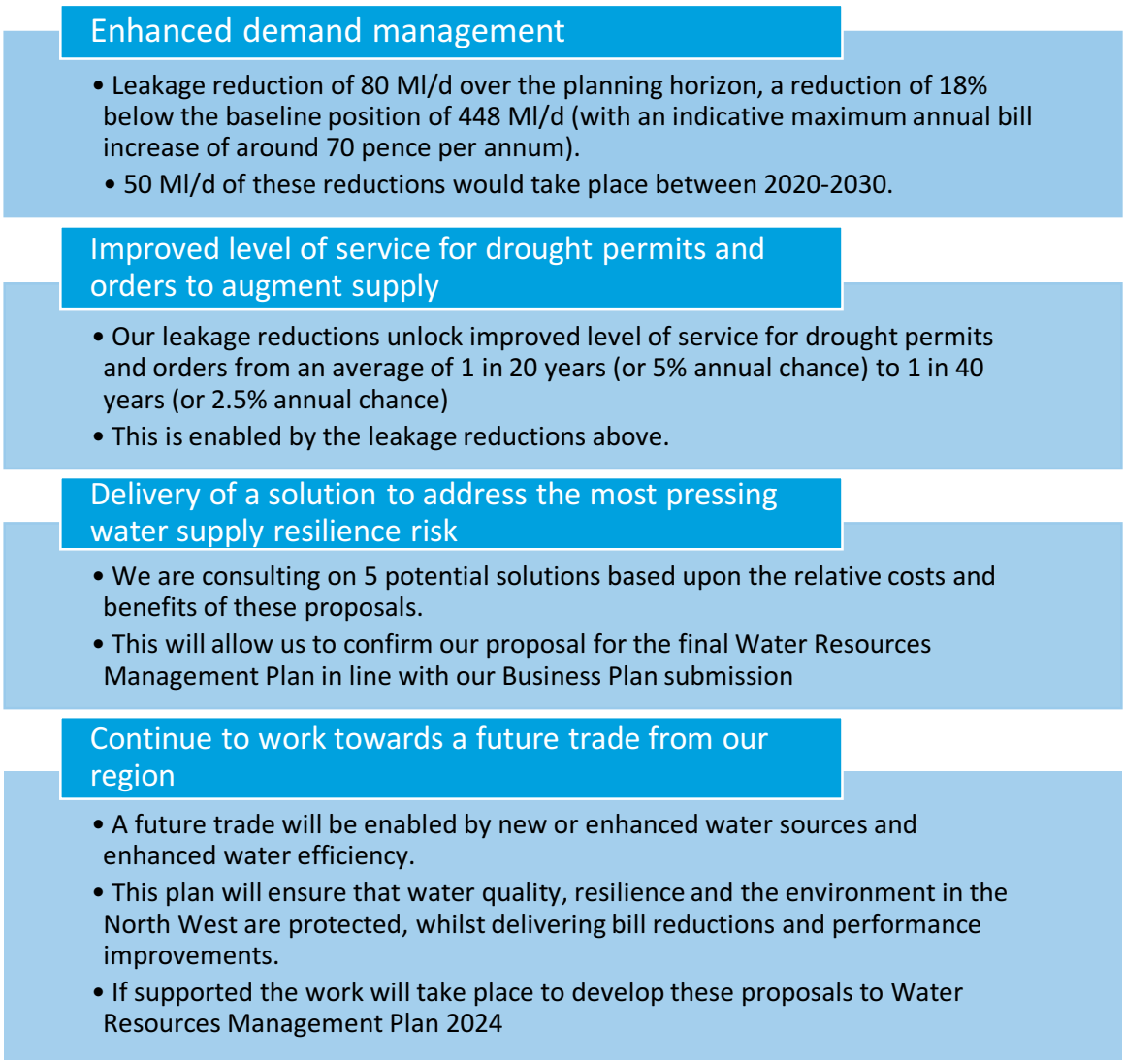


Figure 2 Summary of our preferred plan

The diagram below shows how our preferred plan evolves over the planning horizon and the potential alternative paths that may be followed depending on whether future water trading proposals are adopted.

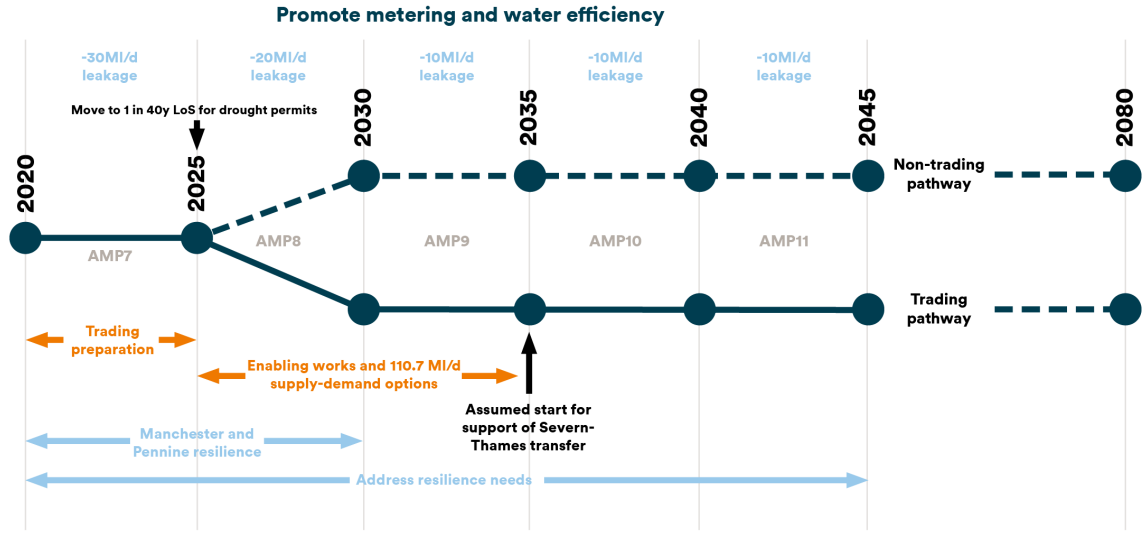


Figure 3 Summary of our plan timeline and potential future pathways

To facilitate a future water trade as part of the preferred plan, our assessments propose the following options totalling a capacity of around 110 Ml/d:

Enabling the redistribution of water

- Divert water sources from the River Dee, currently supplying other areas, to areas currently supplied from Vyrnwy
- Pump a portion of this along existing large diameter trunk mains to the existing water treatment works which treats water from Vyrnwy

More efficient use of water

- Water efficiency (education programme, goods and advice on metering, home checks on metering) - *10 Ml/d total*
- Improved reservoir compensation release control (local reservoirs, regional reservoirs) - *22 Ml/d total*

New sources of water

- Further develop existing groundwater sources (Tytherington, Worsthorne, Bold Heath, Python Mill, Franklaw) - *49 Ml/d total*
- Third party supply (Shropshire Union Canal at Hurleston WTW) - *30 Ml/d*

Figure 4 Details of our proposed options for water trading

As outlined above, we have proposed a plan that we believe represents the most cost effective and sustainable long-term solution, and we would like to consult upon our proposals in this draft Water Resources Management Plan to take account of feedback in developing our final plan. We expect public consultation to start in early 2018.

Your views

We have published this draft Water Resources Management Plan for consultation and would like to hear your views on it. This helps us continue to ensure that we take into account the preferences and priorities of customers and other key stakeholders as we continue to develop our plan. Responses to consultation on this plan must be sent to both us and Defra at the following addresses:

- **water.resources@defra.gsi.gov.uk; and wrmpconsult@uuplc.co.uk;**

Or by post at

- **Secretary of State for Environment, Food and Rural Affairs WRMP, c/o Water Resources Policy, Area 3D, Nobel House, 17 Smith Square, London, SW1P 3JR**
- **Head of Water Network+, Haweswater House, Lingley Mere Business Park, Lingley Green Avenue, Great Sankey, Warrington, WA5 3LP**

We expect public consultation to start in early 2018. We will then publish a revised draft version of this plan in summer 2018 taking of the feedback received.

Consultation questions

As well as inviting general feedback, we have a number of specific questions for consultation that we would like to invite feedback on to allow us to further develop our final Water Resources Management Plan. We are also looking for feedback on our Strategic Environmental Assessment, published alongside this plan, and include two questions relating to this below:

1. Developing our plan

This is summarised in Section 1.3.4.

a. *We have used new and more sophisticated methods for this draft plan. Do you have any views on the tools and techniques that we have used?*

b. *Are there any areas of the plan or supporting technical reports that you think are unclear or warrant further explanation?*

2. Leakage reduction

This is summarised in Section 6.2.

a. *Do you support our proposal for further leakage reduction? Yes or No. Please state why.*

b. *Do you agree with the targeted leakage reduction, and the timeframe that we have set out to achieve it? Yes or No. Please state why.*

c. *Have we achieved the right balance between customer, economic, and regulatory factors in our proposals? Yes or No. Please state why.*

3. Drought resilience

This is summarised in Section 6.3.

Our demand management plan provides some improvement in resilience to drought, which we believe to be robust. Do you;

a. *Support our conclusion that we already have an appropriate level of resilience to extreme droughts? Yes or No. Please state why.*

b. *Agree that there is no further immediate need to invest and improve our resilience position further? Yes or No Please state why.*

4. Level of service for drought permits and orders

This is summarised in Section 6.3.

a. *Do you support our strategic choice to improve levels of service for drought permits and orders from 1 in 20 years (5% annual chance) to 1 in 40 years on average (2.5% annual chance)? Yes or No. Please state why.*

5. National water trading

This is summarised in Section 6.5.

a. *What is your view on our proposal to work towards exporting water to other parts of the UK in future?*

b. *If we are to progress our proposals for water trading, would you like to be consulted as we explore delivery plans in more detail? In developing our delivery plan, we would like to collaborate further with our stakeholders to explore areas of mutual benefit. Would you welcome this and if so why?*

6. Preferred plan

This is summarised in Section 7.

Our preferred plan is to reduce leakage further; improve levels of service for drought permits and orders; to mitigate the resilience risk to water supplies in Manchester and the Pennines; and explore national water trading (Section 7.7).

a. *Is this the right combination of strategic choices? Yes or no? Please state why.*

b. *Does our portfolio of options demonstrate we are being innovative and providing an appropriate balance of options? Yes or no? Please state why.*

c. *Do you have any concerns regarding any of the specific options selected in the preferred plan? Yes or No. Please state option and concern.*

d. *Do you agree that our preferred plan meets our objective of the "most cost effective and sustainable long-term solution"? Yes or No. Please state why.*

7. Resilience to other hazards

This is summarised in Section 6.4.

a. *In the plan we identify the need to mitigate resilience risks to water supplies in Manchester and the Pennines. We outline five alternative ways of addressing this, with different costs and benefits for each alternative. Which proposal do you think we should prioritise and develop? Please state why.*

8. Consulting upon the plan

This is summarised in Section 2 and detailed stakeholder responses are in the Draft WRMP19 Technical Report – Customer and stakeholder engagement.

a. *We have engaged with stakeholders and regulators to develop this draft Water Resources Management Plan proposal, in particular through our pre-consultation exercise in autumn 2016. Do you have any comments on these activities and how we've demonstrated that your feedback has influenced our plans?*

b. *Do you have any comments on our approach to consultation and how we might improve this in future?*

9. Environmental Report

This is summarised in Section 7.7.

We would welcome your views on any aspect of the Environmental Report, together with supporting evidence where appropriate. We are particularly interested to receive your response to the following questions:

a. *Do you think that the Environmental Report has correctly identified the likely significant effects of the draft Water Resources Management Plan? If not, what other significant effects do you think we have missed, and why?*

b. *Do you agree with the conclusions of the Environmental Report and the recommendations for avoiding, reducing or off-setting significant effects associated with the implementation of the draft Water Resources Management Plan? If not, what do you think should be the key recommendations and why?*

c. *Do you agree with the proposed arrangements for monitoring the significant effects of the implementation of the Water Resources Management Plan? If not, what measures do you propose?*

1 Introduction

Key points

- **This is our draft Water Resources Management Plan 2019. It has been produced according to the latest methods, regulatory guidelines, and Defra guiding principles**
- **The development of the plan has been influenced by some significant national themes, such as water trading and water supply resilience**
- **To drive the most cost effective solutions we've embraced innovation, whether this be in the way we have identified options, or in our planning methods to define the best plan**
- **This document contains a summary of the technical work to develop the plan. Further detail is available in technical appendices published on our website alongside this document**
- **We'd like your views on this draft, and have defined several key questions around the key decision or choice areas**

1.1 Background

United Utilities Water Ltd is the main licensed water company for North West England. We provide water and wastewater services to three million household customers and around 200,000 businesses across the region. We are committed to sustainably providing high quality, safe, clean and reliable drinking water to customers.

Given the criticality of ensuring sufficient water supply to meet demand to society, development of a Water Resources Management Plan is a statutory requirement. This draft Water Resources Management Plan sets out our proposed strategy for water resources and demand management to ensure adequate water supplies to customers and that the environment are protected. It describes our assessment of the future supply and demand over the period from 2020 to 2045 (with testing of our plans beyond this period). We also explore potential future alternative plans, taking account of water supply resilience, enhanced demand management and the potential for water trading from our region.

We are consulting upon this draft plan, so that customers, regulators and stakeholders can comment on how we have built our plan and further contribute to its development. We will publish a revised version in summer 2018. This Water Resources Management Plan will feed into our five yearly Ofwat 'Price Review' and PR19 company Business Plan for the period 2020-2025; as such they have been developed in an integrated manner. The Water Resources Management Plan is also complemented by our Drought Plan[8], which sets out the short-term operational steps we will take as a drought progresses, and we have ensured that the links between these plans are accounted for.

[8] unitedutilities.com/corporate/about-us/our-future-plans/water-resources/drought-plan/

1.2 Improvements from our Water Resources Management Plan 2015

In preparing this Water Resources Management Plan there are some key changes from our 2015 plan:

- We have updated our planning process to meet the latest methods, guidelines, and Defra guiding principles. We've used sophisticated new techniques to allow us to explore a much wider range of scenarios and uncertainties than in previous plans (summarised in Sections 1.3.4 and 7.2);
- We have used earlier, more extensive, and more innovative customer engagement (see detail in Section 2), alongside increased stakeholder and regulatory engagement. The customer research is integral to this plan and the PR19 company business plan;
- As well as a single supply demand balance view, this plan includes strategic choices and a focus on risk, choices and potential future plans (Section 6);
- We have put processes in place to ensure board assurance of the Water Resources Management Plan, including a statement to the Drinking Water Inspectorate that drinking water quality is fully protected under our plans (Section 9);
- We consider water supply resilience to look at 'shocks' to the supply system (Section 4.7). This includes the impacts of other hazards (for example flooding, contamination or a freeze-thaw event);
- This plan has an increased focus on identifying third party, supply and demand options (Section 5); and
- In collaboration with other water companies, we have considered water trading as a pathway in our preferred plan. A pathway is a plan within a plan, to show what our strategy for water resources in the North West might look like with or without a future water trading export from the region (Section 6.5 and 7).

1.3 Our approach to water resources planning

1.3.1 Listening to customers, stakeholders and regulators

In this document we investigate what makes the best plan for customers and how we can best serve the needs of the North West. To do this we really need to understand the views of customers, regulators, and other stakeholders. We talk about this in further detail in Section 2. In particular we have sought to engage early, engaging widely, and used different or innovative approaches (described further later in this section) to engagement where beneficial to do so.

In autumn 2016 we completed an extensive pre-consultation exercise on the development of this plan with regulators and stakeholders, which has informed its development. We have also sought to discuss the Water Resources Management Plan in other forums, for example, through our engagement activities on the Drought Plan or as part of engaging with local authorities as part of our normal liaison activities. We established and continue to run a Technical Stakeholder Group for the first time for this 2019 Water Resources Management Plan, which has been informative to developing the plan. We thank the volunteers on this group for their contributions.

We have discussed progression of the plan with regulators throughout the development of the plan, as well as during pre-consultation. We have held bi-monthly meetings with the Environment Agency, supported by 'special interest sessions' on key topics, and also regularly engaged with Natural Resources Wales, Natural England and Ofwat. We have also discussed our approach with the Drinking Water Inspectorate.

1.3.2 Key influences and themes for this plan

In developing this Water Resources Management Plan we account for government priorities, as outlined in particular within the *Defra Guiding principles for water resources planning* (referred to as the 'guiding principles'). We are meeting the government priorities by:

- Ensuring we are compliant with relevant legislation and have suitably assured the plan;
- Ensuring that future growth and economic development can be accommodated;
- Taking a long term, strategic approach to protecting and enhancing resilient water supplies;
- Considering every option to meet future public water supply needs;
- Acting collaboratively to protect and enhance our environment;
- Promoting efficient water use and leakage reduction; and
- Ensuring our plans continue to meet drinking-water quality standards and that customers continue to receive a wholesome, safe supply of water.

The government is currently working on proposals to reform the abstraction licensing system, known as abstraction reform. We don't expect abstraction reform to be implemented until after 2020 and as indicated in the guidance we have made no allowance for changes in this plan.

As some of our sources are located in Wales we are carefully considering the priorities of the Welsh Government, in particular focussing on the Wellbeing of Future Generations Act (2015). This links to future water trades *via* Lake Vyrnwy and the River Severn, explained further below, and we are continuing to explore what this means under this legislation as any potential trades become more defined, supported by stakeholder engagement and research.

The key supporting national themes influencing this plan can be seen in Figure 5, and are described further below.

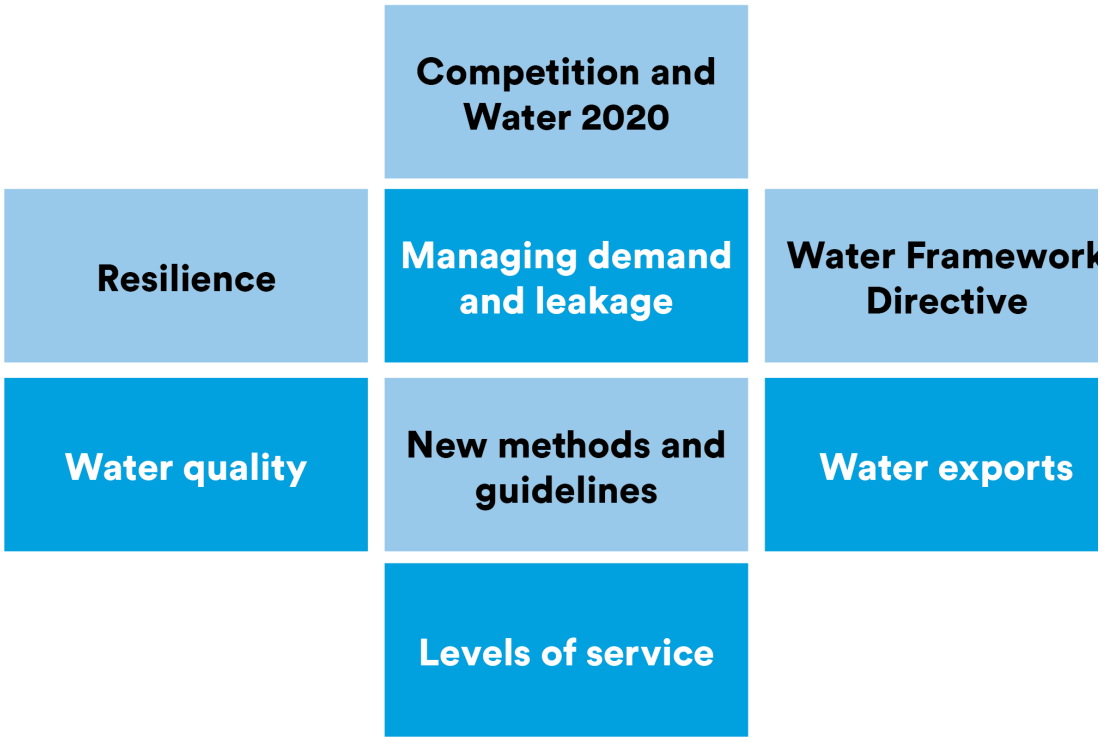


Figure 5 Key national themes influencing this Water Resources Management Plan

- **Drinking water quality –** The Drinking Water Inspectorate has recently released new guidance for the long term planning for the quality of drinking water supplies[9]. In our plan we ensure that we continue to meet drinking water quality standards[10] and that in the long-term we ensure that there is no deterioration in the quality of the water which is supplied.
- **Water exports –** A national study has recently been completed by Water UK; the Water resources long-term planning framework (2015-2065), Water UK (2017). This aimed to explore the long-term water resources resilience at a national level. The study showed the North West as a potential donor region to transfer water to areas of the country with severe water shortage in future. We have explored this further in this plan;
- **Managing demand and leakage –** Customers frequently raise this as a priority area, which is consistent with the views of the government and regulators. The Defra guiding principles state that companies should choose demand-side options as part of any proposed future plans wherever it is reasonably likely that the benefits will outweigh the costs. There is also a desire to see a downward trend (generally reducing over time) in leakage, and Ofwat have recently set out aspirations to reduce leakage by around 15% as part of the Business Plan process. We explore this as a strategic choice in our plan;
- **Water supply resilience –** This is the ability of our water supply system to be able to cope with shocks or stresses, and recover from them. There is a strong emphasis on resilience through the planning guidelines, guiding principles, and government policy. In this plan we use new methods and further incorporate appropriate parts of our wider business planning to assess our resilience effectively;
- **Water Framework Directive –** The Environment Agency has carried out a review of waterbodies currently seen as 'at risk of deterioration in future', and issued new guidance on how this should be assessed in Water Resources Management Plans. We have ensured that our plans do not result in the deterioration of these waterbodies and that we support Water Framework Directive objectives;
- **New methods and guidelines –** There are new regulatory planning guidelines[11] and guiding principles that we have taken into account in building this plan. There are also enhanced industry methods[12] that we have adopted to identify the best-value long-term plan;
- **Levels of service –** In our last plan we committed to explore further the potential to reduce the frequency of drought permits (powers to take more water from the environment during drought). Alongside this we have explored different levels of service to understand the resilience of our supply system, and this detail is included in our plan;
- **Competition and Ofwat 'Water 2020' –** The Water 2020 framework has been introduced by Ofwat to promote efficiency so that industry challenges can be met at an affordable price for customers. Of particular relevance is the promotion of efficiency and innovation. For water resources it recognises that in order to meet future national water resources challenges there are potentially significant savings for customers resulting from consideration of water trading and third party options. Ofwat have outlined steps to promote competition in this

[9] Drinking Water Inspectorate. Guidance Note: Long term planning for the quality of drinking water supplies, September 2017.
[10] The Water Supply (Water Quality) Regulations 2016 (as amended).
[11] Environment Agency and Natural Resources Wales - Water Resources Planning Guideline: Interim update – April 2017 (referred to as the planning guidance, or guidelines).
[12] Developed as part of UKWIR (UK Water Industry Research). We actively participate on steering or working groups as part of this organisation.

area, including the need for companies to publish market information and a bid assessment framework[13] for water resources options. However, in this plan we have already taken steps in this direction with a view to identifying all possible options and driving innovation by initiating a market engagement process as part of this Water Resources Management Plan 2019.

1.3.3 Applying the latest industry methods

In preparing for this plan we have consulted the Environment Agency and Natural Resources Wales and followed their *Water Resources Planning Guideline*, along with the complementary supporting documents (for example, on water resource zone integrity, drought plan links, and climate change). We have adopted the current national best practice methods in the management of our water resources and in preparation of this Water Resources Management Plan. In doing so we have followed key new reports such as the UKWIR decision making framework (UKWIR, 2016), UKWIR risk based planning guidance (UKWIR, 2016) and WRMP19 Methods – Population, Household Property and Occupancy Forecasting (UKWIR, 2015).

The UKWIR methodologies outline a framework of planning methods, from which to choose the most appropriate based on the risks and complexity associated with the planning problem. This allows companies to choose the most sophisticated methods where they drive the greatest benefit to the process. In this plan we have chosen new and advanced methods, as outlined in the next section, in particular to support the assessment of water trading against a backdrop of future climate change uncertainty. Our assessment of risk against the planning framework is described further in Section 3.7.

1.3.4 Innovation in developing our plan

We have sought to innovate throughout the development of our plan. This allows us to develop the most cost effective long-term, sustainable plan for our region. This section gives some key examples of where we have applied i nnovation i n developing the plan (noting that this list is not exhaustive).

Third party engagement to identify potential solutions

As part of the plan we have requested bids from third parties for both new water resources provision and demand management options. The process involved issuing a Prior Information Notice (PIN) to businesses, organisations and individuals to identify as many third party options as possible, both within and outside our region for consideration in the plan. In total an additional 66 options from third parties were included alongside our own options. This not only allowed us to identify a wider range of potential supply-demand options, but also identified potentially innovative solutions (for instance technologies that focus on detecting plumbing losses and supply pipe leaks) that we could use in collaboration with third parties. This is particularly the case on options to manage demand, and we have used the outputs of this activity to define a plan that delivers a more cost effective demand management programme over the planning horizon.

Customer engagement

We've innovated in our customer research by testing new survey or research techniques to inform the choices in our plan. As part of developing the plan we developed an interactive web-game, that

[13] The purpose of the bid assessment framework is to support a future bidding market for water resources, demand management, and leakage services that Ofwat are seeking to develop. The market information is required to support the development and operation of this market.

allowed customers to 'build their own plan' based on a hypothetical supply-demand problem. We have also for the first time explored risk and resilience further with customers, using techniques to bring to life what it would mean to be without water in order to get customers views on the value and investment they would support in this area.

'Stochastic hydrology' and climate change

In this Water Resources Management Plan we are using sophisticated 'stochastic weather'[14] to test the response of our supply system to more severe and different patterns of drought than we have seen historically. This also complements and supports the application of new options appraisal or decision-making methods described below. The work, completed with our framework partners Atkins, involved creating 17,400 years of stochastic flow data for 25 catchments. We have also combined this work with that of Thames Water in order to further assess the coincidence of drought in different areas of the country[15].

As we found in our climate change work in the last Water Resources Management Plan, handling large numbers of scenarios or large hydrological datasets can be challenging. To support our assessment of different droughts and climate change, our work with Atkins has developed a rapid assessment or emulator model of our system[16] to allow testing of large numbers of scenarios, drawing on Cloud computing technology[17], and get around this constraint.

Options appraisal and decision-making

We are one of a number of leading companies applying new water resources management planning methods in this planning round. We have been working with our framework partners Atkins to apply cutting edge, innovative techniques to support development of our plan, using approaches from a new framework of methods published by UKWIR[18]. Our chosen approach uses 'Robust Decision Making (RDM)' principles, and is tailored to the challenges faced in our region.

The Defra guiding principles outline the concept of developing a long-term 'best-value' plan (also referred to in the planning guidelines as 'cost effective') rather than just 'lowest-cost'. Our new approaches support the traditional supply and demand balance approaches to help define the best-value plan in a number of ways. They:

- Test potential plans under a wide range of weather conditions and better understand the risks of particular events occurring;
- Allow us to test the plan under a wide range of possible futures (e.g. different climate and demand), including beyond the 25 year planning horizon out into the 2080s to see how different potential plans perform; and
- Test the performance of our plans to a range of key performance metrics[19] related to key aspects of interest and 'value' to customers and stakeholders on water resources.

[14] A method to create alternative weather patterns that are realistic, but have not been recorded historically.

[15] This builds on strategic work on long-term water resources resilience completed by Water UK.

[16] The modelling package is called Pywr.

[17] Cloud computing is the practice of using a network of remote servers to store, manage, and process data, rather than a local server or a personal computer.

[18] UKWIR decision making framework (UKWIR, 2016) and UKWIR risk based planning guidance (UKWIR, 2016). We were an active steering group member of these projects.

[19] Traditionally, Water Resources Management Plans are focussed on supply-demand balance assessments, but these techniques recognise there are a wide range of other factors of interest when determining a water resources strategy.

The technical work underpinning this work breaks new ground for Water Resources Management Plans. For example, the screening of drought risk in combination with multiple climate change scenarios involved processing the equivalent of several billion days' worth of simulated data, which hasn't been applied elsewhere on such a scale.

1.4 Level of service: balancing customer and environment needs

The fundamental aim of our water resources and demand strategy is to strike the right balance between potentially competing requirements of supply reliability, affordability, and environmental protection. In doing so we have listened to the views of customers, regulators and other stakeholders, as described in Section 2.

Following customer experience of the 1995/96 drought, United Utilities adopted an improved level of service for water supply (Figure 6), and this remains our baseline for developing this plan. This improved level of service was effective from the year 2000 onwards. Since this change, there has been one hosepipe ban implemented in 2010, but no drought permits or orders have been implemented. However in this plan we are considering further improvements to our levels of service, and these are presented as strategic choices in Section 6.

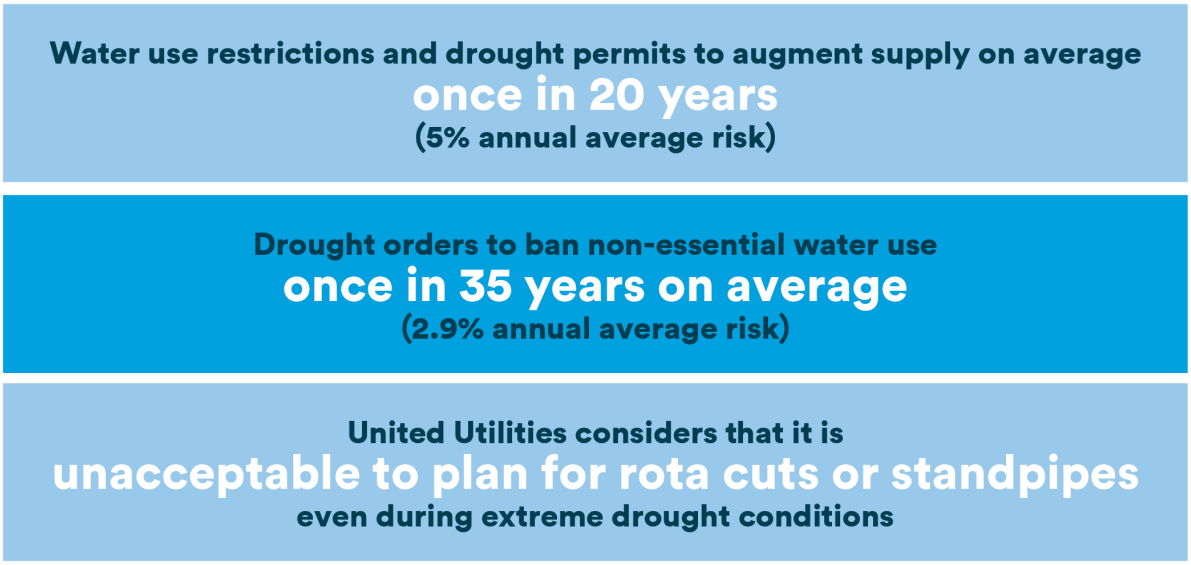


Figure 6 United Utilities' baseline minimum level of service for water supply reliability standards (our future proposed position for consultation is included in Section 7.7)

1.5 What do we want to learn from this process?

Responding to consultation on this draft Water Resources Management Plan provides customers, regulators and other stakeholders with the opportunity to influence the direction of our plan. Whilst we are interested in collating feedback on all elements of the plan, there are a number of key areas of interest for which we have created specific consultation questions, as presented in the 'Summary of our Plan' section at the beginning of this report. At key points in the document we also include some key reminders of our consultation questions when presenting our future plans.

1.6 Structure of the document

Our plan structure broadly follows the process of developing the Water Resources Management Plan itself. Table 1 below summarises the key sections and the topics covered:

Table 1 Summary of key topics covered in this plan

Topic	Where?
What is a Water Resources Management Plan and what principles have we applied to its development?	Section 1: Introduction
How has United Utilities taken account of customer and stakeholder views in preparing this Water Resources Management Plan?	Section 2: Customer and stakeholder involvement
Where do we get our water from and how are water supplies managed in North West England? How have we chosen planning methods appropriate to the characteristics of these zones?	Section 3: Our water supply system
What is the future supply-demand position in our region, and how has it been derived, including climate change and our environment programme? How have we accounted for uncertainty in our forecasts? What is our baseline programme for leakage and water efficiency? How resilient are we to more extreme drought or other hazards?	Section 4: Our Baseline position
What water supply options and demand management options have been considered? How have we taken account of water quality, environmental, and social considerations in defining potential solutions? How have we engaged with third party suppliers and other companies?	Section 5: Identifying future options
What are the key decision areas in the plan? How far are we proposing to reduce leakage in future? What are we proposing to increase water supply resilience? How have we considered potential water trading and its impact on the North West?	Section 6: Strategic choices
How have we appraised the options in our plan, and what are we proposing? What are the costs and performance of the alternative plans? How would these plans cope if the future turns out differently than forecast?	Section 7: Alternative plans and Section 8: Testing our plans
How have we assured the plan?	Section 9: Assurance and Board engagement
Can we summarise the plan? What are the next steps?	Section 10: Conclusions

2 Customer and stakeholder involvement

Key points

- **In line with Defra's guiding principles we set out to gain a broad and in-depth view of customer and stakeholder views**
- **We engaged both stakeholders and customers from the beginning of the planning process, and contacted over 450 stakeholders and consultees *via* email. We have ensured that the views and opinions captured are reflected in how we have shaped our plan**
- **We've used new innovations to engage with customers more effectively, such as online interactive experiments and 'immersive' research methods**
- **Prior to running customer research, we've engaged our Your Voice panel to seek feedback and inform our approach to make it is as effective as possible**
- **We have liaised closely with regulators to ensure the plan is produced according to all published guidelines**
- **We publish this draft Water Resources Management Plan for consultation and would like to hear your views on it as we continue to develop our plan**

2.1 Overview

We value the views of all customers in our region, and wish to provide the service they expect whilst maintaining affordable bills. We also recognise that our plans and activities are of particular interest to specific organisations or individuals, and seek to take into account the views of stakeholders when developing our plans.

With this in mind, in developing this Water Resources Management Plan we have gone even further than previous plans to engage and collaborate with others. We started this activity much earlier in the planning process to maximise the benefit of this dialogue and to ensure we can take customer, stakeholder and regulator feedback fully on-board in developing this Water Resources Management Plan. For example, we commenced our stakeholder pre-consultation process in autumn 2016.

Given the strategic influences and choices for our plan, and noting the Defra guiding principles, we have also completed a larger and more diverse customer research and engagement programme for this Water Resources Management Plan compared with our 2015 plan. This has taken us beyond more traditional survey methods such as 'willingness to pay' surveys, using a range of qualitative and quantitative engagement techniques including a detailed analysis of our business as usual data. This allows us to build up consensus and evidence from a range of sources, and ensures that results are not the product of any single method or survey. Innovative approaches, such as an interactive online game[20] to allow customers to

[20] Known as a programme choice experiment.

'build their own plan' (Figure 7), have sought to find improved ways to gain informed views from customers.

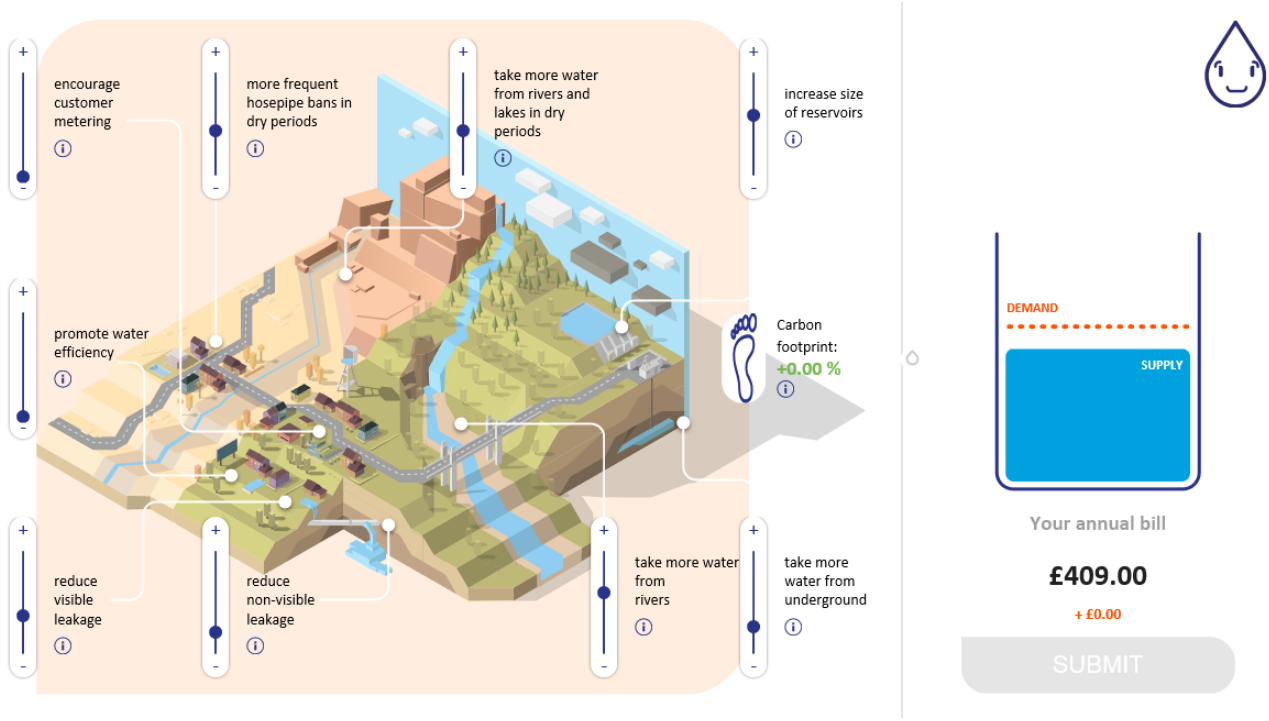


Figure 7 Example screenshot of our innovative programme choice experiment

This section summarises our activities to collaborate, engage and involve customers, regulators and stakeholders in the development of the Water Resources Management Plan. Given the scale of our activities in this area, further detail is available in our *Draft WRMP19 Technical Report - Customer and stakeholder engagement*.

2.2 Pre-consultation on this Water Resources Management Plan

We launched an enhanced pre-consultation phase in autumn 2016, contacting all statutory and non-statutory consultees. We contacted over 450 stakeholders and consultees *via* email, which included stakeholders from our previous Water Resources Management Plans and Drought Plans (for example, environmental groups, local authorities, and local businesses). The pre-consultation process was supported by four public stakeholder events across the region in conjunction with consultation on our Drought Plan. We also published a briefing note[21] of the key expected plan themes and our approach to plan development.

We received numerous comments and questions through our pre-consultation process, and have taken account of these comments in building this plan. Some of the themes and specific topics from our pre-consultation responses are summarised in Table 2. Further details of the issues raised and our responses to them is included in our *Draft WRMP19 Technical Report - Customer and stakeholder engagement*.

[21] This was 'Crystal Mark' accredited by the Plain English campaign as part of making our material more accessible to stakeholders.

Table 2 Summary of issues raised at pre-consultation and our response

Issue	You said	We said
Leakage and demand management	We should do more to reduce leakage and should explore options to reduce demand before considering new water sources.	This plan goes further than in the last planning round. We have explored a range of leakage reduction scenarios, and put forward proposals to significantly reduce leakage in Section 6. We've also engaged with third parties to explore innovative demand management options (Section 5) and fully explored demand management options as part of building our preferred plan (Section 7).
Resilience to drought and non-drought hazards	We support your proposals to assess water supply hazards other than drought.	Whilst previous plans have focused upon the key resilience hazard of 'drought' other significant resilience hazards are already incorporated in our wider business planning assessments. These other hazards are reviewed in Section 4.7.
West Cumbria future and redundant assets	You want to know more about the future of West Cumbria following the completion of the Thirlmere pipeline, due in 2022, and any potential redundant assets.	As this plan covers the period 2020-2045, it has been developed around the future supply system following completion of the Thirlmere project by 2022. Based on this feedback, we have therefore covered the future of West Cumbria as part of a new and specific technical report as an appendix.
Level of service for drought permits	We should look at reducing the frequency of needing drought permits.	In Section 6.3 we outline our proposal to improve level of service for drought permits by 2025 following delivery of our first tranche of leakage reduction activities.
Environment and Water Framework Directive	You want us to make sure we explore enhancements to the natural environment and protect the environment. You also want assurance that we are meeting everything set out in the Water Framework Directive. You should consider the potential to use natural capital / ecosystem services approaches.	The environment has been a core theme throughout development of our plan and our supply forecasts include delivery of enhancements under the Water Industry National Environment Programme (WINEP). The development of options in the plan (Section 5) has been subject to screening taking account of environmental factors. Our options appraisal process also ensures that our plans avoid any negative impacts to customers or the environment (Section 7), and we have worked closely with the Environment Agency to ensure that our preferred plan does not link to deterioration under the Water Framework Directive. Our plans also include proposals for less frequent drought permits and orders in the future (Section 6.3). Our plan development includes environmental and social costing. In terms of considering environmental 'value' in its broadest context, following review, we did not consider it practical to specifically include natural capital / ecosystem services approaches in this plan. However, we have completed studies to help ascertain how to approach this in future plans. See Section 5.4.1 for more details.
Water trading	You are concerned that there is insufficient surplus to allow us to trade water without leading to a water deficit in the North West. You also want assurance that any potential water trading would not have any detrimental effects on the North West region.	We have assessed water trading in the plan with a view to protecting water quality, resilience, the environment and our stated level of service. Our new sophisticated planning techniques have enabled us to do this. At this stage we do not have the full picture of how water trading will progress in the future. Our plan accepts that significant future work will be required in future to build on the strategic assessment in this plan. This is a key topic for consultation. See Section 6.5 for more information.

Issue	You said	We said
Abstraction from Windermere	You have concerns with the current approach to abstraction from Windermere.	We reviewed the operation of abstraction from Windermere in the Drought Plan 2017, and this draft Water Resources Management Plan is consistent with the outcomes of the Drought Plan process. We have commissioned a review to assess the impact of our abstraction licence in relation to recreational users, commercial interests and the environment, and this is due to complete in spring 2018. Any implications of this review on the Water Resources Management Plan process will be considered when we have the results of the study.

As part of pre-consultation, we also asked for volunteers for a Technical Stakeholder Group to further inform and participate in development of the draft Water Resources Management Plan (complementing other stakeholder engagement activities). The aim was to develop a small 'working group', and the group met on two occasions during 2017 prior to submission of the draft Water Resources Management Plan. We thank the contribution and ongoing participation of the Technical Stakeholder Group on plan development. More detail on the activities of this group may be found in the technical report.

2.3 Your Voice

We have an established customer challenge group (CCG) known as, 'Your Voice – customer and stakeholder panel'. They are a group of independent representatives from different sectors, backgrounds and areas of expertise. The expertise embodied in the panel ranges from Citizens' Advice, to the CBI; from environmental organisations to public health; and from flood and coastal defence organisations to consumer interests. They help us to reflect on what type of consumer representation is needed and how this relates to the company's existing governance arrangement. To ensure that our stakeholder engagement and customer research was appropriate it was discussed with Your Voice at various stages. As an independent body the Your Voice panel aims to ensure that customers are at the heart of our business planning engagement.

2.4 Regulator Liaison

We have engaged with regulators from early in the planning process and have maintained extensive engagement through the process. We shared detailed internal methodologies with the Environment Agency in advance of plan development during spring-summer 2016. We have ensured that feedback from this process along with that from other stakeholders has been taken into account when developing this plan. Regulators were consulted during our pre-consultation period to discuss methods and approaches to reduce the risk of change later in the planning process. This was supported by submission of an overarching method statement at pre-consultation in autumn 2016 to the Environment Agency, Natural Resources Wales and Ofwat.

We have engaged with the Environment Agency, Natural Resources Wales, Natural England, the Drinking Water Inspectorate and Ofwat through the process of developing the Water Resources Management Plan to inform them of our progress and chosen approach. For the Environment Agency, Natural Resources Wales and Natural England in particular, this has also been supported by holding bi-monthly Water Resources Management Plan liaison meetings and a number of 'special interest' sessions on specific technical topics such as climate change, water trading and water supply modelling. The environmental

regulators were also engaged as part of scoping our Strategic Environmental Assessment and Habitats Regulations Assessment processes.

Given the potential impacts of Water Resources Management Plan solutions on water quality, we discussed the development of the plan at liaison meetings with the Drinking Water Inspectorate and we will continue to engage with them as we progress any proposed plans to ensure drinking water quality is protected. We have aligned our plan to comply with the latest guidance; Long term planning guidance for the quality of drinking water supplies, Drinking Water Inspectorate (2017).

2.5 Overview of all stakeholder and customer engagement activities

Through our extensive engagement process we have a wealth of responses from numerous events and activities. An overview of our customer and stakeholder engagement activities is shown in the timeline below (Figure 8), along with a summary of the key messages from these interactions in Table 3. This is not an exhaustive summary of all of our engagement activities, but reflects salient areas of feedback relevant to the choices in this plan. Engagement with third parties regarding potential supply-demand options, exports or solutions is also covered in Section 5.

We have also sought to inform and engage stakeholders on the Water Resources Management Plan or related topics as part of our 'business as usual' activities. For example, updates on plan development have been provided to local authorities as part of our normal engagement on local growth and development. We've also used existing customer data, a process known as 'data mining', to investigate customer views and strength of opinion in certain areas. In some cases, this has shown that outside of drought, some water resources issues such water use restrictions feature little in customer interactions, demonstrating the need for specific customer engagement in this area as part of developing the plan.

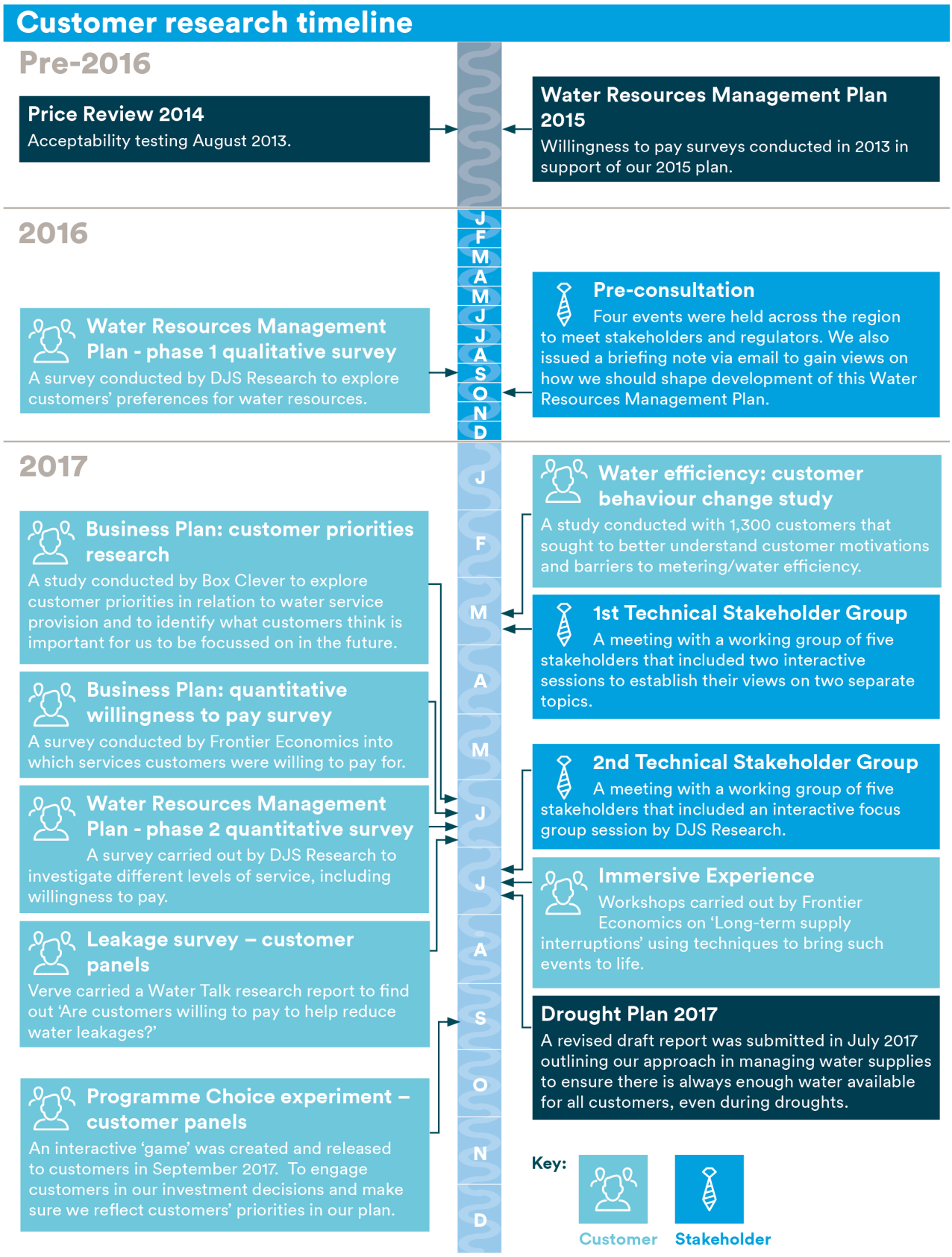


Figure 8 An overview of our engagement activities including a summary of our key messages

Table 3 Key messages from our engagement activities

Engagement activity	Outcome
Price Review 2014	• Affordability was an important factor in whether customers found our proposals acceptable; and • Research supported our proposed approach to leakage control at that time (as outlined in our Water Resources Management Plan 2015) to not reduce leakage further given affordability considerations.
Water Resources Management Plan 2015	• There was customer willingness-to-pay for an improved level of service for drought permits to move from 1 in 20 to 1 in 40 years on average or better (5% annual average risk to 2.5% annual average risk). We have investigated this further for our Water Resources Management Plan 2019; and • The analysis supported the existing level of service for hosepipe ban frequency at 1 in 20 years on average (5% annual average risk).
Water Resources Management Plan Qualitative Willingness-to-pay survey (August 2016)	• Current level of service for temporary use bans, non-essential use bans and drought permits is generally seen as acceptable; • Leakage reductions, water efficiency measures, reservoir storage and groundwater abstraction were favoured water resource/demand management options. Reliability has a big influence on option choice; and • Generally customers were supportive of water trading, but wanted to ensure that resilience, the environment and water quality were protected in the North West.
Pre-consultation (September/ October 2016)	See Section 2.2 for further information.
Price Review 2019 Willingness-to-pay survey (March 2017)	• This survey found that on average customers were willing-to-pay an extra 6% on top of their current bill to see an improved level of service across water and wastewater services; • However, vulnerable customers were only willing to see an extra 0.3% rise; • Customers highly valued supply resilience; and • Affordability considerations will be tested further in programme 'acceptability testing' which is due to take place in winter 2017.
1st Technical Stakeholder Group (March 2017)	• Two activities were carried out to understand stakeholders preferences on potential supply-demand options and metrics/measures use for 'extended methods'; • The top ranked supply-demand options chosen from a list of 14 were: reduce leakage further and further promote and support water efficiency; and • Discussion on metrics/measures to support our options appraisal illustrated the need for further work to refine communication and presentation of performance metrics.
Water Resources Management Plan Quantitative Willingness-to-pay survey (April 2017)	• High 95% acceptability of current levels of service for customer water use restrictions, and 84% for drought permit level of service; • High acceptability for drought resilience with little difference in acceptability between drought severities or risk levels; • Despite the above, there was material willingness to pay for both level of service areas, and even greater valuation to avoid deterioration in performance; and • Both household and non-household customers chose to reduce leakage further and take sea water via 'desalination' as potential future options, prior to costs being taken into account. Household customers also wanted us to further promote and support water efficiency, whilst non-household customers wanted us to encourage more meter usage.
Leakage survey (June 2017)	• Customers think leakage is an important issue for us and believe we should be reducing leakage to prevent water wastage and reduce water bills; and • Customers would be willing to pay more to reduce leakage further, however, the amount was marginal relative to the estimated costs of actually achieving those reductions.

Engagement activity	Outcome
2nd Technical Stakeholder Group (July 2017)	• The current level of service on temporary use bans was considered acceptable, whilst drought permit service levels of once every 40 years (2.5% annual average risk) and 60 years (1.7% annual average risk) on average were considered most acceptable; • Of the water resource options proposed, stakeholders favoured reducing leakage further and encouraging customers to use meters; • Stakeholders least favoured taking more water from rivers, desalination, storing water in new reservoirs, increasing existing reservoirs, transferring water from other regions and more frequent drought permits; and • Stakeholders selected the highest leakage reductions from choices offered, feeling the indicative bill impacts to be justifiable on the grounds of environmental benefit.
Drought Plan 2016/2017 (published November 2017)	• We presented four drought triggers for each of the four resource zones; • Extensive feedback was sought from stakeholders through the process relevant to the development of this plan; and • We engaged with stakeholders and regulators to seek agreement on the operation of our strategic pumped sources – this draft Water Resources Management Plan is consistent with the outcome of those discussions.
Immersive Customer Research (July 2017)	• The long-term supply interruptions workshop found that customers deemed a long-term interruption intolerable; and • Supply resilience was considered highly important – for long-term supply interruptions (of 3-14 days) customers placed a value of £290 per day to avoid such an event.
Programme Choice (September 2017)	• Within the first two weeks we received 866 responses; • Customers were willing to pay enough on their bills to reduce leakage by 44 Ml/d; • Customers were keener on reservoir and boreholes options, and less so on abstraction from rivers; • The average choice for temporary use ban level of service was a frequency of once every 13 years on average (7.7% annual average risk), showing acceptability of our current level of service (once every 20 years on average or 5% annual average risk); and • Marginally less frequent drought permits were preferred at once every 24 years on average (4.2% annual average risk).
Data mining	Throughout the year we collect existing customer data to investigate customer views in certain areas. The most pertinent data to the Water Resources Management Plan relates to leakage, supply interruptions (collected between April 2014 and January 2017) and the 2010 hosepipe ban. In general: • Outside of drought, some water resources issues such as water use restrictions feature little in customer interactions (by their inherent nature, these occur less frequently than other areas of customer contact), demonstrating the need for specific customer engagement in this area as part of developing the plan. • Customers regularly contact us to report a variety of leaks and problems associated with defective fittings and meters. Unplanned water supply interruptions accounted for 38% of the contacts received during the April 2014 to January 2017 period, reinforcing the value that customers place on resilience.

We have taken feedback on board throughout the development of our plan. In particular, customer and stakeholder feedback has helped to guide our strategic choices and help to explore the proposals in each one.

The strategic choices, which we discuss further in Section 6, are listed below:

- Enhancing leakage reduction;
- Improved level of service for drought permits and orders to augment supply;
- Improved resilience to non-drought hazards; and
- Exploring national water trading.

In each case we summarise the reason for each of our choices and how this maps back to relevant customer, stakeholder and regulator feedback. These strategic choices are combined to form our preferred plan, which is discussed in Section 7.

? Consultation question – consulting upon the plan

We have summarised our engagement approach in Section 2 above, and our responses to stakeholder and regulator feedback during pre-consultation are included in the *Draft WRMP19 Technical Report – Customer and stakeholder engagement*.

- **We have engaged with stakeholders and regulators to develop this draft Water Resources Management Plan proposal, in particular through our pre-consultation exercise in autumn 2016. Do you have any comments on these activities and how we've demonstrated that your feedback has influenced our plans?**
- **Do you have any comments on our approach to consultation and how we might improve this in future?**

3 Our water supply system

Key points

- We supply water to 7.1 million people in four water resource zones and assume completion of the Thirlmere Transfer scheme in this plan
- Currently, we have a few relatively small transfers of water between our area and surrounding companies
- The assessment methods we are using align to the complexity of each resource zone and the strategic questions they face
- Our representation of water resources management in this plan is consistent with the Drought Plan; this includes the outcomes of recent discussions with stakeholders on the operation of our strategic pumped sources

3.1 Water supply in North West England

We supply water to a population of 7.1 million across Cumbria, Lancashire, Greater Manchester, Merseyside, most of Cheshire and a small area of Derbyshire. We own and operate over 100 water supply reservoirs, various river and stream intakes, as well as lake abstractions and numerous groundwater sources. More than 90% of the water supplied by us comes from rivers and reservoirs, with the remainder from groundwater. This contrasts with the general trend in England, where on average only 60% is supplied from rivers and reservoirs. Abstracted water is treated at water treatment works before being supplied to customers through an extensive network of large diameter trunk mains and water mains. In a normal year we currently supply around 1,730 Ml/d of drinking water, but we would expect this to be higher in a dry year.

What is a water resource zone?

A water resource zone is an area within which water sources can be shared effectively. Customers within a resource zone should experience broadly the same risk of supply failure from a resource shortfall (i.e. dry weather or drought). Dry weather or drought is a system 'stress'.

In Section 4.7 our water supply resilience assessment examines system shocks, which are often short-term isolated incidents (for example, a freeze-thaw event during winter or asset failure). In such assessments, sub-zonal scales of assessment are typically more relevant.

3.2 Our water resource zones

Our water resource zones have been reviewed in accordance with the Environment Agency's 'Guidance for ensuring water resource zone integrity' (2016) and have been concluded to be 'fit for purpose'.

In our Water Resources Management Plan 2015 we assessed four water resource zones, and identified a future deficit in the West Cumbria Resource Zone. The Thirlmere

Transfer scheme was selected to meet the deficit by using some of the spare water available in our Integrated Resource Zone. We will build a new water treatment works and a pipeline between West Cumbria and Thirlmere Reservoir, one of our largest sources. Once finished by 2022, West Cumbria will be in one of the UK's largest water resource zones.

Therefore, as a long-term 25 year strategic view, this plan now reflects the merging of the previous West Cumbria and Integrated Resource Zones. We are now calling this the Strategic Resource Zone to draw distinction with the previous zones. As well as the change in resource zone boundary, the name also reflects the functionality of the zone, where key strategic sources are balanced to manage supply to customers. In this plan, we also include a new resource zone for Barepot. This is geographically within the Strategic Resource Zone, but has been delineated as a separate zone as it comprises a non-potable supply to industrial customers at Barepot in West Cumbria. The zone is supplied by a surface water abstraction from the River Derwent at Barepot, Workington. Whilst we have other non-potable or commercial supplies, those at Barepot lack connectivity into an existing resource zone.

With the exception of Barepot, the only sources not supported directly or indirectly from the rest of the regional supply system covered by the Strategic Resource Zone are in the far north of our region in the Carlisle Resource Zone and the North Eden Resource Zone. Key details about our water resource zones are included in Figure 9 below.

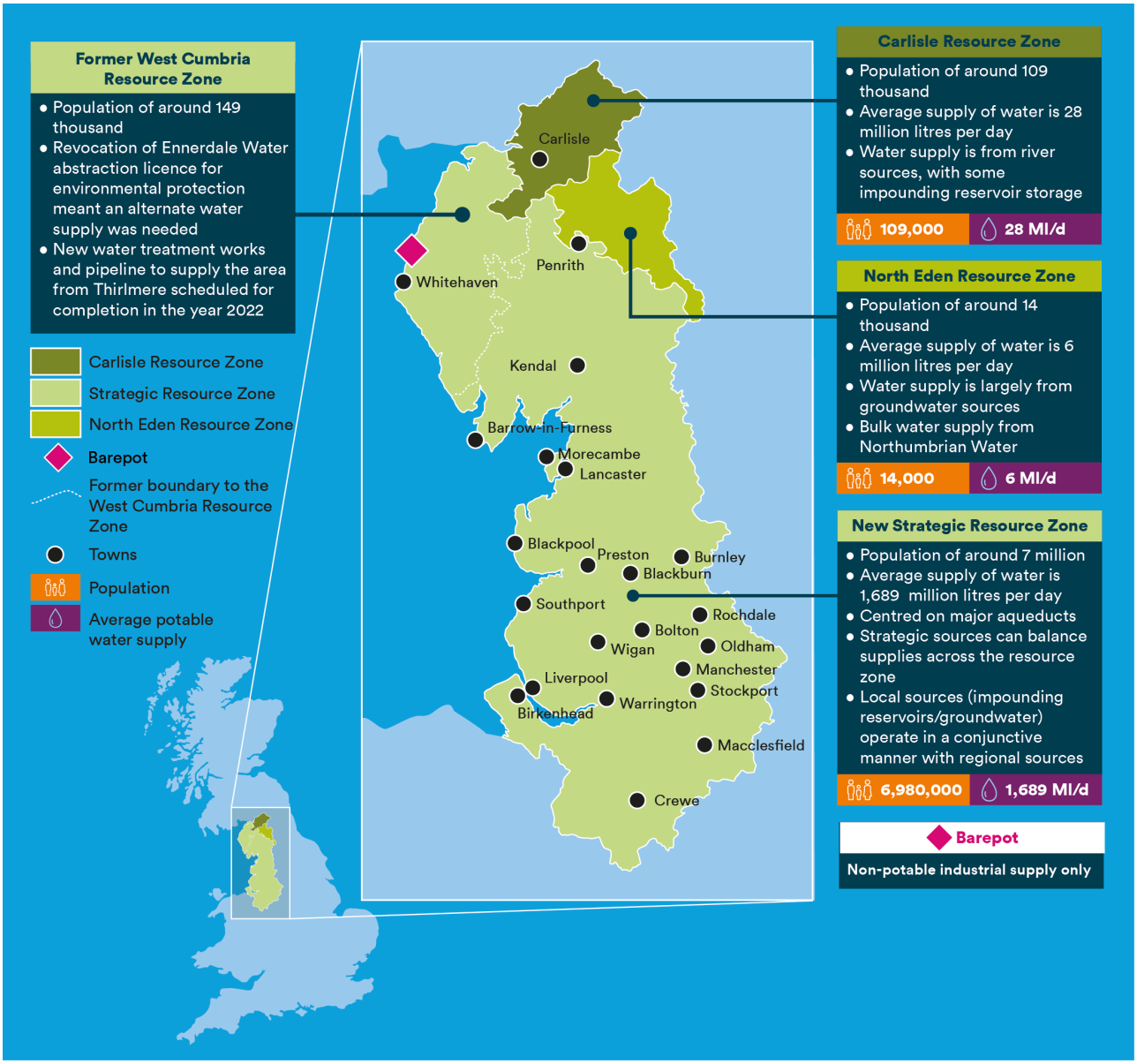


Figure 9 United Utilities water supply area and resource zones from 2022/23

3.3 Agreements with other licensed water suppliers

Following changes to the water market from 1 April 2017, holders of new water supply licences can provide supplies of water to eligible non-household premises. There are currently eight licensed water suppliers[22], with retail authorisation, operating within our area. We share water resources with other water undertakers, and include more detail on these in the bullet points and Table 4 below:

- The River Dee, managed by Natural Resources Wales through a regulation scheme. Other abstractors from the River Dee include Dŵr Cymru Welsh Water, Dee Valley Water PLC (now owned by Severn Trent Water Ltd) and the Canal and River Trust. We also have a few very small

[22] Details of all licensed water suppliers can be found at http://www.ofwat.gov.uk/regulated-companies/ofwat-industry-overview/licences/

bulk supplies with Dee Valley Water PLC and Severn Trent Water Ltd, including imports and exports from both companies;

- Lake Vyrnwy is owned by Severn Trent Water Ltd, regulated by the Environment Agency with Severn Trent Water to manage the River Severn regulation system. Other abstractors from the River Severn include; Severn Trent Water, South Staffordshire Water and Bristol Water;
- Burnhope reservoir supplies Northumbrian Water Ltd, who also provide a small import of water from this source into our supply area around Alston; and
- Leep Water Networks Ltd (formerly Peel Water Networks Ltd) also operates as a water and sewerage undertaker to the MediaCityUK development in Greater Manchester.

Table 4 Summary of import and export arrangements with other companies

Water undertaker	Resource Zone	Amount	Information
Imports			
Dee Valley Water PLC	Strategic	<0.1 Ml/d	Crewe by Farndon
Northumbrian Water Ltd	North Eden	1.3 Ml/d	Supply from Burnhope reservoir
Severn Trent Water Ltd	Strategic	<0.1 Ml/d	Mow Cop
Exports			
Dee Valley Water PLC	Strategic	1.2 Ml/d	Gredington
Dŵr Cymru Welsh Water	Strategic	28 Ml/d	Raw water (Heronbridge)
Leep Water Networks Ltd (formerly Peel Water Networks Ltd)	Strategic	0.3-1.0 Ml/d	The agreement is for us to supply up to 1.6 Ml/d, however current supply is around 0.3 Ml/d, and we forecast this to increase to around 1 Ml/d across our planning horizon (MediaCityUK)
Northumbrian Water Ltd	Carlisle	<0.1 Ml/d	Reaygarth
Severn Trent Water Ltd	Strategic	<0.1 Ml/d	Biddulph, Congleton and Kidsgrove
Severn Trent Water Ltd	Strategic	Contingency	Llanforda (used by exception for contingency purposes)

3.4 Water resources management

Our water sources are managed in accordance with operating and control policies to provide a secure safe and clean water supply to customers. These dictate the actions to be taken at different times of the year to protect water supplies against the worst drought conditions on record (such as pumping from rivers or lakes when river flows are high enough to enable the conservation of water stored in our reservoirs). We carry out frequent hydrological and hydrogeological monitoring in conjunction with the Environment Agency. Assessments of these data provide the basis for optimising the supply of water to customers, recognising drought conditions at an early stage and identifying the need for, and timing of, any drought management measures.

Following the dry winter and spring of 2016/17 we reviewed and amended our operational decision-making process for strategic pumping. Further details are included in Appendix 8 of our Drought Plan 2017. As a result of this review we have committed to pumping from Ullswater and/or Windermere when storage at Haweswater is below a specified level and subject to certain other conditions. In May 2017 we held discussions with the Environment Agency and Windermere stakeholders to explain this revised approach to the strategic pumping decision making process. We have also agreed to hold regular meetings with the

Environment Agency and Windermere stakeholders to review recent strategic pumping, and held the first of the regular review meetings in October 2017.

Many of our drought management actions are an integral part of our normal water source operational activities. Only in serious drought conditions will the use of specific legal powers and/or other exceptional measures be required.

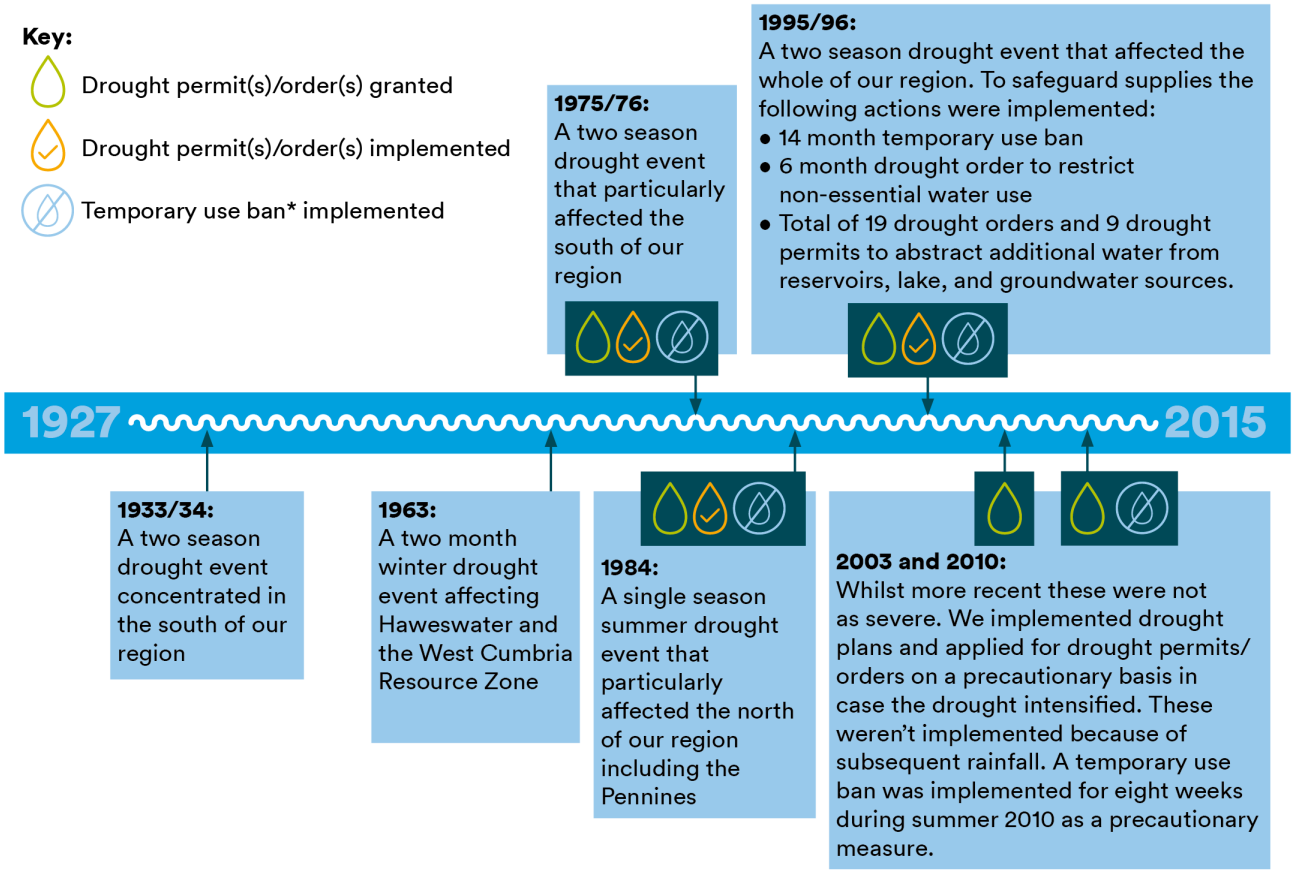
Our assessment of water supply security indicates that, even with a repeat of the worst drought on record, our reservoirs will not empty, but will reach very low levels (with the remaining storage equivalent to a minimum of 20 or 30 days of supply reserve). However, before reaching these very low levels, it is necessary to take action to conserve water supplies in case the drought is more severe than any previously recorded. Consequently, water use restrictions and drought permits/orders need to be implemented before reaching the very lowest reservoir levels to safeguard water supplies. This plan ensures that the frequency of needing such measures are line with the levels of service introduced in Section 1.4.

Full details of our drought management plans are presented in the United Utilities Drought Plan, which can be found on our website at www.unitedutilities.com/corporate/about-us/our-future-plans/water-resources/drought-plan.

3.5 Historic droughts

The most significant historic droughts within the United Utilities supply area are detailed in Figure 10. In previous plans, we have tested our system against the worst drought in history, which we currently assess to be around a 1 in 100 year event (1% annual average risk) accounting for possible future effects of climate change. In this Water Resources Management Plan we are using sophisticated 'stochastic weather'[23] to test the response of our supply system to more severe and different patterns of drought than we have seen historically. For example, we assess a 1 in 200 year event (0.5% annual average risk, or twice as unlikely as a 1 in 100 year event) and a 1 in 500 year event (0.2% annual average risk, or five times as unlikely). This allows us to assess the resilience of our plan and consider whether to improve our resilience to extreme droughts.

[23] A method to create alternative weather patterns that are realistic, but have not been recorded historically.



*Since 2010, hosepipe bans have been replaced by 'water use restrictions' under the Flood and Water Management Act 2010. This Act introduced a new Section 76 within the Water Industry Act 1991 and allows water companies to temporarily restrict a range of water uses by customers. It allows companies to restrict a greater range of water uses than before (the powers under the original Section 76 were generally referred to as a "hosepipe ban") it also requires companies to publicly consult before such restrictions are imposed.

Figure 10 Significant historic droughts experienced in our region

3.6 Recent events and operations

In the North West we experience a varied weather pattern, and in recent years have experienced both flooding and hot sunny periods. The extreme flood events of late 2015 serve as a reminder of the potential challenges of weather and climate. More recently we experienced a dry winter in 2016; total rainfall between October 2016 and January 2017 was 64% of the long term average for the North West, and the Haweswater catchment had the driest October to January in the 85 year record.

Following these types of significant events we assess how our assets have been impacted and how we can improve the operational choices we make. Following the dry spell in early 2017, we reviewed our operation of strategic pumping and included detail of this in our 2017 Drought Plan. Similarly, as part of the detailed design work for the Thirlmere Transfer scheme we committed to consider infrastructure changes to enable greater releases from Thirlmere to reduce flood risk. These changes have been accounted for in this Water Resources Management Plan. Detailed environmental studies associated with these changes are being delivered as part of the Thirlmere project.

We are working with Defra, the Environment Agency, Ofwat and another water company to determine what opportunities may exist for future use of reservoirs for flood mitigation. There are a number of

potentially conflicting issues which must be considered regarding reservoir use in such circumstances, including impacts on the supply demand balance and Water Framework Directive implications. Any potential flood mitigation projects will only progress if all our statutory obligations can be fully met. We will seek to report on developments in this area as part of the Annual Water Resources Management Plan review process.

3.7 Choosing methods appropriate to the risks

The UKWIR decision making framework (UKWIR, 2016) includes a stage called 'problem characterisation', which helps a water company to identify the scale and complexity of their plan, as well as their vulnerability to strategic issues, risks and uncertainties. The benefit of this stage is to guide us to select the most appropriate decision making tools for this Water Resources Management Plan. We carried out an initial problem characterisation for each resource zone, using information from our 2015 plan such as the outputs of the climate change vulnerability assessments. For the Strategic Resource Zone this assumes the completion of the Thirlmere Transfer scheme in 2022. A summary of the results is presented in Figure 11.

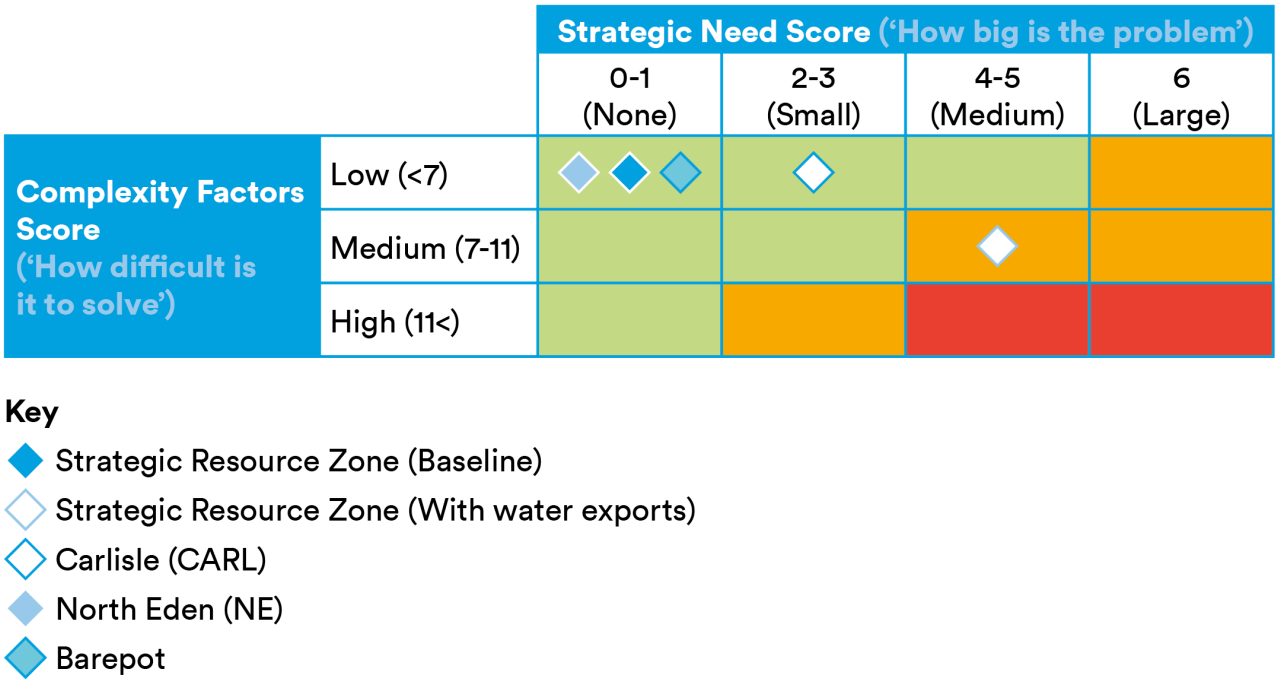


Figure 11 Summary problem characterisation scores

This exercise led to a focus on drought resilience and climate change, driven by the nature of the Strategic Resource Zone[24] and these uncertainties being critical to the long-term direction of water resources.

The outcome from the problem characterisation allowed us to identify where new and innovative approaches would add value to the planning process, based on the scale and complexity of the future challenges. Further detail on these methods are detailed in Section 7. This exercise concluded that:

[24] This zone is complex both in terms of its scale and number of assets. In particular, it is complex because of how it responds to weather events, because the zone is large and therefore big differences in weather patterns and timing might occur across the zone. This leads the system response to be what is known as 'non-linear'.

- Barepot, Carlisle and North Eden Resource Zones have low strategic needs which is consistent with the lower complexity of these zones. Focus in this Water Resources Management Plan is on the traditional core planning methods.
- The Strategic Resource Zone is more complex due to the non-linear, conjunctive use nature of the zone. In a 'traditional' plan sense it has a low complexity score, but when considering a water trading configuration[25] it is more complex, lending itself to simulation type methods to explore different potential futures. Therefore the Scenario Simulation with Robust Decision Making (RDM) principles have been selected to explore risk and determine the best value long-term plan.

3.8 The national context

In 2016 we worked with the other UK water companies to assess the long term water resources context for England and Wales. The resulting Water UK publication 'Water resources long-term planning framework (2015-2065)' is available on the Water UK website[26].

The report found that there is a significant current risk of severe drought across many regions in the South and East of England. It also found that the least resilient and most water stressed areas in the South and East are also subject to the most population growth and climate change risk. The need for changes to current abstractions to preserve the natural environment add to these pressures, again particularly affecting the South and East. More Northern and Western regions were found to have generally higher levels of resilience.

The report recommends that a minimum standard of drought resilience is adopted. Consistent with this, the Environment Agency Water Resources Planning Guideline has adopted a 1 in 200 year reference level of service (0.5% annual average risk) for measures such as standpipes and rota cuts. To meet such standards many companies will need to consider a mix of interventions including extensive demand management, supply enhancement, and water transfers. The value customers place on avoiding such severe restrictions and the affordability of such interventions will be key considerations.

The report also says there should be a national level 'adaptive plan'. Such a plan would identify the key 'trigger points' that will determine which set of investments and policy interventions are needed, depending on how risks materialise in the future. In this plan, companies will need new ways of working across their boundaries, with a wider range of stakeholders, to optimise the use of nationally scarce water resources, particularly through inter-regional water transfers.

In this context, we would expect to have less of a need for interventions to maintain resilience of supplies, and perhaps be able to offer higher resilience standard than some other water companies. Indeed the Water UK report considers our region to be a potential exporter of water, having potential to contribute to the national need for water resource.

Water UK's report is an early high-level assessment. We've undertaken further work in preparing this Water Resources Management Plan, and by working with others as they have prepared their plans. The national report has set some important context for those plans. It also indicates that after publication of

[25] This relates to potential future water trading (Section 6.5). The current size of bulk imports and exports between neighbouring companies is relatively small (see Section 3.3).

[26] www.water.org.uk/water-resources-long-term-planning-framework

the plans there will continue to be further developments through the ‘adaptive planning’ approach. Water UK will carry out further work on the extent to which companies have been able to take account of this national framework in their plans.

4 Our baseline position

Key points

- Ensuring a reliable supply to meet future demand is a key customer priority. This section outlines our forecasts of available supply and future demand for the 25 year period to 2045
- We account for uncertainty in our forecasts by using 'target headroom', with the choice of percentile reflecting both the degree of confidence in data and potential risk
- Our demand forecast shows reductions in demand over time even accounting for future economic and population growth, due to increasing water efficiency and metering
- Over the planning horizon supply is forecast to decrease slightly due to the impacts of climate change
- Our resource zones maintain a positive supply demand balance throughout the planning horizon in a dry year
- We have also tested our water supply system to more severe, and different patterns of drought, and we show a good level of resilience to these events
- Our plan also looks at how resilient our water supply system is to a host of non-drought hazards (including flooding, freeze-thaw, contamination, asset failure and power failure), and as a result we are planning for improved resilience across the next 25 years

4.1 Supply-demand balance concept

This section of the plan sets out our assessment of potential changes in our region for the availability of supply of water (water available for use), the future demand for water (dry year demand), and target headroom (a calculated allowance for uncertainties). Together these three components comprise the supply-demand balance, which determines if there is sufficient supply to meet demand in each of our resource zones. The supply-demand balance concept is illustrated in Figure 12.

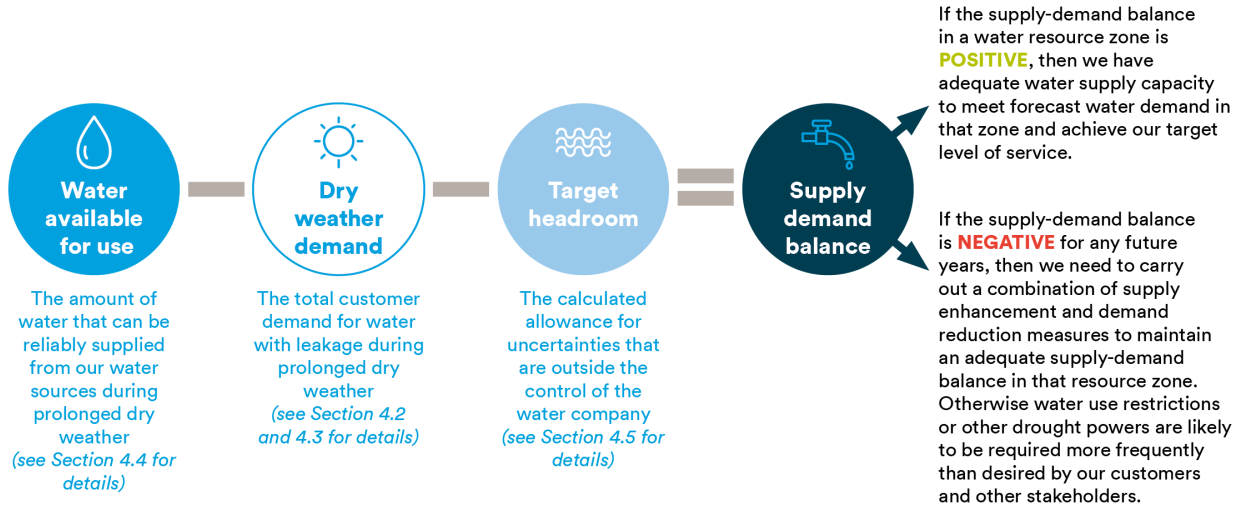


Figure 12 The supply-demand balance concept and outcomes

The surplus or deficit outcome from the supply demand balance is traditionally how a Water Resources Management Plan has been defined. However, this doesn't always show the full picture, for example which assets might be vulnerable to particular non-drought hazard events. The supply-demand balance focuses on a dry year, however in this plan we also cover wider considerations around risk and resilience (see Section 4.7).

The step change improvement in planning methods helps us to move beyond the traditional supply-demand balance view, to include a better appreciation of water resources risk, value, and performance. We have used simulations and defined metrics (that we introduce in Section 7) to help determine what is the best-value plan for customers in the long term. We will also ensure that our future plans do not result in any deterioration of drinking water quality. This alternative view is crucial in helping us to understand how our system responds to different scenarios, where there are areas of resilience or vulnerability and drive the best choices for future investment.

4.2 Baseline demand management

This section provides a high level summary of our baseline position for leakage management, water efficiency and customer metering. We have included more detail of the methods and results from our assessments documented within our *Draft WRMP19 Technical Report - Demand for water*.

Our 'baseline' forecast indicates what would happen if we didn't take any new demand actions or implement any further changes to our current policies and existing operations. This enables us to assess a number of strategic choices which include different levels of future demand management actions. As part of consultation on this draft plan we'd like to gather customer and stakeholder views to help us to select a preferred plan that represents the best-value way to balance supply and demand. The strategic choices and alternative plans are discussed in more detail in Sections 6 and 7.

4.2.1 Importance of demand management

Demand management is a key component of our strategy to balance supply and demand. We have significantly reduced leakage since 1996 to help achieve and maintain a high standard of water supply

reliability. Water efficiency promotion has been significantly enhanced since 2010[27] and overall water demand is around its lowest levels for the last 25 years.

We know that reducing both demand and leakage is an important issue for customers, stakeholders and regulators. For example, through our Leakage survey customer panels, leakage reduction was ranked just below 'providing safe, clean drinking water' and 'providing a reliable water/wastewater service' and 93% of customers think that United Utilities should do more to reduce leakage. More detail on our customer research is included in the *Draft WRMP19 Technical Report - Customer and stakeholder engagement*, and this information has helped to inform our strategic choices in leakage (Section 6.2).

In the guiding principles Ofwat, the Environment Agency and Defra have strongly encouraged water companies to achieve further reductions in demand through increased efficiency and innovation. We explore this further as part of our strategic choices in Section 6.

4.2.2 Leakage management

Leakage management contributes to the overall reduction in demand and plays a key role in our management of water resources.

We have met or exceeded our regulatory leakage target for over 10 years, despite experiencing two severe winters in 2009/10 and 2010/11. This has been achieved by carrying out an extensive range of leakage control actions at significant cost. We continually strive to improve and ensure that we are operating as efficiently and effectively as possible. This means that we have managed to achieve steady reductions in leakage over the past few years and our lowest ever leakage in 2016/17.

What is leakage?

In the UK leakage is defined as loss of water from any point downstream of a water treatment works, up to a customer's property. It includes water lost from connections to properties (communication pipes) and the associated supply pipes owned by customers, known as supply pipe leakage (see Figure 13). Levels of leakage can be affected by weather and in particular cold winters, which are associated with freeze-thaw events.

Table 5 shows our leakage performance since 2011/12 and the three-year average used to determine the baseline for this plan. At 448.2 Ml/d this is 14.5 Ml/d below the target set in our Water Resources Management Plan 2015. We have included this as the starting point to any strategic choice around potential for further leakage reduction (Section 6.2) beyond this baseline commitment.

[27] The step change since 2010 is associated with the regulatory targets for water efficiency that were introduced by Ofwat in AMP5.

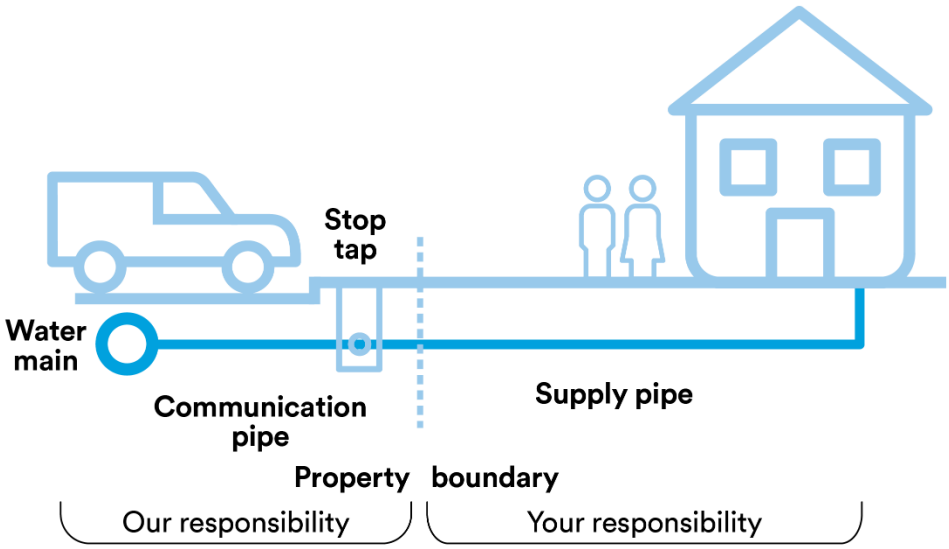


Figure 13 Water lost from customer owned supply pipe is included in leakage numbers

Table 5 Annual leakage performance since 2011/12

	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	3yr average (from 2014/15 to 2016/17)
Total leakage (Ml/d)[28]	453.0	457.4	451.9	453.6	451.9	439.2	448.2

In order to realise this baseline leakage level we have committed significant operational and capital resources to achieve this through:

- Maintenance of our monitoring equipment which identify leaks within district metered areas;
- Widespread pressure management to reduce the breakout and flow rate of leaks;
- Good quality data and continual review of our leakage management and information systems;
- Efficient leakage detection and repair using the latest technologies;
- Replacement and refurbishment of poor performing water mains;
- Providing free supply pipe repairs for domestic customers; and
- Improving customer and community awareness (Leakline campaigns).

Leakage baseline

For our baseline demand forecast we have assumed a flat leakage target of 448.2 Ml/d. In our future plan we also explore additional leakage reductions beyond this baseline level. This is detailed further within Section 6.

[28] There is no potable network for Barepot Resource Zone so the total is based on the sum of our Strategic, Carlisle and North Eden Resource Zones.

4.2.3 Water efficiency

As a water company we have a statutory duty to promote the efficient use of water as required by the Environment Act 1995 and the Water Industry Act 1991. We also recognise the important contribution water efficiency actions have in achieving and maintaining an adequate and sustainable supply-demand balance. This section contains a high-level description of our current water efficiency policies and actions.

Although no mandatory water efficiency targets have been imposed by Ofwat since 2015/16, in the demand forecast from our Water Resources Management Plan 2015 we committed to continue to achieve, as a minimum, a continued annual saving of 1 litre per property per day through the planning horizon. It should be noted that although the target savings remain at the same level as our previous Water Resources Management Plan, water efficiency savings become progressively harder to achieve, so we need to continually innovate and adapt with our approach in this area. This remains in place for the baseline demand forecast of this plan.

We have a number of policies that impact directly on the water efficient behaviour of customers. These include policies related to water efficiency, supply pipe repairs and replacement, sustainability and carbon emissions, and a Free Meter Option scheme.

Building on previous activities we continue to:

- Supply free, easy to install water efficiency devices which can be ordered *via* agents, online or picked up at some of the events we attend;
- Run our education programme for primary schools across the North West, which includes topics such as the water cycle, water safety, and water efficiency; and
- Carry out free visits to customers' homes to fit free water efficiency devices.

These are summarised along with some of our other water efficiency activities in Figure 14 on the next page.

We are mindful that in order to maintain the long-term forecast we need to keep our approach fresh. We are constantly looking for ways to enhance our offering to customers through research and partnership working, and we have undertaken customer research to understand the benefits, barriers and motivations to desired behaviours and willingness to act to achieve greater water efficiency. The results of the research will be used to better inform our approach and we will continue to drive behavioural change through our customer messaging *via* community engagement; social media and digital presence; and more traditional printed messaging on customer correspondence.

A more detailed description of our current and proposed future water efficiency activities is included in our *Draft WRMP19 Technical Report - Demand for water*.

Supply free, easy to install water efficiency devices which can be ordered via phone, online or picked up at events we attend

We run an education programme for primary schools across the North West

Use customer feedback to update the design and content of our bills. This includes information that is tailored to the customer based on information we hold on them, covering water saving advice and information about meters

Work in partnership, for example with housing associations and the Lake District National Park Partnership, to research and co-create new opportunities for customers

Carry out free visits to customers' homes to fit free water efficiency devices

let's get water tight

CASE STUDY: We have researched attitudes towards water efficiency and metering to inform a joined up communications strategy for water efficiency, metering and water demand using segmentation to target groups of customers with tailored messaging, including community groups. We tested the promotion of water efficiency at community level in Egremont, Cumbria where we developed key messages and creative marketing material

Understand what is most successful in reducing water use by changing behaviours. We are incorporating behavioural economics along with trials of activities and communications

Refresh and update our messaging and marketing material based on feedback from our activities and research

Figure 14 Summary of our water efficiency activities

4.2.4 Customer metering

Customers with a meter typically use less water than those without one. Metering is an opportunity for customer engagement, which if sustained, can be useful for promoting water efficiency. Metered customers are able to review the impact of their behaviour on their bills, and metering also gives us the opportunity to use tariffs based on consumption. 'Paying for what you use' is a well-supported principle. Approximately 40% of household customers are now on a water meter.

Compulsory metering of new premises was introduced in 1990, after the introduction of community charge[29] and the cessation of applying rateable values. The Water Industry Act 1999 gives customers the right to opt to have a water meter fitted for free and this is often referred to as the 'Free Meter Option'. Between 2020 and 2025 we plan to install a total of around 180,000 water meters. Figure 15 below shows the meter penetration forecast until 2045, which is equivalent to 76% meter penetration. This forecast is lower than our 2015 plan, as in the intervening period the number of optants has dropped. We have continued a series of promotional events to increase meter uptake, but despite this the overall uptake is still lower than the previous five years. Working with Artesia Consulting, we have also updated the models used to forecast the uptake of the Free Meter Option. This helps to ensure that we have a robust view of the potential numbers of customers who would be willing to opt for a meter each year (Figure 15).

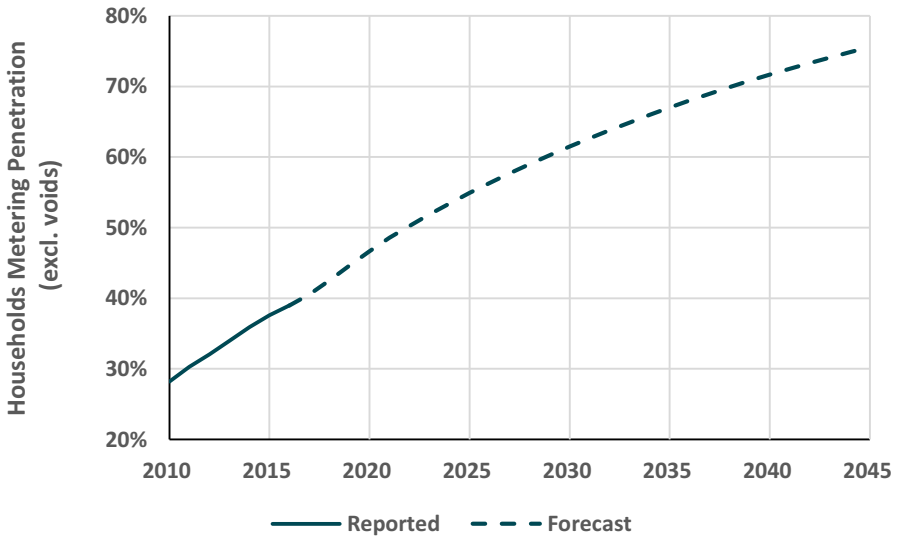


Figure 15 Meter penetration forecast

We continue to promote free meters with inserts in unmeasured bills and from time to time we send out targeted mailshots to specific customer segments. We also make this visible on our website where we have an online calculator to help customers decide if a meter is right for them. Additionally, we promote our Free Meter Option in relevant publications such as All Together Now, a local newspaper targeted at the older demographic which will include Priority Services customers. Customer research has indicated that some customers worry that by switching to a meter they may end up paying more for their water. We are

[29] The 'Community Charge' was the Government's tax system introduced in 1990 (most people remember this as the Poll Tax). The Community Charge replaced the Rates system when taxes where based on the Rateable Value of a property. When the Rates system was abolished, and the Valuation Office no longer assessed Rateable Values, we introduced compulsory metering for new premises (since there was no longer a rateable value to base charges on).

currently trialling a new metering proposition – the Price Promise which has been developed to overcome this barrier.

The Price Promise means that if a customer doesn't save money once the meter is fitted, we will cap the charge to their previous fixed annual bill. This happens automatically so there is no need for the customer to contact us. The Price Promise runs for two years from the meter installation, and during this time customer can still choose to switch back to a fixed annual bill if they think they won't benefit from a metered charge. We're also trialling the installation of water efficiency devices along with the Price Promise when a meter is installed to further enhance customer experience, promote water efficiency behaviour and the potential financial savings for customers. We requested participants for the trial in specific areas between July and October 2017, and we will need to monitor and assess the data for two years to determine whether the trial has been successful.

All water meter installations will be equipped with automated reading technology to allow greater frequency of data collection and more efficient meter reading. This will also help us identify when customers' consumption changes or 'leak alarms' are triggered so we can proactively notify customers of the changes. Automated readings can play a key role in leakage detection as the availability of frequent data and alarms allows leaks to be detected earlier, rather than relying on when a bill is generated.

4.3 Customer's future demand for water

This section describes how we forecast the future demand for water, before the benefit of any additional metering, water efficiency or leakage programmes. We call this the 'baseline' demand forecast. As a result of our demand management activities described in Section 4.2 this baseline demand forecast includes assumptions of water efficiency savings of 1 litre per property per day and the meter penetration forecasts shown in Figure 15. Further detail on the work underpinning this section can be found in our *Draft WRMP19 Technical Report - Demand for water*.

Demand for water is made up of several key components which are illustrated in the bottom half of Figure 16. This figure also shows how distribution input is a common measure between the water we supply and demand for water, as well as where several other components of supply and demand are accounted for.

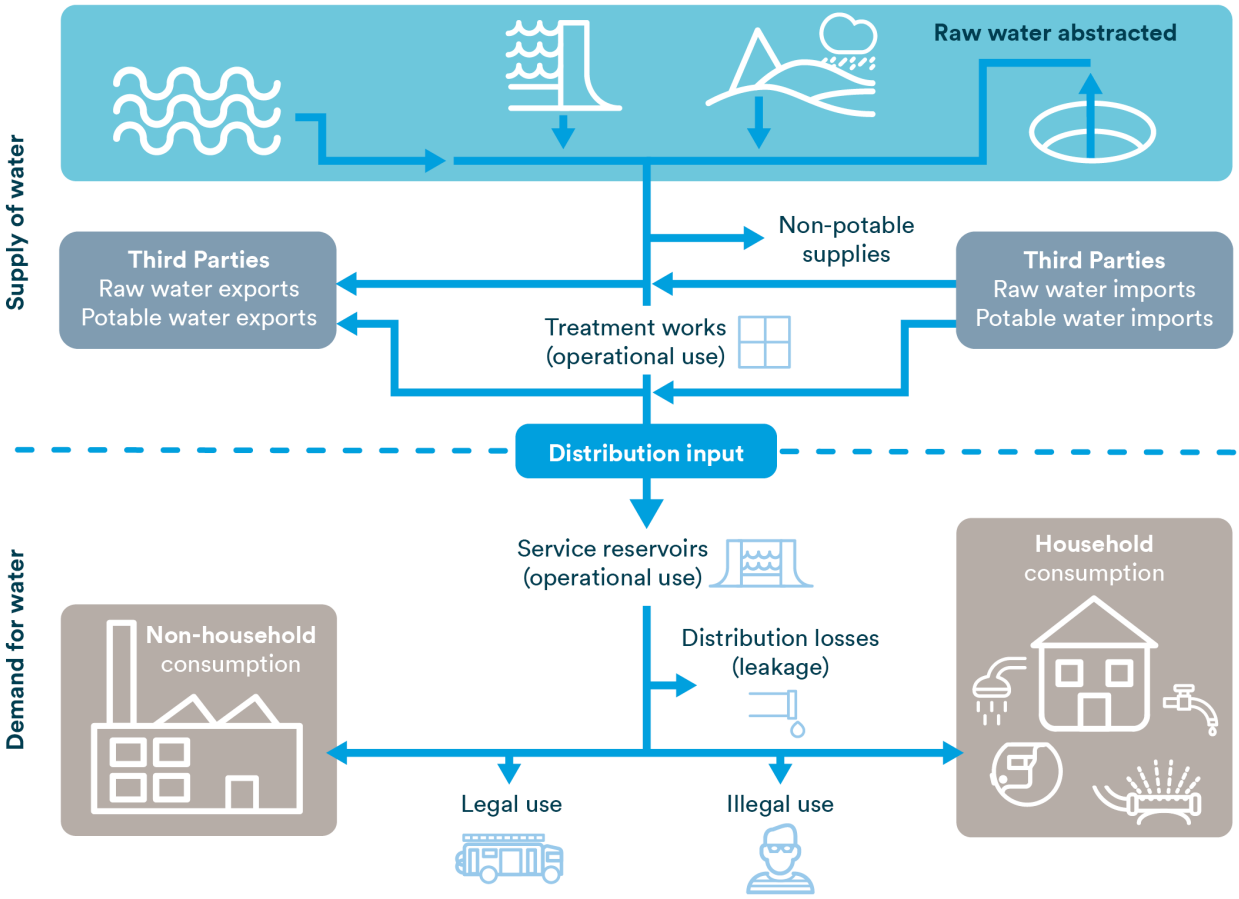


Figure 16 The key components forming supply and demand

4.3.1 Historic demand for water

Since the mid-1990s, the population in the North West has increased by 300,000 and economic output has increased by £75 billion[30]. Despite this, the demand for water in our region has fallen and is significantly

[30] In terms of regional gross value added (income approach) at current basic prices (Office of National Statistics, December 2016).

lower than in the recent past, as shown in Figure 17. This is largely due to significant leakage reductions, as well as metering and water efficiency activity reducing customer consumption.

Year on year the demand for water can fluctuate and in the last few years we have seen slight increases in demand, potentially due to more population growth within our area. However, our forecasts aim to capture the long-term trend in demand for water, as well as accounting for future uncertainties such as population growth and reductions in household consumption associated with meter uptake. The overall reduction in demand for water has not only influenced the starting point of our demand forecast (or 'base year'), but this information also helps to inform the forward look, as discussed further in the next section.

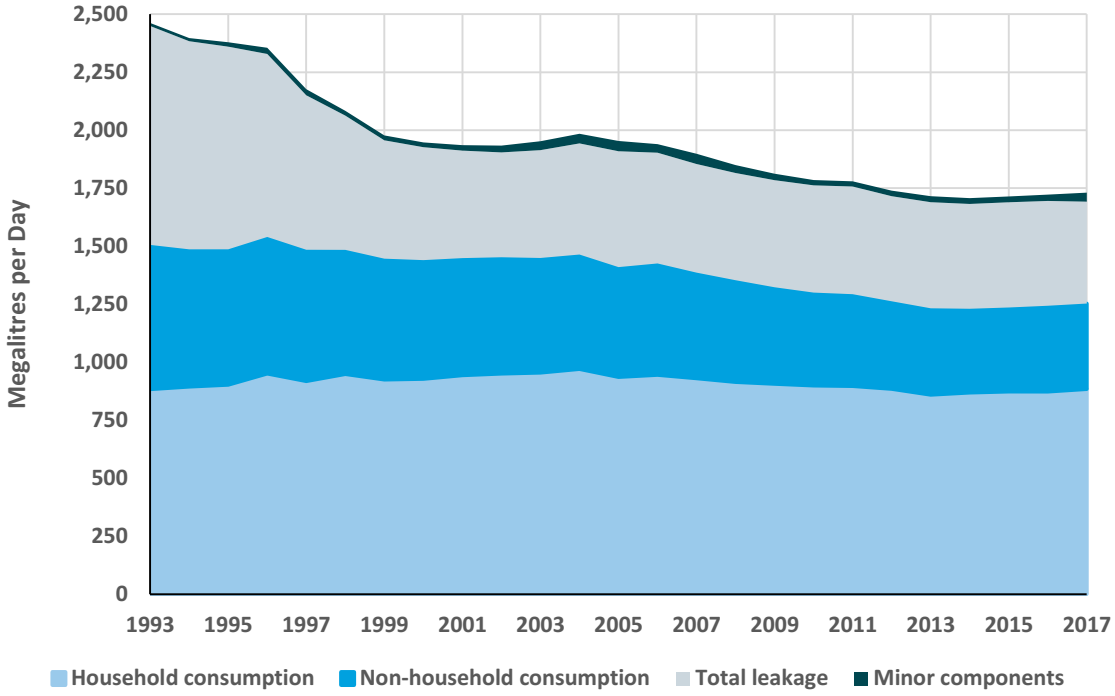


Figure 17 Demand for water by component over the last 25 years

4.3.2 Forecasting demand for water

By adhering to the guiding principles, as set out in the Environment Agency's *Water Resources Planning Guideline*, and following industry best practice, we aim for a robust forecast of demand for water over the planning horizon[31]. There are several key factors that affect customer consumption:

- Population (as well as property and occupancy) change;
- Changes in water use behaviour and design standards;
- Metering (this has been discussed in Section 4.3.5);
- Increasing water efficiency and sustainable water use practices (this has been discussed in Section 4.2);
- Economic conditions; and
- Climate change and weather patterns.

[31] From our 'base year', which is 2015/16 for the draft Water Resources Management Plan to, at least, the year 2044/45.

Explaining how these factors affect customer consumption is important when looking to forecast overall demand for water. However, it is equally important to recognise the need to understand the sensitivity of any forecast to the inherent uncertainty. We account for uncertainty in our target headroom assessment which is detailed in Section 4.5.

4.3.3 Growth in population and household properties

Population growth has the potential to lead to higher total household customer consumption. To forecast population change, we have considered the latest Office for National Statistics (ONS) projections[32]. However, in line with the Environment Agency's *Water Resources Planning Guideline*, we have also engaged with Local Authority Districts and Unitary Authorities to understand how many household properties are likely to be built in our region over the planning horizon. Using this information, along with assumptions for occupancy[33], we have created a plan-based population forecast. Table 6 shows the plan-based population forecast for each resource zone and for our region.

Table 6 Plan-based population forecast by resource zone

	2015/16	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Strategic Resource Zone	6,980,386	7,301,526	7,551,216	7,732,309	7,906,330	8,075,297	8,198,640
Carlisle Resource Zone	109,469	117,287	123,395	128,284	130,955	132,873	133,820
North Eden Resource Zone	13,746	14,619	15,202	15,661	16,011	16,213	16,264
Region	7,103,601	7,433,432	7,689,812	7,876,254	8,053,296	8,224,384	8,348,723

Taken in isolation, an increasing population in an increasing number of household properties would result in a higher forecast of household customer consumption. However, this effect is counteracted by the influence of a number of other factors meaning that an increase in overall demand for water may not necessarily occur; these factors are discussed in the following sections.

4.3.4 Changes in water use behaviour and design standards

Changes in water use behaviour and design standards could have a major impact on future household customer consumption. As well as developers building more water efficient homes, more water efficient and even waterless products are increasing. We use a technique called micro-components analysis to help us understand the potential impact of these trends.

Information from industry-led research[34], as well as surveying household customers, allows us to understand more about the usage of certain appliances or devices that use water[35], termed 'micro-components'. This information includes:

- The number of customers that own certain appliances or devices, termed 'ownership';

[32] At the time of writing, this was the 2014-based subnational population projections (published in May 2016), updated to use the 2015 mid-year population estimate (published in June 2016) as the 'base year'.

[33] Our 'base year' occupancy rates have been informed by a customer survey, carried out with DJS Research and using best practice from the UKWIR behavioural integration project (published in 2016). Our forecast occupancy rates have been informed by Department for Communities and Local Government (DCLG) headship rates from the 2014-based household projections (published in July 2016).

[34] Including the UKWIR behavioural integration project (published in 2016) and the Market Transformation Programme (provided evidence to support UK Government Policy on sustainable products, published in 2011), as well as other studies, such as those carried out by WRc plc and Waterwise.

[35] Appliances/devices like baths, showers, washing machines, dishwashers etc.

- The frequency that customers use certain appliances or devices, termed 'frequency'; and
- The amount of water that certain appliances or devices use, termed 'volume'.

With the same industry led research[34], we have forecasted the change in ownership, frequency and volume to create an overall forecast of household customer consumption. We have also tested the sensitivity of our forecast to different assumptions for ownership, frequency and volume, discussed more in our *Draft WRMP19 Technical Report - Demand for water*.

Water efficiency and sustainable water use improves over time. Information from a survey of household customers and other industry-wide research helps inform our 'baseline' household water efficiency target. This reflects the 1 litre per household property per day additional water saving each year from the continuation of the activity set out in Section 4.2.3.

To detect any potential shifts in non-household customer water efficiency activity, we have engaged with retailers around their water efficiency programmes. We have also used the econometric modelling, discussed in Section 4.3.6, to pick up on trends in water efficiency and create water efficiency scenarios.

4.3.5 Metering

We recognise the important contribution of customer metering and tariff actions in reducing demand for water. As discussed in Section 4.2.4, this plays a key role in our demand management plans. Over the 25 years we expect meter penetration to increase to 76%, resulting in a reduction in household consumption of 100 Ml/d. However, this assumption is very sensitive. For example, it may be that those households most likely to save water have already switched to metering, with the net effect that further meter penetration has a lower impact.

During the 1990s, we carried out an extensive programme of metering non-household properties, wherever practicable. Therefore, the number of properties remaining unmeasured is small[36] meaning this is a relatively minor component of the non-household customer consumption forecast.

4.3.6 Economic conditions

Non-household customer consumption is closely linked to economic conditions. The EU referendum result has created significant uncertainty in the outlook for the UK economy, both in the short and longer term. At the same time, the relatively strong performance of the UK economy over the past four years signifies that it has recovered ground lost during the 2007/08 recession more quickly than seemed likely a few years ago.

We use an economic model to find relationships between certain metrics, for example levels of employment and non-household customer consumption for different industry sectors, such as construction or fuel refining. This allows us to forecast the likely consumption for different industry sectors to derive an overall non-household customer consumption forecast, which is shown in Figure 18.

[36] At Regulatory Reporting 2015/16, there were 14,730 unmeasured non-household properties and 154,262 measured non-household properties.

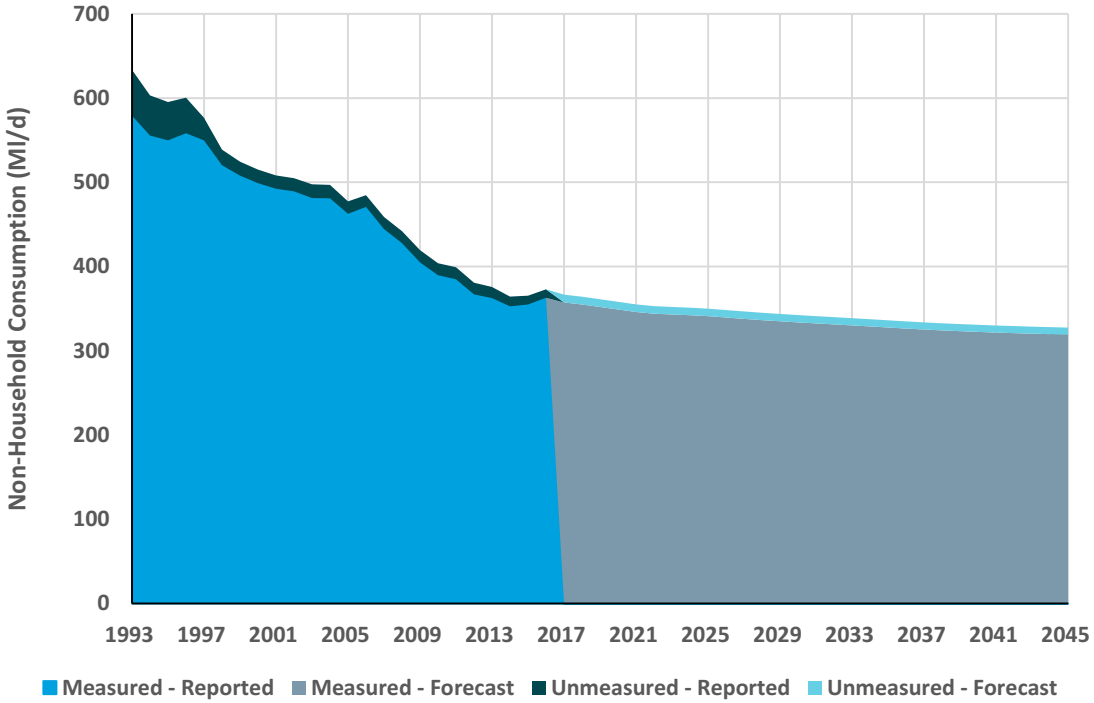


Figure 18 Reported and forecast non-household customer consumption

We have also investigated a range of alternative scenarios that could affect consumption for different industry sectors. These scenarios are documented further in our *Draft WRMP19 Technical Report - Demand for water*, and include:

- Economic growth scenarios for the North West of England, such as a 'Northern Powerhouse' scenario, which envisages that the northern regions undergo a period of economic transformation and fulfil the aspirations of the vision set out in Her Majesty's Treasury analysis;
- Water efficiency and tariff scenarios, which explore the potential benefit of increasing competition within the water industry, leading to efficiency saving for customers[37]; and
- Customers swapping from and/or to non-public water supply, particularly focussing on the agricultural sector and informed by a National Farmers Union survey[38].

4.3.7 Climate change and weather patterns

Consumption of water is higher during 'hot' and 'dry' periods, due mainly to a significant increase in the watering of gardens. The higher demand for water, associated with this increase in consumption, is often termed 'dry year' demand.

We've worked with the United Kingdom Meteorological Office to understand how weather metrics, like temperature and rainfall, affect the consumption of water by looking back at historical records. This allows

[37] Assumptions are consistent with the stated water efficiency benefits of competition in the water industry in Scotland.
[38] NFU Water Survey (2011) http://www.demonstratingcatchmentmanagement.net/wp-content/uploads/2012/01/NFU-Water-Survey-2011_-FINAL-EXTERNAL-V4-2.pdf

us to understand the likely increase in demand for water in a dry year[39] so that we can apply an uplift to customer consumption to account for this.

A similar approach is taken to account for the potential impact of climate change on demand for water. The dry year demand for water is further uplifted, based on the findings from industry research[40].

In the Carlisle Resource Zone, water sources are 'flashy' and can go from full to their lowest level in a few months. The time taken for this to happen is called the 'critical period' and the demand for water over this period is known as critical period demand. As the critical period can coincide with the hottest and driest months of the year, the uplift applied to demand is even higher than for the dry year demand and critical period demand is presented as a separately in Table 7.

4.3.8 Our baseline forecast of demand for water

The methods and assumptions described above have been used to prepare baseline demand forecasts. The central forecast of dry year demand for water, as well as the upper and lower forecast of dry year demand for water, is presented in Figure 19. The upper and lower forecast of dry year demand for water are used to inform our target headroom assessment which is detailed in Section 4.5. The central baseline demand forecast for each resource zone, by component, is summarised in Table 7. As mentioned earlier, in the last few years we have seen slight increases in demand and we are alert to the fact that this could be the start of an upward trend. However, it is clear that there are significant uncertainties (detailed in Section 4.3.1) which make accurate prediction of future demand difficult, as evidenced by the wide variance in the upper and lower demand forecasts shown in Figure 19. This is a key reason for reviewing our Water Resources Management Plan on a regular basis and we will continue to monitor demand for water, assessing it against our demand forecast, as part of our annual review process.

[39] Following the Environment Agency Advice Report on our Water Resources Management Plan 2015, as well as further discussions, we have revised our design dry year from 1995/96 to the 95th percentile from a distribution showing how demand over the last 55 years has been impacted by weather.

[40] The Impact of Climate Change on Water Demand UKWIR project (published in 2013), which is still the principal source of climate change demand uplift information.

Table 7 Forecast demand for water by component and resource zone (Ml/d)

	2015/16	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Strategic Resource Zone							
Household consumption	857	850	849	844	844	846	849
Non-household consumption	361	347	341	334	328	323	321
Total leakage	444	440	440	440	440	440	440
Minor components	27	27	27	27	27	27	27
Demand for water	1,689	1,664	1,656	1,645	1,638	1,635	1,636
Demand for water in a dry year	1,697	1,673	1,667	1,656	1,651	1,650	1,651
Carlisle Resource Zone							
Household consumption	14.2	14.4	14.9	15.2	15.3	15.4	15.3
Non-household consumption	7.1	6.7	6.4	6.2	6.0	5.8	5.7
Total leakage	5.9	5.6	5.6	5.6	5.6	5.6	5.6
Minor components	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Demand for water	27.5	27.1	27.3	27.4	27.3	27.2	27.0
Demand for water in a dry year	27.7	27.3	27.5	27.6	27.5	27.4	27.3
Demand for water in a critical period	29.1	28.7	28.9	29.1	29.0	28.9	28.8
North Eden Resource Zone							
Household consumption	1.7	1.7	1.8	1.8	1.8	1.8	1.8
Non-household consumption	1.3	1.3	1.2	1.2	1.2	1.2	1.1
Total leakage	2.6	2.8	2.8	2.8	2.8	2.8	2.8
Minor components	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Demand for water	5.8	5.9	6.0	6.0	6.0	5.9	5.9
Demand for water in a dry year	5.8	6.0	6.0	6.0	6.0	6.0	6.0
Region							
Household consumption	873	866	866	861	861	863	866
Non-household consumption	370	355	348	341	335	330	328
Total leakage	452	448	448	448	448	448	448
Minor components	27	27	27	27	27	27	27
Demand for water	1,722	1,697	1,690	1,678	1,671	1,669	1,669
Demand for water in a dry year	1,732	1,708	1,702	1,692	1,686	1,684	1,686
Barepot Resource Zone[41]							
Non-potable demand	26.9	26.9	26.9	26.9	26.9	26.9	26.9

[41] The Barepot Resource Zone covers a supply of non-potable water only. Although, in the Water Resources Management Plan process, non-potable water supplied is taken away from available supply, rather than included as a component of demand, it is shown in this table for completeness.

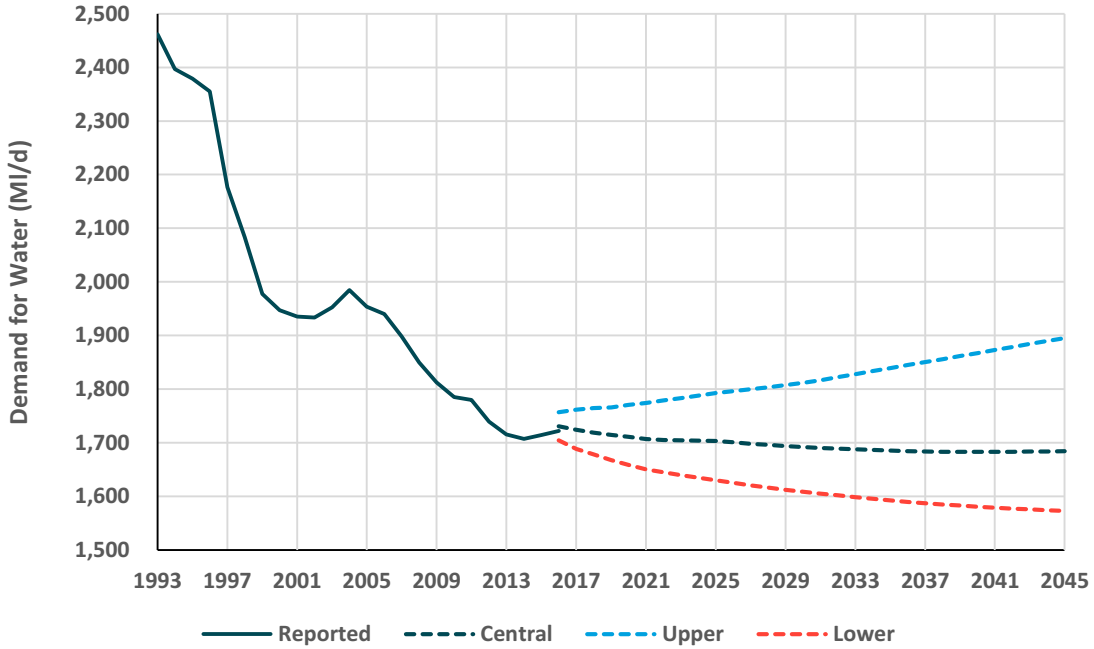


Figure 19 Reported regional demand for water, with the central forecast of dry year demand for water, as well as the upper (accounting for the 'Northern Powerhouse' scenario) and lower forecast of dry year demand for water[42]

[42] The different starting point for each forecast relates to the inherent uncertainty in the starting point, for example, the uncertainty in the dry year uplift that has been applied to demand for water.

4.4 Forecasting our future supply

4.4.1 Introduction to supply forecasting

A key component of the Water Resources Management Plan is the assessment of water supply availability. This is determined over the full 25 year planning period (2020-2045) using two standard industry measures; deployable output and water available for use. The water available for use is the basis for the supply component of the supply-demand balance comparison.

Deployable output:

The maximum quantity of water output from a source or group of sources in a dry period. It accounts for: water quality, abstraction licence limits, water treatment, supply system capabilities, climate change, and sustainability reductions

Water available for use:

A calculation taking deployable output and then accounting for: raw water, treatment and operational losses, imports, exports, and potable bulk supplies to determine the actual volume of water available for use

In assessing available supplies we have followed national best practice methods. Whilst we focus on the 25 year planning horizon, we have also looked beyond this as far as the 2080s. This analysis helps to test the future performance of potential plans beyond the year 2045, and is supported by the new sophisticated methods that we have adopted for this plan (Section 8).

A high-level overview of the approach to supply forecasting, and the resulting water available for use, is described in this section. A more in depth view of the process followed and the results for different components of the supply forecast can be found in our *Draft WRMP19 Technical Report - Supply forecasting*.

4.4.2 Calculating deployable output

Deployable output is the maximum quantity of water that can be provided from a resource zone whilst meeting our stated level of service (Section 1.4 and 6.3). For this plan we assessed deployable output for all resource zones and adopted different approaches in line with resource zone complexity. The Barepot Resource Zone is a simple single source system. The North Eden Resource Zone has low complexity, and therefore the yields of the different sources in the resource zone are simply summed together. The Strategic and Carlisle Resource Zones are more complex. These systems are surface water dominated and sources are used in a 'conjunctive' nature, as the supply network means that water from different sources can be moved around the resource zone to balance water resources risk. System constraints mean that it is inappropriate to simply sum together source yields so to determine deployable output we used water resources models in the Aquator™ package (developed by Oxford Scientific Software). This is documented further in our *Draft WRMP19 Technical Report - Supply forecasting*.

In calculating deployable output for this plan we have reviewed and, where necessary, refreshed our data. In aggregate these updates result in a small decrease in deployable output of 26 Ml/d. The following bullet points show where we have reviewed and refreshed our data:

- Hydrological and hydrogeological yield of sources using historic records typically between 54 and 89 years in length;
- Asset constraints;
- Abstraction licence constraints and conditions;

- Demands; and
- Dead water and emergency storage within impounding reservoirs.

4.4.3 Sustainability changes

A sustainability change (or sustainability reduction as it is sometimes termed) is any change to a water company abstraction licence to protect (prevent deterioration) or improve the environment. The Environment Agency works with water companies to identify sustainability changes *via* the Water Industry National Environment Programme (WINEP), which sets out measures needed to protect and improve the environment.

In determining water available for use any reductions associated with achieving sustainable abstraction must be accounted for. In line with the guidance we have liaised with Environment Agency and Natural Resources Wales to determine if we have any abstractions from water bodies that are at risk from deterioration, and include the requirements set out in the WINEP. Details for sites with a risk of failing to meet the standards have been provided by the Environment Agency.

In our Water Resources Management Plan 2015 we included a number of sustainability changes and in this 2015-2020 period we are investing to implement them[43]. The sustainability changes from our 2015 plan have therefore been accounted for in assessing our baseline supply forecast. There are no new sustainability changes to include in our baseline supply forecast. However, we identify potential future sustainability changes that require further investigations in the 2020-2025 period to confirm if they will go ahead.

Working closely with the Environment Agency we have assessed the impact of our plan on the Water Framework Directive, in particular ensuring that it does not lead to deterioration of water bodies that we abstract from now, or plan to abstract from in the future. Further detail can be found in our *Draft WRMP19 Technical Report - Supply forecasting*.

4.4.4 Climate change

It is important for us to consider the likely impact of climate change on our water resources to help define the resilience of our supply system. Our assessment of climate change impacts follows the highest tier of analysis and has been completed to meet the requirements of the latest Environment Agency guidance. Climate change has been assessed in a risk-based manner and our choice of approach is based on the outcomes of a resource zone vulnerability exercise. We engaged with the Environment Agency extensively throughout this process and held a full day special interest session with regulatory stakeholders.

The approach for assessment comprises four stages:

- Vulnerability assessment;
- Calculate river flows for a resource zone in the 2080s as recommended by the latest Environment Agency guidance;
- Calculate deployable outputs for the 2080s; and
- Scaling and uncertainty.

[43] Two sustainability changes at Ennerdale Water and Over Water in our West Cumbria Resource Zone will come into effect on completion of the Thirlmere Transfer scheme in March 2022.

In line with the framework outlined in the guidance we adopted an approach that is suitably appropriate based on the outcomes of the vulnerability assessment and the complexity of each resource zone[44]. The approach chosen uses 10,000 climate change projections, from which the deployable output is calculated for a representative sub-selection of 20 scenarios. For the Strategic Resource Zone we expanded our analysis to test 100 of the scenarios using an emulator model[45] of the resource zone. For the Barepot Resource Zone, results were translated from a similar catchment and applied to the flows at the River Derwent. For the North Eden Resource Zone the groundwater source yields were reassessed for each of the 20 climate change scenarios. A scaling factor is used to apply the deployable output impact at the year 2080 and adjust it for the time period of our planning horizon.

The results of the climate change assessment for each resource zone are shown in Table 8. There is no impact in the North Eden Resource Zone due to the sources being constrained by licences rather than the underlying hydrogeology. There is no impact in the Barepot Resource Zone despite being supplied from a surface water source. The resource zone itself is constrained by the abstraction licence, and the yield under each of the 20 climate change scenarios was found to be greater than the source deployable output. Therefore the source is not impacted by climate change. For the other resource zones the simulated impact of climate change in 2080 is highest in the Strategic Resource Zone; with a reduction in resource zone deployable output of 205 Ml/d, or 9.7%. For the Carlisle Resource Zone the resulting reduction in deployable output is 1.1 Ml/d, or 3.1%.

Table 8 Summary of deployable output impacts of climate change over planning horizon

	Strategic Resource Zone	Barepot Resource Zone	Carlisle Resource Zone	North Eden Resource Zone
Simulated baseline deployable output (Ml/d)	2,118	34.1	35.7	8.7
Simulated impact (at the year 2085)				
Highest simulated impact (Ml/d)	-469	0.0	-4.3	0.0
Lowest simulated impact (Ml/d)	+144	0.0	+1.0	0.0
50th percentile deployable output impact (Ml/d)	-205	0.0	-1.1	0.0
Year in the planning horizon and deployable output impact (Ml/d)				
2020/21	-86	0.0	-0.5	0.0
2025/26	-95	0.0	-0.5	0.0
2030/31	-104	0.0	-0.6	0.0
2035/36	-113	0.0	-0.6	0.0
2040/41	-123	0.0	-0.7	0.0
2044/45	-130	0.0	-0.7	0.0

[44] In line with the assessment framework outlined in the Environment Agency supporting guidance we adopted a Tier 3 approach, which is suitable where the outcome of our vulnerability assessment indicates there is a high vulnerability. This is known as the 'UKCP09 / water company own approach' and uses the UKCP09 probabilistic projections

[45] The emulator model of our Strategic Resource Zone aggregates some parts of our supply system and enables the rapid assessment of both climate change and different hydrological scenarios.

4.4.5 Outage allowance

An outage allowance is applied to recognise that some sources will temporarily become unavailable during the planning period due to events such as:

- Short-term water quality problems and pollution incidents;
- Seasonal effects on surface water sources, e.g. algae problems and geosmin, turbidity;
- Asset failure or temporary constraints at water sources and treatment works; and
- Reservoir safety works requiring a drawdown of reservoir level.

The assessment is based on our actual recent experience of events, coupled with an assessment of the risk of events happening in the future. It follows the methodology detailed in the report 'Outage Allowance for Water Resource Planning' (UKWIR, 1995) and is in line with the Water Resources Planning Guidelines (Environment Agency, 2017) and supplementary information from the Environment Agency in July 2016.

For this 2019 Water Resources Management Plan we made some key updates to our approach from the last plan, including:

- An extensive review and update of input data, which defines both the likelihood of an asset experiencing an outage and the impact on deployable output;
- Improved representation of intermittent assets, as some sources or assets are not used continuously, even in a dry year;
- The inclusion of key potable aqueducts; and
- Reassessment of the percentile choice[46], which has been updated to the 80th percentile in line with the latest industry methodologies (we used the 95th percentile in our 2015 plan). The percentile choice is consistent across all resource zones, as we believe it is appropriate for the level of outage risk to be the same for all supply areas.

The total outage allowance, displayed in Table 9, is modest and reflects the high degree of integration of the supply system, which enables us to respond efficiently to planned and unplanned events. Further detail on our outage allowance assessment for this 2019 Water Resources Management Plan is included in our *Draft WRMP19 Technical Report - Supply forecasting*.

Table 9 Outage Allowances included in this plan

	Strategic Resource Zone	Barepot Resource Zone	Carlisle Resource Zone	North Eden Resource Zone
Outage allowance (Ml/d)	101.3	Zero	1.55	0.05

4.4.6 Raw water exports and bulk supplies

As noted in Section 3.3 there are raw water exports to Dŵr Cymru Welsh Water and non-potable supplies from the River Dee (Strategic Resource Zone) totalling around 80 Ml/d. In addition, there are a limited number of very small imports, exports and potable bulk supplies for the Strategic and North Eden Resource Zones.

[46] Choice of percentile reflects both the degree of confidence in the data and potential risk.

4.4.7 Supply forecasts

The forecasts of deployable output and water available for use for each water resource zone are summarised in Table 10. Only the start and end of the planning period are shown here; the results for the full period are shown in Section 4.6 with the supply-demand balance for each resource zone.

Table 10 Water supply forecasts for each resource zone

Component of supply forecast (Ml/d)	Strategic Resource Zone		Barepot Resource Zone		Carlisle Resource Zone		North Eden Resource Zone	
	2020/21	2044/45	2020/21	2044/45	2020/21	2044/45	2020/21	2044/45
Baseline deployable output	2,112.6	2,115.6	34.1	34.1	35.9	35.9	8.7	8.7
Sustainability changes (from 2020/21)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Climate change	-85.5	-130.1	0.0	0.0	-0.5	-0.7	0.0	0.0
Forecast deployable output	**2,027.0**	**1,985.4**	**34.1**	**34.1**	**35.4**	**35.2**	**8.7**	**8.7**
Non-potable/raw water supplies	-71.6	-75.0	-26.9	-26.9	0.0	0.0	0.0	0.0
Raw water and process losses	-42.0	-42.0	-0.03	-0.03	-0.6	-0.6	-0.04	-0.04
Outage	-101.3	-101.3	0.0	0.0	-1.6	-1.6	-0.05	-0.05
Imports	0.03	0.03	0.0	0.0	0.0	0.0	1.3	1.3
Exports[#]	-1.6	-2.1	0.0	0.0	0.0	0.0	0.0	0.0
Water available for use	**1,810.6**	**1,765.0**	**7.17**	**7.17**	**33.3**	**33.1**	**10.0**	**10.0**

[#]Note that potential future exports are explored later in this document in Sections 6.5 and 7.6

4.4.8 Extreme droughts, and links to our Drought Plan

In developing past Water Resources Management Plans, we have relied on the analysis of recorded hydrological data such as rainfall, river flow and reservoir levels. Our key measure of supply, deployable output (Section 4.4.2), is calculated based on the most severe drought in this record. We refer to this as the design drought; in the Strategic Resource Zone this is the 1984 event which has a return period of around 1 in 90 years (1.1% annual average risk).

We have good hydrological records, reaching back to the 1920s for the majority of our region. Increasingly we wish to understand the risks posed by extreme droughts, for example, those we might expect to experience only 1 in 200 (0.5% annual average risk) or 1 in 500 years (0.2% annual average risk) on average. However, even with a record length as long as 100 years it is difficult to assess this in a reliable way[47]. Therefore, we have developed a stochastic flow dataset; this is derived from rainfall that is statistically realistic, but has not occurred in the observed record. It has allowed us to extend the length of our records to over 17,000 years (200 statistically plausible versions of our historic record), to contain a vast array of

[47] In previous Drought Plans we have used a technique known as Extreme Value Analysis.

different patterns and severities of drought. We have also developed a suite of modelling tools[48] to allow us to simulate the effects of this large volume of hydrological data on our supply system.

Water Resources Management Plans and Drought Plans are set out in legislation as separate plans and are intended to serve different purposes. Water Resources Management Plans are long-term strategic plans where the case can be made for investment to maintain supply over a set planning period. Drought plans are tactical plans that set out triggers and measures in response to drought events. However, the two plans share the same broad objective of maintaining a secure and sustainable supply of safe, clean water for customers. The Environment Agency has released a new Water Resources Management Plan table that is referred to as the Drought Links table[49]. The table helps companies to consistently demonstrate how their supply system will respond to a range of relevant drought scenarios (e.g. 1 in 200, 1 in 500 and 1 in 1000 years[50]). It also enables companies to disaggregate the effects of drought measures from normal non-drought supplies. A full account of how we have populated the table is provided in the *Draft WRMP19 Technical Report - Supply forecasting*.

There is also a new Defra reference level of service for emergency drought orders (standpipes, rota-cuts and bowsers) of 1 in 200 years on average (0.5% annual average risk). Companies are expected to include this level of service in the Water Resources Management Plan as a scenario and determine the required level of investment to achieve it. Our analysis completed for the Drought Links table indicates that once emergency storage[51] is taken into account we already exceed this level of service; i.e. we have a high level of resilience to droughts. As a result of this, and when coupled with customer views on the matter, we have decided not to explore the possibility of investing to further increase drought resilience at this stage. However, our proposals in this plan will result in supplementary benefits from our investment in other areas, which manifest in further improved drought resilience, as summarised in Section 7. Our plans mean that emergency drought orders would not be required except in only very extreme drought events. In Section 6.3, we also explain that we are considering improved stated level of service for non-essential use bans, to account for corresponding changes to level of service for drought permits and orders frequency.

[48] As mentioned in Section 4.4.4, we have used an emulator model of our Strategic Resource Zone that enables the rapid assessment of both climate change and different hydrological scenarios.
[49] This is the Table 10 Drought plan links as included in the Environment Agency Planning tables.
[50] 1 in 200 year event has a 0.5% annual average risk, a 1 in 500 year event has a 0.2% annual average risk, and a 1 in 1000 year event has a 0.1% annual average risk.
[51] This storage would expected to be used only in drought events more severe than on the historic record. It is used in this analysis as we are testing events more severe than on the historic record.

4.5 Target headroom

4.5.1 Role of target headroom

It is difficult to forecast demand for water or water availability with complete accuracy, especially over a 25 year period. Uncertainties exist in all the components of the supply-demand balance. These include political, social, environmental, climate change and technical factors that may significantly influence components of the supply-demand balance. Target headroom is the buffer which is incorporated into water resources planning to protect customers from the uncertainties associated with the supply and demand forecasting over the planning horizon. This buffer aims to safeguard sufficient water to supply customers throughout the planning horizon. Further detail on how we calculate target headroom can be found in our *Draft WRMP19 Technical Report – Target headroom.*

4.5.2 Target headroom values

For each of the water resource zones a calculation of all of the supply demand uncertainty components is completed[52]. Of all the components, climate change makes up the largest proportion of headroom. The output of the headroom calculations is a probability distribution that represents a likely range of values for headroom for each year in the planning period. The actual target headroom values included in the supply demand balance are determined by a choice of percentile. This choice represents the confidence in the supply-demand data and the level of risk we are prepared to accept in being able to maintain a reliable supply of water to customers into the future. We have completed some sensitivity testing on the potential percentile choices to help understand the level of risk and inform our choice. The percentiles alter over time to account for the opportunity for our plans to be modified and adapted to changing circumstances, to prevent the risk of planning long-term investment on the basis of high uncertainty.

For the Strategic and Carlisle Resource Zones we vary the percentile choice over the planning horizon in line with the guidance. Starting with 5% uncertainty (95th percentile) in the year 2020 with a linear increase in uncertainty to 30% (70th percentile) in the year 2045, as shown in Figure 20. A different approach of a continuous percentile choice of 5% uncertainty (95th percentile) was chosen for the Barepot and the North Eden Resource Zones. This is due to the small amount of uncertainty in these resource zones which are constrained by abstraction licence limits and to avoid there being no buffer later in the planning horizon.

[52]A breakdown of each of the individual components is provided in our *Draft WRMP19 Technical Report - Target headroom*.

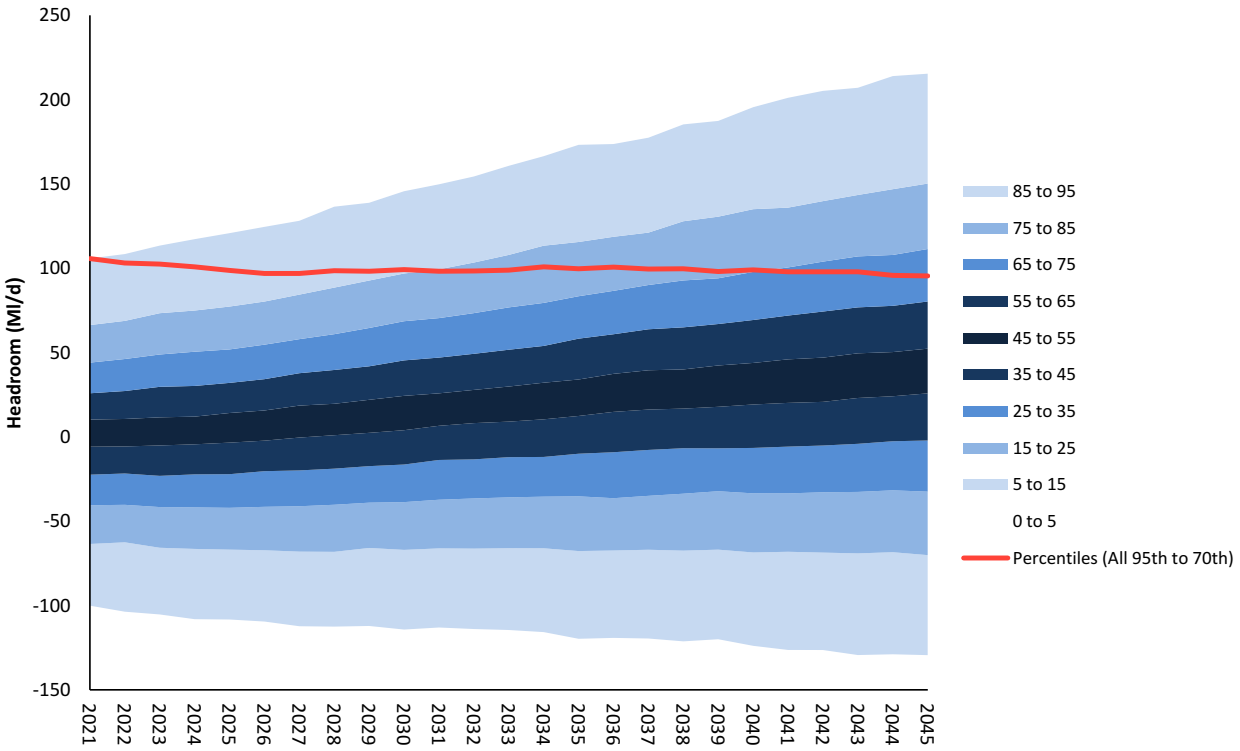


Figure 20 Illustrative results for headroom uncertainty with risk profile for the Strategic Resource Zone

The headroom values tend to fluctuate through time, with upward pressures due to increasing uncertainties (namely climate change impacts and forecast demand), and downward pressures in line with the increasing percentile profile. The baseline target headroom values are shown in Table 11. These values are considered alongside the forecasts for supply and demand to determine the baseline supply-demand balance in Section 4.6.

Table 11 Target headroom values (including climate change) for each resource zone, 95th to 70th percentile for the Strategic and Carlisle Resource Zones and a continuous 95th percentile for the Barepot and North Eden Resource Zones (Ml/d)

Year in the planning horizon	Strategic Resource Zone (Ml/d)[53]	Barepot Resource Zone (Ml/d)[54]	Carlisle Resource Zone (Ml/d)[53]	North Eden Resource Zone (Ml/d)[54]
2020/21	105.84	1.41	2.55	0.27
2025/26	96.95	1.41	2.19	0.27
2030/31	98.24	1.41	1.93	0.28
2035/36	100.67	1.41	1.61	0.29
2040/41	97.92	1.41	1.25	0.32
2044/45	95.46	1.41	1.07	0.33

[53] 95th to 70th percentile for the Strategic and Carlisle Resource Zones.
[54] Continuous 95th percentile for the Barepot and North Eden Resource Zones.

4.6 Supply-demand balances

4.6.1 Initial baseline

The initial 'baseline' supply-demand balances are summarised in Table 12. Each balance indicates the difference between water available for use and baseline demand forecasts including target headroom. Figure 21 to Figure 23 show the initial supply-demand balance for our water resource zones. Note that Barepot is shown in isolation in Figure 24 as it is a non-potable supply. These show a positive supply-demand balance over the period to 2045, i.e. on a traditional planning approach there are adequate resources available to meet demand.

Our baseline demand forecasts include the effects of the following (as described in Sections 4.2 and 4.3):

- Continuation of existing leakage control policies to maintain regional total leakage at 448 Ml/d, based on the three-year average from 2014/15 to 2016/17. The use of a 3-year average is defined in the planning guidelines;
- Continuation of existing water efficiency activities;
- Continuing to meter all new properties;
- Continuation of the Free Meter Option scheme, utilising targeted promotion. We plan for 345,000 households to opt between 2020/21 and 2029/30; and
- Continue with existing tariff structures for water bills.

Table 12 Initial supply-demand balances 2020/21 to 2044/45

Ml/d	2020/21	2025/26	2030/31	2035/36	2040/41	2044/45
Strategic Resource Zone						
Water available for use	1,811	1,802	1,792	1,782	1,773	1,765
Dry year demand	1,628	1,667	1,656	1,651	1,650	1,651
Target Headroom	106	97	98	101	98	95
Supply-Demand Balance	77	38	37	31	25	19
Barepot Resource Zone*						
Water available for use	34.1	34.1	34.1	34.1	34.1	34.1
Dry year demand	26.9	26.9	26.9	26.9	26.9	26.9
Target Headroom	1.4	1.4	1.4	1.4	1.4	1.4
Supply-Demand Balance	5.8	5.8	5.8	5.8	5.8	5.8
Carlisle Resource Zone (Critical Period)						
Water available for use	33.3	33.3	33.2	33.2	33.1	33.1
Dry year demand	28.7	28.9	29.1	29.0	28.9	28.8
Target Headroom	2.6	2.2	1.9	1.6	1.3	1.1
Supply-Demand Balance	2.1	2.2	2.2	2.6	3.0	3.2
North Eden Resource Zone						
Water available for use	10.0	10.0	10.0	10.0	10.0	10.0
Dry year demand	6.0	6.0	6.0	6.0	6.0	6.0
Target Headroom	0.3	0.3	0.3	0.3	0.3	0.3
Supply-Demand Balance	3.7	3.7	3.7	3.7	3.7	3.7

*The Barepot Resource zone is non-potable water only, non-potable water is not usually presented in demand, however for the purposes of presenting all resource zones in the same manner this has been included in demand for the Barepot Resource Zone.

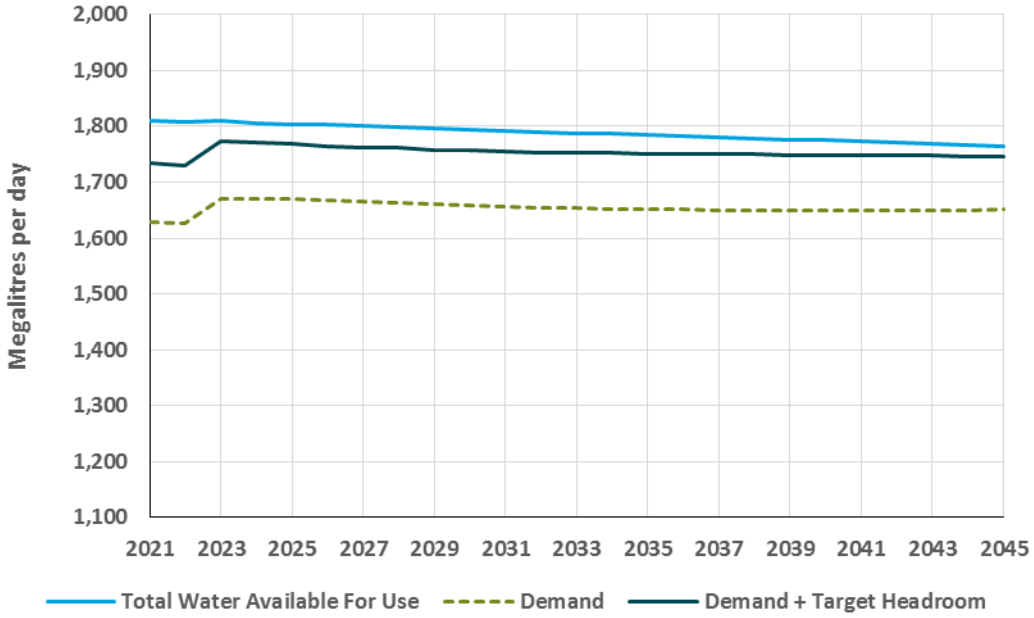


Figure 21 Initial supply-demand balance for the Strategic Resource Zone

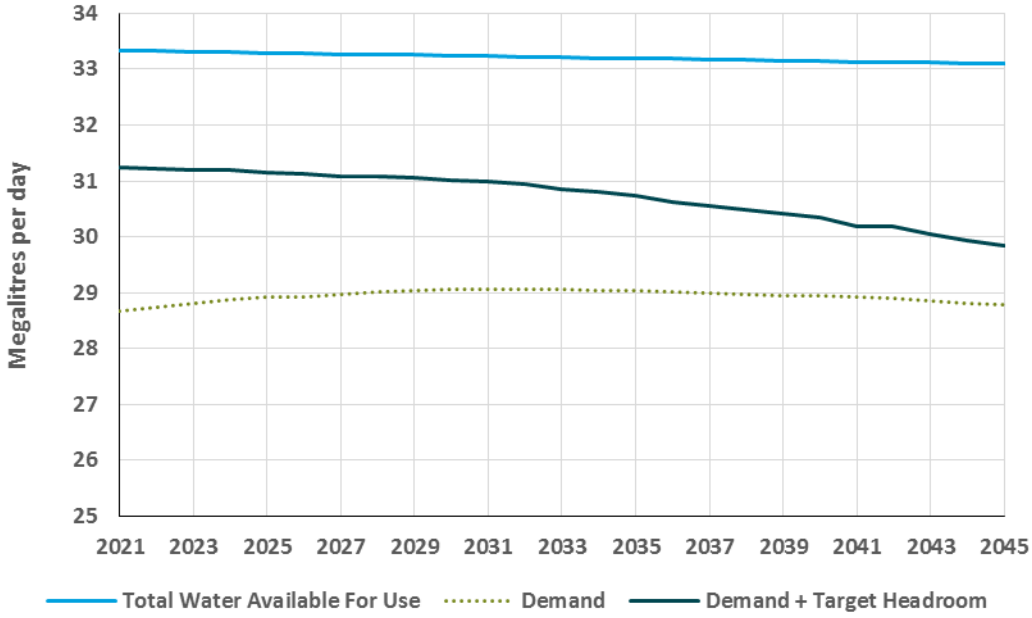


Figure 22 Initial supply-demand balance for the Carlisle Resource Zone (critical period)

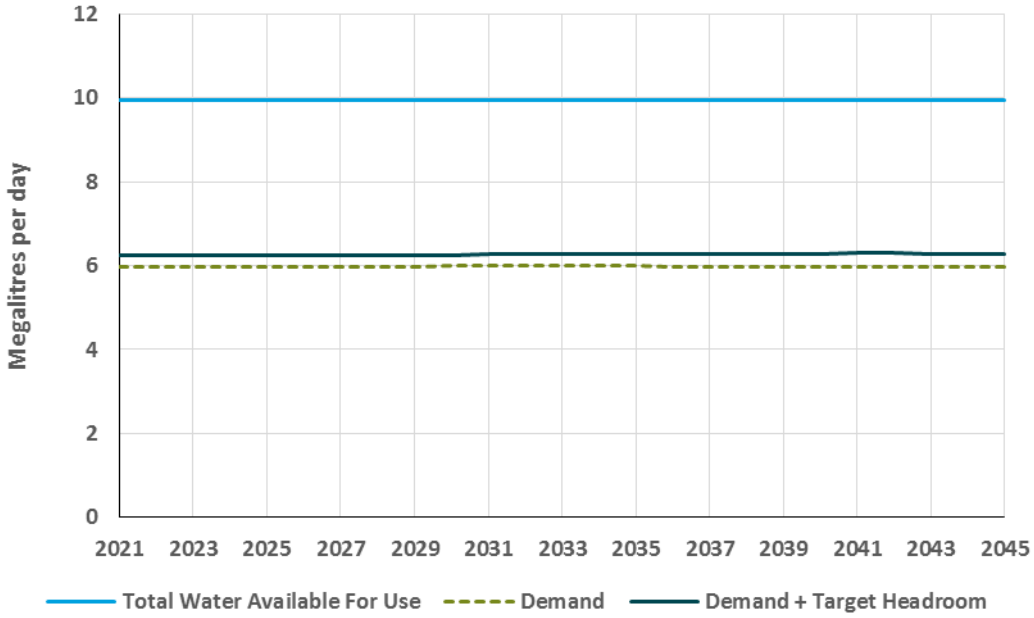


Figure 23 Initial supply-demand balance for the North Eden Resource Zone

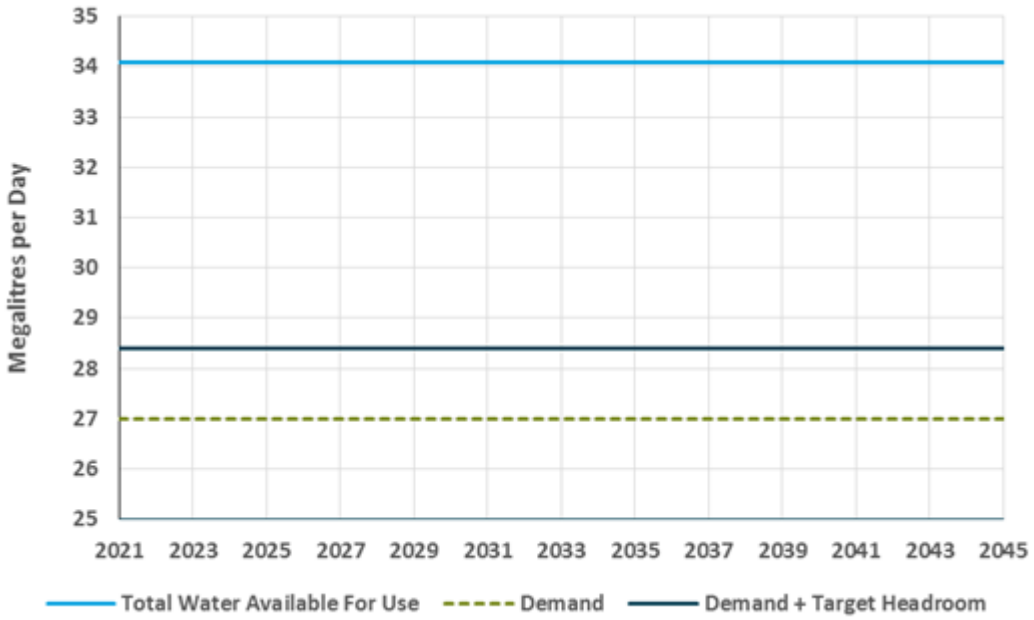


Figure 24 Initial supply-demand balance for the Barepot Resource Zone (non-potable). Note that demand reflects non-potable demand only for illustration.

4.6.2 What does our baseline forecast mean?

Overall each of our resource zones is forecast to maintain a positive supply-demand balance over the planning horizon. As there is enough water to meet demand and we do not need to take any further action. However, following the *Water Resources Planning Guideline*, we will consider this forecast surplus, with possible new source or demand management investment, as part of exploring our strategic choices. This is discussed further in Section 6. A summary of each resource zone follows below.

Strategic Resource Zone

Water available for use in the Strategic Resource Zone is expected to reduce by about 46 Ml/d over the planning horizon due to the incremental impacts of climate change. There will be some additional demand of around 43 Ml/d between 2020/21 and 2022/23, when the planned integration of the West Cumbria Resource Zone into the Strategic Resource Zone is realised (upon delivery of the Thirlmere transfer scheme). No supply deficit is forecast, with a surplus of around 38 Ml/d in 2025/26 dropping to around 20 Ml/d by the end of the planning horizon in 2044/45.

Carlisle Resource Zone

Water available for use in the Carlisle Resource Zone is forecasted to remain stable between 2020/21 and 2044/45, with a small reduction of around 0.2 Ml/d due to climate change. A supply demand balance of over 2.0 Ml/d is forecasted to be maintained between 2020/21 and 2024/25, and increases to 3.3 Ml/d by 2044/45 due to a reduction of target headroom forecasted.

North Eden Resource Zone

There are no supply deficits forecast in the North Eden Resource Zone throughout the planning period.

Barepot Resource Zone

There are no supply deficits forecast in the Barepot Resource Zone throughout the planning period.

4.7 Resilience to other hazards

Assessing our resilience to hazards other than drought is a new feature of this Water Resources Management Plan compared to previous plans. Resilience of our water service is a clear and pressing priority for our business, customers and other stakeholders. In our recent stakeholder workshops, resilience was consistently the highest ranked topic area. We have a comprehensive risk assessment process to help us to identify and evaluate resilience risks that could impact our supply of sufficient, wholesome water supplies to all customers. Whilst previous Water Resources Management Plans have focused upon the key resilience hazard of 'drought' other significant resilience hazards are already incorporated in our wider business planning assessments. These other hazards are reviewed in this 2019 Water Resources Management Plan to identify the potential impact they could have on maintaining a reliable, safe and clean supply of water.

In this section we explain how we:

- Define resilience and measure it;
- Currently manage resilience and give examples of how we have improved our resilience in the past and will continue to do so now and into the future;
- Include corporate and financial resilience considerations, as they also have potential to impact water service resilience;
- Have researched customers' and stakeholders' expectations to understand how and at what pace they want us to deliver resilience improvements; and
- Are planning for improved resilience across the next 25 years.

In order to rank and assess our current resilience needs we have: looked at the effects of a severe drought; modelled our system against freeze thaw shocks; and identified critical assets risk of failure to flood, power outage, contamination and malicious physical and cyber-attacks. We have related all current identified water service resilience risks to their potential impact upon customer supplies both in terms of their likelihood and consequences. In addition, we have assessed risks associated with our dams and reservoirs and manage these assets to reduce societal risk.

We use a cost benefit assessment to identify the most appropriate option to address each resilience risk. Options are identified and reviewed based upon their ability to reduce the resilience risk towards an acceptable level at an affordable pace. Each option is classified using the four 'R's of resilience: 'resistance', 'reliability', 'redundancy' and 'response and recovery', see the example schematics in Figure 25 below:

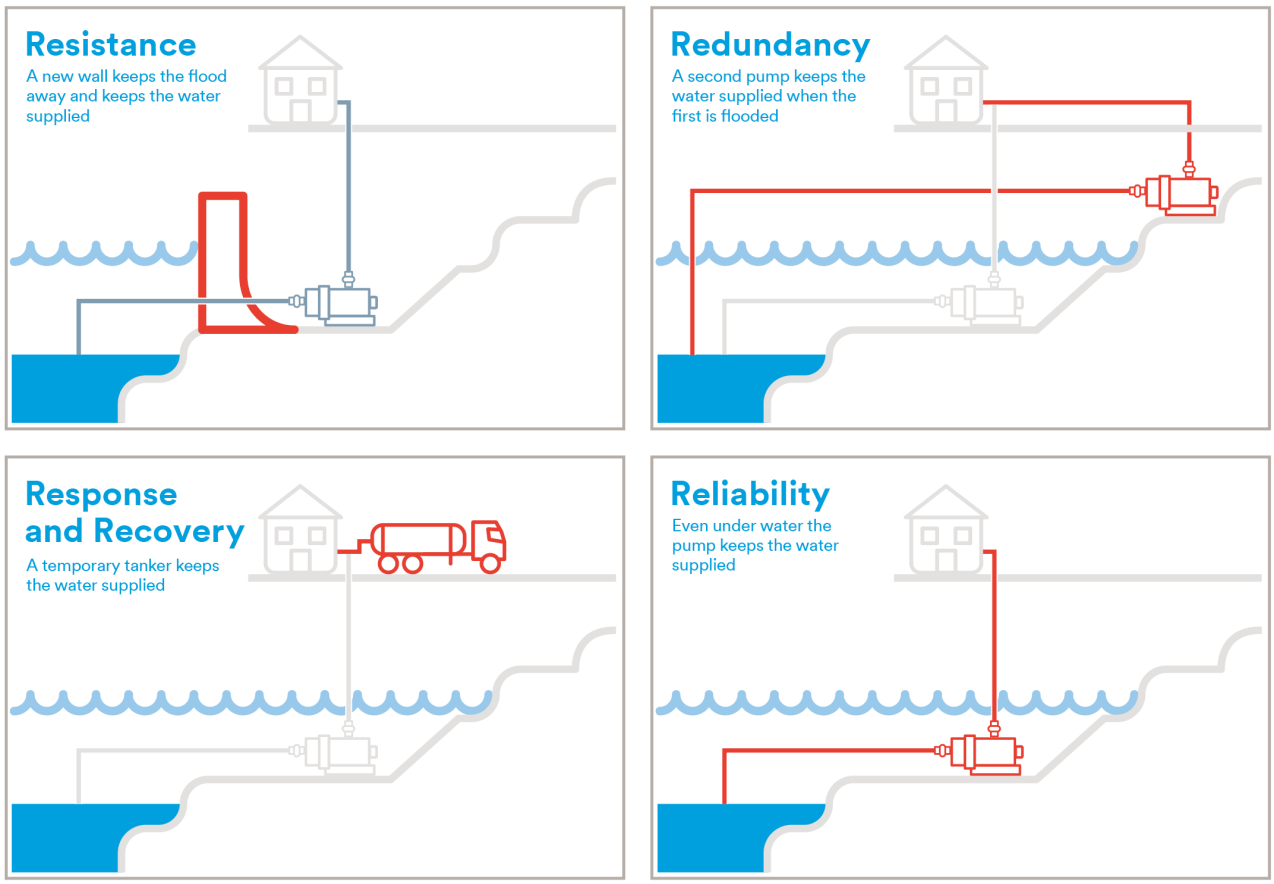
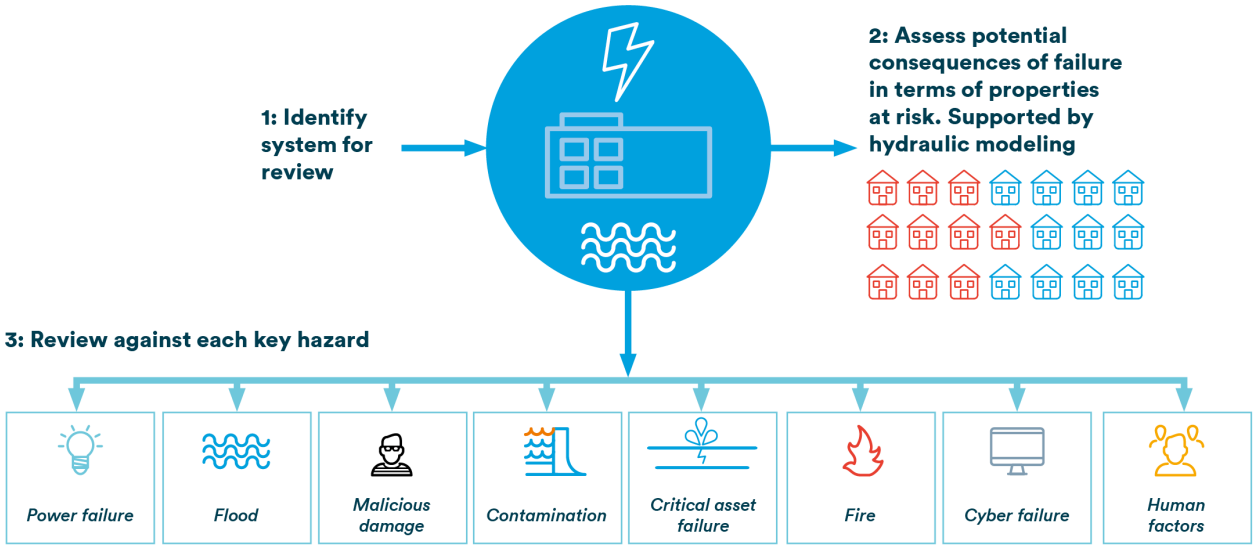


Figure 25 An example representation of the four 'R's of resilience for our water service

Further detail on how we have assessed our water supply resilience needs can be found in our *Draft WRMP19 Technical Report – Water supply resilience.*

4.7.1 Methodology and assessment of resilience by hazard

We have assessed our water supply system in a structured way to identify asset resilience risks to both water supply and water quality through a range of hazards. Whilst this risk is quantified in terms of supply interruption in customer days per year, the process models hazards that may lead to poor water quality as resulting in a loss of supply, as we have a legal obligation to only supply compliant water. This approach allows us to compare different risks and hazards that could result in either a loss of supply or a poor quality supply on a common basis. The high-level process is illustrated in Figure 26 below.



4: Assess probability of each hazard and probability of resultant services failure. Driven by risk factors, failure data, flood maps, etc.

5: Assess expected duration of failure for each hazard accounting for available storage and existing response and recovery capability

6: Calculate current risk position = Properties at risk x likelihood x expected duration of service failure

Figure 26 Multi-hazard approach to resilience risk assessment

4.7.2 Overview of resilience considerations

Ofwat was given a responsibility to further its resilience objective in the Water Act 2014. Since then, the industry has maintained a collective focus on resilience, particularly across operational and business planning activities. We have always had a significant focus on the delivery of a resilient, wholesome water supply, but understand that we can do more to reduce the risk to a failure of customer service.

Our assessments indicate that we have a strong position with a resilient water resources supply-demand balance and substantial drought resilience (Section 4.4.8), but it is important to understand the wider aspects of resilience and to ensure that our supply system is resilient to other shocks and stresses.

The UKWIR technical report 13/RG/06/3 includes an 'all hazards' list which was developed to identify and categorise most potential hazards that could be relevant to the UK water industry. We have selected the hazards that are most significant to our service and used these as the basis for a comprehensive risk assessment process. This includes the susceptibility to the following key hazards:

- Drought;
- Freeze-thaw;
- Power failure;
- Flood;
- Malicious damage;
- Contamination;
- Critical asset failure;
- Fire;
- Cyber failure; and
- Human factors.

The assessment of drought as a hazard is a natural extension of the dry year supply-demand balance assessment, as described already in Section 4.4.8. Our approach to assessing the other non-drought hazards outlined above is summarised in our *Draft WRMP19 Technical Report – Water supply resilience.* The Defra guiding principles in particular reference flood and freeze-thaw hazards in the context of the Water Resources Management Plan, and for this reason, we have provide specific summary of our assessments for these hazards later in this section (Section 4.7.5).

The subsequent sections below summarise our baseline risk position for water supply resilience resulting from the assessment of all hazards.

4.7.3 Assessment of our resilience

Most of the hazards that we have assessed are 'shocks' to the supply system, although the dry year hazard and extreme drought are longer duration 'stresses' as are some of the specific, long duration, asset failures that we have evaluated. Other resilience 'stresses' to our water supply system that we are including within the option evaluation process include the effects of climate change and of population growth. All of these 'stresses' have the effect of increasing the risks associated with other resilience 'shocks' by slowly reducing the level of resilience in the system. These are described in turn below.

Water treatment works resilience risks

- By 2020 we expect to have 25 water treatment works where a major failure can't be fully offset through supplies from another water treatment works. In most of these cases we have sufficient potable water storage to cover the vast majority of incidents and demand scenarios. However, our resilience assessments have identified credible failure modes related to a range of resilience hazards, typically for extreme scenarios where high demands are coupled with the hazard. During the current investment period from 2015 to 2020 we have carried out substantial investment to reduce these risks as well as further improved our operational risk assessments to better manage resilience of supply; a summary of some of these improvements is included within the section 'water service specific controls' in Section 4.7.4. Coupled with our improved response and recovery capabilities these investments have significantly reduced our baseline level of resilience risk across our treatment works.

Regional aqueduct system resilience risks

- Our regional aqueduct system enables us to proactively move raw and potable water supplies across our network with approximately a dozen key, strategic transfers. Some of these assets have single points of failure and in certain cases sections are approaching the end of their operational asset lives. We have identified resilience risks on some of these systems that will require monitoring and some investment. We are reviewing, updating and testing our operational contingency plans that cover the potential failure of any of these systems. We will also continue our planned outages and inspections of these key assets.
- The largest resilience risk that we have identified is associated with numerous potential single points of failure on our regional aqueduct system, which supplies water to Manchester and Pennine areas. The customer service risks associated with this asset can occur throughout the Strategic Resource Zone, as this aqueduct transports potable water from the Lake District through Cumbria, Lancashire and south to Greater Manchester. It also provides critical support to the south of the zone and can be used to offset supply from the River Dee and Lake Vyrnwy, including during an outage event if we experienced contamination in the River Dee. The development of solutions to

address this risk to the Strategic Resource Zone is collectively referred to as 'Manchester and Pennine Resilience'.

- The long distance aqueducts that supply Manchester have been the subject of investigation and refurbishment since the 1990s. Considerable planning and investment in enabling works was required to complete a 4 week outage of a 109 km potable water supply aqueduct commissioned in the 1950s. The findings from this outage investigation, completed in the winter of 2016, indicate that there are a number of risks that could affect the resilience of our service to customers.
- The Manchester and Pennine Resilience risk could, in the future, result in a widespread water quality incident (for example advice to boil water for drinking purposes for over a million properties) or loss of supply to many thousands of properties for an extended period. We have carried out extensive risk analysis covering a range of failure modes and consequences, with the risk increasing as the asset ages and deteriorates over the coming years. For the purposes of customer research and consultation we have simplified this into three indicative events to represent the overall baseline system risk over a future 10 year period:
  - 65% probability that 1.2 million properties could be affected by water quality problems for at least one week
  - 35% probability that 120,000 properties could be affected by supply interruptions for up to three months
  - 10% probability that 240,000 properties could be affected by supply interruptions for up to two weeks

These represent the baseline risk in the absence of any options which are discussed in the following sections. The baseline risk ranks highly when assessed alongside other water assets in accordance with the company risk assessment process.

Trunk main resilience risks

- The trunk mains that connect our water treatment works to the local distribution mains are another potential point of failure that can have major service implications, as often a large number of properties are fed from a single main. Our network is very flexible and for the majority of mains a burst can be isolated and supplies re-established quickly. However, we have identified some mains where a repair could take a long time to complete and there is no current provision to maintain a supply to customers for the full duration of the repair.

Impounding reservoir and dam risks

- We own a large number of dams and reservoirs which can exhibit a risk to people and infrastructure in the North West of England. We have a well embedded risk assessment process and supporting systems to evaluate, track and manage the societal risks associated with these assets in line with Health and Safety Executive guidance. We are committed to a long term programme of risk reduction through programmes of work aimed at reducing the risk of a catastrophic failure whilst improving our source reliability. We are making our reservoirs and dams more resilient to hazards such as extreme flood events through improving reservoir capacity as well as reducing the risk of failure by erosion with other measures.

Catchment resilience

- We own over 50,000 hectares of catchment land in North West England, providing high quality raw water into our reservoirs and other sources, and we work with third parties to ensure that the remaining 720,000 hectares of our catchment land not in our ownership is managed to the same high standard. Together this land provides a resilient water supply and protection against downstream flooding as well as wider environmental and social benefits including biodiversity, carbon sequestration and recreational opportunities. Through the delivery of our innovative 'Sustainable Catchment Management Programme' (SCaMP) we are recognised as industry leaders in securing multiple benefits at a landscape scale. Working with the Environment Agency we routinely design catchment safeguard zones to protect water sources from pollution. Safeguard zones and other catchment initiatives rely heavily on partnership working with land owners and other stakeholders to deliver sustainable and resilient catchments.

The rest of our supply network elements can either be represented with one of the above categories or are, for the most part, inherently resilient with inbuilt redundancy. Consequently most sources, service reservoirs, pumping stations and other related assets have rarely been identified as having substantial inherent resilience risks.

4.7.4 Current resilience risk management controls

We have always understood that a reliable, high quality water service is central to our purpose and routinely invest and operate to ensure this service. Some of our recent activities to reduce the risk of service failure are described below:

Water service specific controls

- **Strategic trunk mains and aqueducts -** We commissioned a major new link to our regional supply system called the West East Link Main (WELM) during AMP5 (2010-2015). This enables supplies from the west of our region to support short duration inspections of critical infrastructure supporting Greater Manchester. It also gives us day-to-day flexibility in managing regional supplies, including supporting the west of the region if required. We are also progressing a project to address the highest risk section of one of our aqueducts.
- **Water treatment works risk assessments -** We are carrying out extensive operational risk review processes at each of our treatment works to help us identify and manage risks to water supply in terms of both quality and quantity.
- **Water treatment works start up to waste -** We are in the process of delivering a 'start up to waste' programme that means we can reliably shut down and restart any of our water treatment works in the event of a concern regarding water quality. This helps us to reduce the risk of water quality issues with our potable water supply.
- **Ultraviolet standby capability -** We have been delivering a programme of standby disinfection process capability that will enable us to rapidly deploy powerful ultraviolet disinfection plant at strategic points across our network. This helps to manage the risk of poor water quality affecting customer supplies.
- **Network contingency plans –** We have reviewed all of our network contingency plans for a failure at each of our water treatment works to ensure that we understand in detail which actions are required and when.

- **Service reservoir bypass** – Any service reservoir that can't currently be bypassed has been evaluated and we have developed engineering solutions for delivery.
- **Impounding reservoir risk reduction** – We proactively carry out risk reduction interventions such as improving flood capacity, or installing filters to prevent internal erosion with the work scheduled to be efficient and timely. The risk reduction measures we are undertaking often involve increasing the capacity of the dam to resist floods, ice loading, or earth movement, making the supplies to customers more resistant to interruption.

Wider wholesale and corporate controls

- **Telemetry -** We have updated our regional telemetry system to ensure that it is robust and can resist malicious activity associated with cyber-attacks. The system is subject to a constant cycle of testing and review to manage this threat.
- **Data security** - We have delivered protection to all our assets through improved training systems and processes and will continue to comply with the increasing accountability for data protection in the face of ever-present cyber threats.
- **Human resources** – We keep our succession planning under constant review and ensure strength in depth in all critical business functions as a business as usual activity. Our apprentice and graduate schemes mean that we can ensure vital skills are passed down and that we can shape and grow the future business leaders that we need. We have reinvigorated our training programmes and have enhanced training centres across our region. Our renewed focus on 'back to basics' training is demonstrated by our Water Passport programme, a minimum training requirement for access to any operational site. In addition, we have in place emergency resourcing plans for helping us to deal with major incidents to supplement our existing resources.
- **Supply chain -** We have reviewed our supply chain for critical links where a single supplier, point of infrastructure or other constraint may lead to a vulnerability. Where any weak points have been identified we have reviewed our existing contracts to manage the risks. We also modified our contracting process to eliminate these supply chain risks as much as possible.
- **Financial** - We carry out state of the art financial scenario modelling and forecasting to ensure that we remain on a robust financial footing. Coupled with our integrated corporate risk management process this helps to ensure financial resilience.
- **Enhanced operational response** - We have reviewed and improved our operational response capability, not least through the delivery of our Integrated Control Centre enabling wider remote operation and control across our asset base for improved incident response.

4.7.5 Freeze-thaw and flooding hazards

Freeze-thaw and flooding resilience hazards were specific mentioned in the Defra guiding principles and have been specifically covered within our wider resilience hazards assessment. The approaches to the assessments for these particular hazards are outlined below:

Freeze-thaw

In addition to assessing elements of the water supply system to the multiple hazards indicated in Figure 26, we have conducted some specific modelling to test our resource zones against the hazard of a freeze-thaw event. Freeze-thaw events are relatively rare, but place an extreme stress upon our supply system. This manifests in two related ways:

- Failures on customer properties due to burst pipes leading to increased customer demand during the thaw; and
- Failures of our assets throughout the system from the extreme cold 'freeze' event, from our pipes bursting and from our assets operating at their upper limits in peak demand.

Freeze-thaw events typically exhibit greater demands than even dry summer peaks. This is because the increased demand is almost entirely involuntary, due to burst pipes, and therefore not easily susceptible to mitigation controls. They also tend to be shorter duration and not well reflected in strategic models for dry year water resource availability as these tend to operate with longer time steps that do not reflect the severity and relative short duration of a freeze thaw event.

We have used our MISER system to stress test our supply system for freeze thaw risk. MISER is a water network management modelling package for operational resource planning, widely used in the UK water industry. We use MISER as a business as usual production planning tool, primarily targeting the distribution of regional resources for short term week to week forecasts. The model has a slightly finer resolution than our Aquator™ model for demand modelling, but less hydrological detail. Our MISER model doesn't include local treated water storage as this is not generally necessary for regional resource production planning.

Using MISER we have modelled our last three major freeze-thaw events from the winter of 2010/11, to replicate the historic demand across our system during this particularly widespread series of events. In order to further stress test our system we increased all demands in the system at 5% intervals in order to identify the areas of our system least resilient to this hazard. Since the model doesn't include local storage, deficits may appear earlier in the model than we would expect in our system. This highlights the parts of the system most vulnerable to deficits during freeze thaw events where we would be most reliant upon local storage.

There are two demand management zones (DMZs) that are initially predicted to be most at risk during most of these demand scenarios. Deficits only appear in two of the extreme tested scenarios at +15% and +20% of the historic peak demands. These deficits would in practice be met through an operational contingency plan or local storage not fully modelled in the analysis. Analysing these results further indicates that the current local storage provision provides sufficient contingency for a typical thaw event across all of our network for the baseline case. In the most extreme event, based on the worst historic freeze thaw +20% demand, deficits were noted in a further three DMZs, however, again, we would expect deficits in these zones to be met through local storage.

In conclusion, we are confident in the freeze-thaw resilience of our system, but are continuing to evaluate the specific conditions in these DMZs as part of our wider and ongoing assessment of business resilience.

Flooding

Our risk assessments have indicated that some of our assets are vulnerable to flooding and in fact we have experience of flooding affecting the normal operation of a number of our works. Of the two water treatment works with the biggest flood risk, the demand for one can be fully met through rezoning and hence stood down, the demand from the other can be supported with water tankers and existing storage for sufficient time to return the works to service for most credible floods. We have carried out detailed assessments of the flood risk at all of our larger works that sit within the maximum likely flood extent zones as published by the Environment Agency to support the National Flood Resilience Review carried out by the national government during 2016. We currently have contingency plans for all of our water treatment

works and have a number of strategic assets protected against flood return periods up to a 1 in 100 year flood risk with either permanent or temporary works.

Due to the impact of climate change and our changing understanding of infrastructure flood risk we are reviewing our flood defences, and response and recovery capability on a regular basis as part of our business planning process.

4.7.6 Our current level of water supply resilience risk

We have a resilience ambition to minimise the frequency of large scale service failures of greater than 12 hours duration. Our resilience assessments indicate that approximately a third of customers currently face a resilience risk that exceeds this long-term ambition. Whilst this risk is extremely low for most of these customers, we are actively looking to reduce both the numbers of customers exposed to this risk and the level of residual risk that these customers face. This risk is not evenly distributed across our customer base and one of our ambitions is to provide as even a risk profile as we can achieve within very real bill affordability constraints.

Through our risk assessment process we have identified resilience needs across our resource zones. These are risks where a system failure could lead to a significant service impact both in terms of the number of customers affected and the duration of the impact. The risks themselves vary across different hazards, although our assessments indicate that raw water 'contamination' and 'critical asset failure' are the dominant contributory hazards.

Our water resource zones can be further subdivided into 33 demand management zones (DMZ). We have identified the resilience needs by their DMZs, each of which is formed from a number of water supply zones. The DMZ is largely used for planning purposes. The figure below outlines the current risk position for regional risks and within demand zones.

Our asset resilience risk assessment process has identified that Manchester and Pennines resilience is a key focus area, and we discuss this further as a strategic choice in Section 6.4.

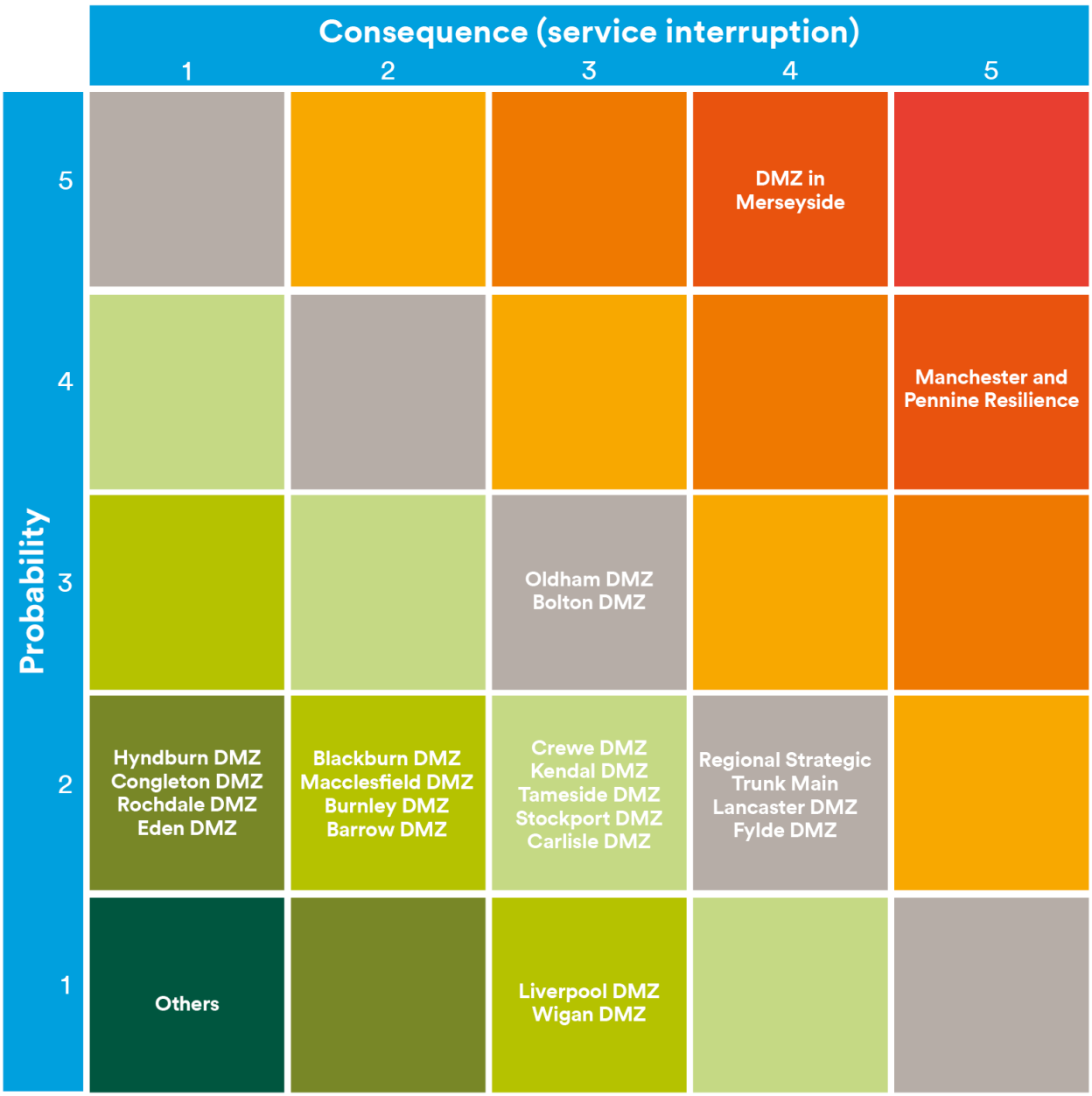


Figure 27 Current water service resilience risks

5 Identifying future options

Key points

- We have completed an extensive exercise to ensure we consider all possible options. This has been completed in line with industry guidance
- We have considered more than 350 possible options which are a mixture of our own options and those from third parties
- The third party options have been assessed in the same way as our own options
- We used many different screening criteria in order to assess the viability of options which resulted in about 150 options being considered during options appraisal
- We summarise the process we have followed to identify non-drought resilience options for consideration to address water supply resilience risks

5.1 Overview – the need to consider all possible options

This section provides a summary of the approach we have taken to identify and develop a range of possible options in order to maintain and enhance our supply-demand balance. This supports development of the most cost effective and sustainable long-term plan. We have included further detail of the methods we have followed and the results of our assessments within our *Draft WRMP19 Technical Report - Options identification*. Section 5.6 also explains the process to developing options for water supply resilience to non-drought hazards.

Identification of the options considered in this section has been carried out in accordance with current regulatory and industry guidelines which includes the Defra guiding principles, Environment Agency and Natural Resources Wales guidelines, UKWIR *Water Resources Planning Tools* report and the Drinking Water Inspectorate Guidance Note: Long term planning for the quality of drinking water supplies. In following these industry guidelines we have fulfilled a number of obligations necessary for completion of a successful Water Resources Management Plan:

- We have explored a full range of options, including those that seek to reduce the demand for water as well as options for new water supplies, to ensure that our final list is comprehensive. This list includes both our own options as well as those from other organisations such as other water companies and 'new market entrants' who were invited to bid into our Water Resources Management Plan process with their own ideas to reduce customer demand or provide new supplies. Collectively, these organisations are called 'third parties'. See Section 5.2;
- Through this process, we have endeavoured to consider innovative solutions. For example, new water treatment processes to prevent the transfer of invasive non-native species (INNS) or new techniques/approaches to reduce the demand for water;
- We have considered risks and uncertainties when designing the scope of our options. For example, raw water quality risks may be significant and we recognise that there is a need to not cause deterioration in the quality of the water which we supply to customers and that this is acceptable to them. Our systematic approach to generating our own options and the approach to gather ideas from third parties are key to us achieving this objective by providing a wide range of options for

consideration in developing our plan. Section 5.2 summarises the process and the categories and types of options;

- In accordance with the latest planning guidelines we have considered drought intervention options (e.g. drought permits) to manage the risk of extreme droughts;
- We have reviewed the Water UK long-term water resources planning study and included relevant options, including potential inter-regional transfers in this plan;
- We have considered the Drinking Water Inspectorate Guidance Note that we should not expose consumers to a greater risk of unwholesome water and that we must always plan to meet our water quality obligations;
- We have considered the resilience and reliability of options including an appreciation of how they can benefit customers, the environment and their susceptibility to climate change and drought. See Section 5.6; and
- We have considered the possible impacts of constructing and operating options taking account of this through the screening process to discount options that could cause damage to the environment. See Section 5.4.2.

The overall process whereby options are identified and assessed through to the start of the options appraisal process is summarised in Figure 28 and the steps involved are described in Sections 5.2 to 5.5.

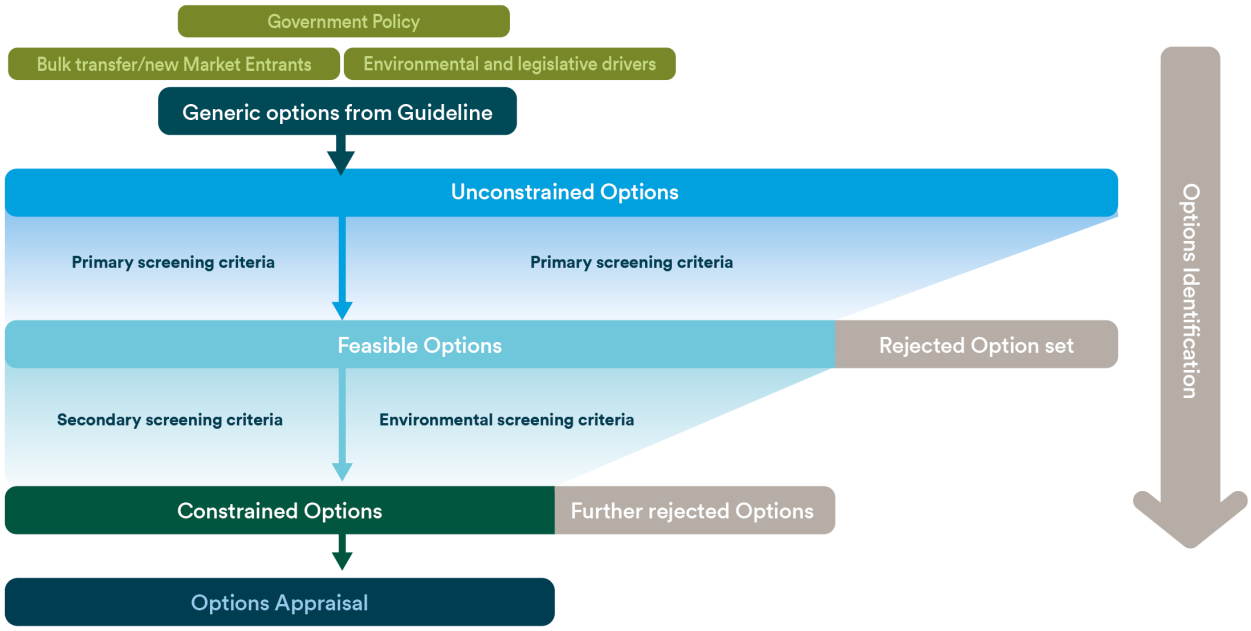


Figure 28 Options identification process

5.2 Seeking innovation – our approach to market engagement

Alongside our own options, we developed a commercial strategy in order to allow other water companies, water/wastewater retailers and third parties the opportunity to put forward ideas for either managing demand or for the supply of new resources. An important resource management option that has been considered in this plan relates to the bulk transfer of water into, out of and within our supply area (e.g. linking water resource zones). Options to improve the connectivity between water companies and to better share or utilise existing abstraction licences can potentially lead to better value for customers, as long as

the quality of the water supply is maintained or improved. Our approach to this market engagement activity is summarised in this section and comprises three main parts:

- Water trading – through bulk supplies between water companies (neighbouring or not);
- Abstraction licence trading/sharing within catchments – this provides a company with an option to purchase or sell abstraction licences to help meet its supply needs or to sell surplus water to other abstractors; and
- Options provided by other water companies or by third parties – allowing others to provide demand and/or resource type options in the plan increases the scope for lower costs and innovative solutions.

5.2.1 Information gathering

We sought to gather information and ideas for options in a number of different ways:

- Communicating with known and potential new third parties from a contact database *via* direct correspondence. This list comprises, for example, water companies, water/wastewater retailers, abstraction licence holders, local authorities, reservoir and landowners, navigation authorities, National Parks, businesses known to offer demand reduction services and options from third parties who we had previously interacted with during our last Water Resources Management Plan. Between August and September 2016, we sent out over 350 individual communications to these organisations notifying them of the Water Resources Management Plan and how they could input to the process;
- Publishing a Prior Information Notice (PIN) within the Official Journal of the European Union (OJEU)[55] with a response template of required information and data of how to contact us with any ideas they wished to submit. We also communicated to the contact database providing notification of the PIN publication and response deadline. This PIN was active for a period of six weeks between August and September 2016;
- Publishing a market engagement request '*Can you help us …*' on our external website with response forms. We had 20 expressions of interest submitted *via* this route; and
- Holding a market engagement event to discuss the process with interested third parties that responded to the communications. Fourteen individuals and organisations attended this event.

5.2.2 Collating and assessing responses

Options from third parties were assembled alongside our own options. The process of assessing the responses was the same for all options through the primary screening process which was completed by an independently appointed organisation to ensure all options were considered equitably, thereby ensuring that the final supply-demand strategy as proposed through our alternative plans (see Section 7) delivers best value for customers. The results of the market engagement approach are discussed further in Section 5.3.

5.3 Unconstrained options and primary screening

As shown in Figure 28, the first part of options identification requires the determination of a list of unconstrained options. At this stage, a number of assumptions have to be made, for example the quality of the water source, the quantity of water the option could provide or the amount of water that could be

[55] It is a legal requirement for companies operating in many sectors, e.g. water utilities, gas, oil, electricity, railway, postal services, port and airport related activities, to publish their tenders in the OJEU. 160,000 tenders a year are published through OJEU of which about 14,000 are from the UK and so the journal is used extensively by potential suppliers of services.

saved (e.g. leakage repair). These assumptions are used to generate the scope of works that is examined in more detail through the development of feasible options, see Section 5.4. The options are aligned to a list of generic option types that are presented within the UKWIR *Water Resources Planning Tools* report. They comprise four main categories:

- Customer side management options – e.g. metering, water efficiency, changes to level of service;
- Distribution side management options – e.g. leakage detection and reduction;
- Production side management options – e.g. leakage detection on raw water systems, water treatment works process loss reduction; and
- Resource management options – e.g. river, groundwater, reclaimed water, abstraction licence trading.

From our Water Resources Management Plan 2015 we already had a comprehensive list of unconstrained options. We have assembled our new unconstrained options based on this and supplemented the list with new options. At this unconstrained options stage of the process, we did not take into account constraining factors, for example the cost of building/operating the scheme, environmental issues (e.g. resilience to climate change), planning restrictions, regulation/legal issues or whether it is promotable/acceptable to customers. Such issues form part of the assessment of the feasible options (see Section 5.4) and screening. However, any options that were not technically feasible were discounted prior to becoming an unconstrained option. In effect this is a pre-screening stage and we documented the reasons why these decisions were made. Table 13 provides a summary of the number of options that we have considered in this plan (including third parties and our own options) at each stage of the options development process. A number of possible options to export water from our supply area are also detailed here; further information on this process can be found in *Draft WRMP19 Technical Report - Options identification*.

The primary screening process is applied to the unconstrained options and assesses their potential viability against a series of specific tests based on questions detailed in the UKWIR report. The overriding principles for the primary screening are to ensure that:

- All options have been subjected to the same scrutiny and testing. It is our priority that these criteria have been applied consistently across all unconstrained options to achieve a balance between the number of feasible options and the availability of realistic choices; and
- The screening criteria as applied provide a consistent view of the potential environmental impacts of options. Discarded options from this stage of the process are likely to have unacceptable impacts that cannot be overcome. More detailed environmental assessments are completed on the feasible options at subsequent stages of the process.

For all options, the screening criteria questions were based around the following key areas to understand the:

- Impact on the resource base (ability to increase deployable output) or on the demand for water;
- Performance against unalterable planning, regulatory and environmental constraints; and
- Risk of failure or inherent uncertainty.

These questions are designed to be objective in order to discount those options that should not progress and be developed as feasible options. This exercise was completed by an independent external consultant to ensure that the third party options were considered equitably alongside any of our own options. The specific primary screening questions and tests were also developed by this organisation as part of this process.

The criteria used for primary screening include, for example, tests relating to the availability of water resources and whether a new abstraction could affect the environment. If significant uncertainty remains, then the option is not screened out at the primary screening stage and further analysis is provided through the feasible options stage and secondary screening. The methodology and results of the primary screening are discussed in Section 4 of *Draft WRMP19 Technical Report - Options identification.*

Discounted options that failed primary screening are not completely dismissed and are placed in a rejected options register and can be recognised as such when the options identification phase is complete. These are available for possible consideration at a later date or in the next Water Resources Management Plan. The results of primary screening were discussed with third parties and reasons provided if the option did not pass this stage of the process.

Table 13 Summary of number of options developed at unconstrained, feasible and constrained stages

Option category	Unconstrained options	Feasible options (after primary screening)	Constrained options (after secondary screening)
CUSTOMER	**72**	**88**	**27**
Third Party	4	1	1
United Utilities	68#	87#	26
DISTRIBUTION	**34**	**54**	**32**
Third Party	12#	15#	14
United Utilities	22#	39#	18#
PRODUCTION	**10**	**7**	**3**
Third Party	2	0	0
United Utilities	8	7	3
RESOURCE	**223**	**160**	**78**
Third Party	48	26	10
United Utilities	162	121	55
United Utilities drought permits and orders	13	13	13
TOTAL	**339**	**309**	**140**
United Utilities Export options	18	18	12

For some demand option scheme types the number of feasible options is higher than the number of unconstrained options because a generic unconstrained option has been sub-divided following primary screening to allow for a robust cost estimate for option delivery.

5.4 Feasible options development and secondary screening

For each feasible option a more detailed scope was developed to allow the option costs to be determined. In the case of the resource type options, this required an assessment of the scheme components e.g. the source of the water, how it would be abstracted, where would the water be taken for treatment, the likely water quality risks associated with the source and the necessary water treatment requirements to ensure we meet our regulatory obligations for water supplies. In particular, changes or uncertainty in raw water quality were noted as being of importance for the scope to consider. This is to ensure that the design of any treatment process would not cause any deterioration in the quality of water supplied to customers e.g. where an option could change the composition of the existing water supply network and potentially cause aesthetic impacts appropriate mitigation would need to be included. A similar approach was taken with the

third party resource options and this required collaborative working to ensure fair representation of the proposed scope along with any assumptions made. For our own customer and distribution type options, costs are derived from the existing known and projected business costs e.g. leakage repair and detection. For third party customer and distribution options, we have worked with the organisation to understand the components of their proposals in order to accurately represent the costs.

The feasible options set has been shared and discussed with environmental regulators (Environment Agency, Natural Resources Wales and Natural England) and early on in the process we held a review workshop in order to highlight any issues that would help inform our secondary screening and the subsequent environmental assessments. We have also engaged with the Drinking Water Inspectorate on the process of developing our options in the plan.

The feasible options have gone through a process of secondary screening; an iterative approach, using various data sets and assessments in order to discount options from the final list of feasible (constrained) options. Major components of the secondary screening relate to understanding the possible environmental effects of implementing different options and non-monetised environmental and social costs. Our Water Resources Management Plan has a statutory requirement to carry out a Strategic Environmental Assessment and a Habitats Regulation Assessment and we have used these pieces of work as part of secondary screening to examine each feasible option in turn. We have also completed assessments, using an external consultant, to ensure that options in the plan do not result in deterioration of catchments and waterbodies linked to Water Framework Directive. We have also completed assessments of climate change risk for the feasible options and whether they have a demonstrable benefit within our supply system when implemented.

As a result of this process we have screened out a significant number of feasible options which were considered to be unacceptable in terms of their potential impacts. This process reduced the number of feasible options from 309 to 140 (see Table 13).

The components of our secondary screening are described in Sections 5.4.1 to 5.4.5.

5.4.1 Environmental and social costs

An assessment of the environmental and social costs of each option has been completed. These are non-monetary costs, derived following an industry standard approach[56], and consider a wide range of issues, as appropriate for each particular option, such as:

- Environmental impacts of water supply schemes, during construction and/or during scheme operation. Examples of impacts considered include those on aquatic flora and fauna, other water abstractors, heritage, archaeology and landscape;
- Social impacts of water supply schemes, during construction and/or during scheme operation. Examples of impacts considered include those of informal recreation activities such as cycling or birdwatching, in-stream recreational activities such as boating, canoeing or rowing, walking, noise, dust, odour, or time delays to people's journeys as a result of work in highways to lay or repair pipelines; and
- Increases or reductions in carbon emissions that could result from the abstraction, treatment and distribution of water. Examples of impacts considered include: fuel consumption of vehicles used in

[56] Environment Agency - Environmental Valuation in Water Resources Planning - Additional Information (2016); Benefits Assessment Guidance (2012).

construction, leakage management, installation of water meters or water efficiency devices, energy use at work sites, emissions from road traffic as a result of diversions or disruptions, embodied carbon in materials used, changes in water use (and thus changes in energy use) within the home.

As part of this work, we also engaged an external consultant to complete a literature review and comparative analysis of different approaches to environmental and social impact assessment namely: a) traditional environmental and social costing; b) an Ecosystem Services approach; c) a Natural Capital approach. This was to identify gaps, complementarities and overlaps as well as potential benefits and limitations of adopting a Natural Capital/Ecosystem Services approach for this Water Resources Management Plan and/or for future plans. We are currently trialling a Natural Capital approach in the River Petteril catchment in Cumbria to appraise options at a catchment level from a Water Framework Directive perspective, specifically related to nitrates, phosphates, bacterial load, flooding and operational carbon footprint.

Natural Capital forms a component part in the development of our Catchment Systems Thinking Approach, aimed at integrated, sustainable and innovative catchment planning in partnership with local environmental and community stakeholders. A primary deliverable of this project is a generic decision support tool to provide a platform to balance and optimise the Natural Capital value of asset solutions and catchment interventions in addressing statutory and non-statutory needs. We will be using the Natural Capital decision support tool and opportunity mapping methodology to assess the River Irwell catchment in collaboration with our partners in the Natural Course[57] group. This assessment will be used to develop our plans for the PR19 Business Plan (drivers include Safeguard Zones, Water Framework Directive and flood resilience) and the prioritisation and delivery of actions in AMP7 (2020-2025) and beyond. As we continue to mature in our use of a Natural Capital approach, we aim to develop a better understanding of how this can be applied to water resources management planning for future plans.

For this Water Resources Management Plan, we have decided not to implement the Natural Capital/Ecosystems Services Approach for a number of reasons, mainly based around the current uncertainty of the approach and the lack of a defined framework from which to make decisions. For example:

- We require a greater understanding of how the benefits and liabilities of Natural Capital will be incorporated within our corporate accounts;
- Collaborative projects and scheme development using Natural Capital requires time to work with partners on this economic approach to avoid the potential pitfall of it being a ‘black box’ decision making process;
- The Ofwat expectation is that the Natural Capital approach would be trialled in AMP7 (2020-2025) and potentially form the basis for environmental planning in AMP8 (2025-3030); and
- Our trials and case study work are ongoing (e.g. Petteril catchment). These will provide lessons learnt that can understand and build on and define our processes for the next Water Resources Management Plan.

Environmental and social costs are heavily dominated by carbon related impacts during the construction and operation of schemes and these can therefore be used as a way of quickly assessing what the environmental and social cost profiles are for options. We used carbon factors for this initial assessment of

[57] An EU LIFE (the EU’s financial instrument supporting environmental, nature conservation and climate action projects) Integrated project, building capacity to protect and improve our water environment, now and for the future.

environmental and social costs for the first part of secondary screening in order to reduce the number of feasible options. The full environmental and social cost analysis was completed on the remaining options that were still considered feasible following this exercise. Our approach to generating environmental and social costs and results of the analysis is documented in our *Draft WRMP19 Technical Report - Options identification*.

The environmental and social costs and benefits were combined with the whole life financial costs of each feasible option to derive a term called Average Incremental Social Cost (AISC)[58], also see Section 7.2. The AISC values for each option are used to generate a ranked assessment of overall option costs, represented as pence per cubic metre. The ranking of options based on AISC can be seen in our *Draft WRMP19 Technical Report - Options appraisal.*

AISC values have been calculated in accordance with the *Water Resources Planning Guideline*. We have calculated the AISC based on using the option being used at its maximum capacity. All prices are base dated at the average in FY17/18 (2017/18 financial year) using RPI (Retail Price Index). The AISC values indicate the relative unit costs of the various options. The development of the most cost effective or economic plan may not necessarily directly reflect the AISC ranking, so options are subject to a detailed options appraisal process. This is detailed further in Section 7.2 and the supporting *Draft WRMP19 Technical Report – Options appraisal.*

5.4.2 Strategic Environmental Assessment (SEA)

The Environmental Assessment of Plans and Programmes Regulations 2004 (known as the 'SEA Regulations') aim to 'provide for a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to contributing to sustainable development'. Undertaking and reporting a Strategic Environmental Assessment is a statutory requirement for our Water Resources Management Plan.

Throughout the course of the development of a plan or programme, the Strategic Environmental Assessment seeks to identify, describe and evaluate the likely significant effects on the environment of implementing the plan or programme and propose measures to avoid, manage or mitigate any significant adverse effects and to enhance any beneficial effects. The purposes of the Strategic Environmental Assessment of this draft plan are to:

- Identify the potentially significant environmental effects of the plan in terms of the feasible and preferred water resource management options being considered;
- Help identify appropriate measures to avoid, reduce or manage adverse effects and to enhance beneficial effects associated with the implementation of the plan wherever possible;
- Give the statutory Strategic Environmental Assessment bodies, stakeholders and the wider public the ability to see and comment upon the effects that the plan may have on them, their communities and their interests;
- Encourage them to make responses and suggest improvements to the draft plan; and
- Inform our selection of water management options to be taken forward into the final plan.

The Strategic Environmental Assessment has assessed the likely economic, social and environmental effects of proposed water management options and has identified ways in which adverse effects can be minimised

[58] The average unit cost of a particular scheme that represents its whole life cost and includes environmental and social costs.

and positive effects enhanced. We have used the results of this piece of work to indicate where there are significant potential impacts against the Strategic Environmental Assessment objectives and screened out options that failed this test.

The preferred plan has been subject to a final environmental appraisal (i.e. to reflect in-combination impacts), as outlined in Section 7.7, taking account of Strategic Environmental Assessment, Habitats Regulation and Water Framework Directive elements of environmental appraisal.

5.4.3 Habitats Regulation Assessment

The Conservation of Habitats and Species Regulations 2010 (as amended) (the 'Habitats Regulations') require a Competent Authority to have regard to the requirements of the Habitats Directive in the exercise of any of its functions. Water companies have a statutory duty to prepare a Water Resources Management Plan and are therefore the Competent Authorities for these plans under the Habitats Regulations.

The Regulations require that Competent Authorities assess the potential impacts of plans and programmes on the Natura 2000 network of European protected sites in a process is known as Habitats Regulations Assessment. It determines whether there will be any 'likely significant effects' of a Water Resources Management Plan on any European site as a result of a plan's implementation (either on its own or 'in combination' with other plans or projects) and, if so, whether these effects will result in any adverse effects on the site's integrity.

The findings of the Habitats Regulations Assessment have been used to inform the assessment of options as part of the Strategic Environmental Assessment process, and in particular the assessment of options against Strategic Environmental Assessment Objective 1: To protect and enhance biodiversity, key habitats and species, working within environmental capacities and limits (see Section 5.4.2). We have used the results of this piece of work to indicate where there are significant potential impacts documented as part of the Habitats Regulations Assessment process and screened out options accordingly.

5.4.4 Water Framework Directive

Each new feasible option has been assessed to identify whether they will comply with the Water Framework Directive. Separate assessments have been completed for each waterbody or Protected Area which could be impacted by the options. The assessments have determined if the options in the draft Water Resources Management Plan could:

- Cause a deterioration at element or waterbody level (only relevant elements based on the waterbody designation will be assessed);
- Prevent the achievement of River Basin Management Plan objectives; and/or
- Prevent the achievement of Protected Area objectives.

The findings of the Water Framework Directive Assessment have been used to inform the assessment of options as part of the Strategic Environmental Assessment process, and in particular the assessment of options against Strategic Environmental Assessment Objective 3: To protect and enhance the quantity and quality of surface and groundwater resources and the ecological status of water bodies.

We have used the results of this piece of work to indicate where there are significant potential impacts documented as part of the Water Framework Directive process and screened out options accordingly.

5.4.5 Water available for use and climate change assessments

Each option was assessed to determine its water available for use benefit or, in the case of demand options, supply-demand balance benefit. This is to identify the usefulness of each option within our supply system, rather than just the option capacity values alone. We have also considered how resource options could be affected by climate change impacts and whether there is a risk of the option not delivering its intended capacity or water available for use benefit. Options have been screened out if either of these components indicated an insignificant water available for use benefit or a significant impact due to climate change factors.

Based on all of these results, a final list of options was presented for appraisal, termed the constrained option set. Those options that fail secondary screening are placed into the rejected options register which at this stage, are not to be considered further. However, rejected options could be reconsidered if the supply-demand requirements required an alternative approach that could not be met by the constrained option set alone.

5.5 Constrained options and options appraisal

The outputs of the secondary screening have been used to inform options appraisal. Our options identification process resulted in 140 constrained options. This has enabled us to consider a wide variety of potential schemes to address the future challenges in our resource zones, which will subsequently be assessed as part of our plans and through our options appraisal process, as detailed in Section 7.2.

It is also important to note that we will continue to progress activities associated with identifying and developing plan options to inform future plan reviews. In particular, building upon our own market engagement process, Ofwat has determined the need for each of the water companies to publish a bid assessment framework for options. The aim of the bid assessment framework is to develop a wider bidding market for water resources options and through 2018 we will be continuing to develop this for submission to Ofwat. In addition, as part of our current process, any rejected options will also continue to be held on register, and if further information comes to light in future then these may be considered in future planning rounds.

In accordance with the Environment Agency position statement on the risk of transfer on Invasive Non Native Species (INNS), we have considered whether the constrained options that form part of the preferred plan could pose a risk. Specifically, to consider if any of the options detailed in Figure 36 link isolated catchments, or if the catchments are already connected. This will dictate whether the scheme needs mitigation measures in place and/or whether an assessment of the increased risk posed by the scheme needs to be carried out. This preliminary assessment has indicated that options WR821 and WR032 would require a more detailed consideration of Invasive Non Native Species risk because these involve ‘water transfers for navigations, including canals’ and ‘water company raw water transfers’ as per the Environment Agency position statement. We recognise that the risk assessments will have to be considered in further detail if the preferred plan is formally adopted, but we are not proposing any further analysis at this stage. We expect to carry out risk assessments, prioritisation of risk and options appraisal between 2019 and 2021, with the implementation of any mitigation measures being delivered during AMP8 (2025-2030). Further detail on our preliminary risk assessment can be found in the *Draft WRMP19 Technical Report - Options appraisal*.

5.6 Water supply (non-drought) resilience options and implications

This section outlines the process to identify options for broader water supply resilience, rather than those conventionally included to address a dry year supply-demand balance, or drought resilience.

The identification of options to manage resilience risks is typically managed through our standard Wholesale Risk and Asset Planning process (WRAP). Central to the WRAP process is a series of 'risk and value' gateways where the need and potential options are challenged by our strategy and engineering teams.

Prior to each gateway we consider a full range of potential options we can use to manage the risk. We ensure that we have covered all credible options by reviewing the risk against a set of generic high-level solutions, see Table 14 below. This challenges us to think about all potential risk management approaches, and to consider ways to manage the risk without a 'new build' solution.

Table 14 Wholesale Risk and Asset Planning process (WRAP) generic high-level solutions

Generic High Level Solution			Resilience 4 Rs
1	Monitor and Respond	Accept the risk and plan to respond in an agreed way if the risk arises with a contingency plan	Response and Recovery
2	Operational Intervention	Return relevant assets to their original performance through one off maintenance, coupled with an agreed contingency plan	Reliability
3	Optimisation	Improve relevant asset performance by changing operational and maintenance regimes, possibly coupled with one off investment to increase the capability of the existing assets	Reliability
4	Refurbishment	Capital investment on relevant assets to prolong asset life and restore their performance to the original design	Reliability
5(a)	Replacement	Replace the relevant assets on a like for like basis where refurbishment is unlikely to be economically viable	Resistance, Reliability
5(b)	New Asset	Capital investment on new or additional assets to meet new performance standards, enhanced reliability or a more cost beneficial solution	Resistance, Reliability, Redundancy
6	Partnership	Collaborative investment shared or wholly provided through a third party with costs and benefits shared across all parties	Any of 4 Rs

This process has been externally audited as a robust methodology by Arcadis Consulting.

Manchester and Pennines resilience is a key resilience focus area having been identified through our asset resilience risk assessment process, as described in Section 4.7.3.

For Manchester and Pennine Resilience assessments we have used a similar process, but more specifically tailored to the complex interaction of risks related to supplies to these areas. Key failure modes were identified to represent the greatest resilience risks, and probability and consequence was determined for each failure mode. These represent water quality and loss of supply risks resulting from failures of different parts of the system. We developed multiple options to reduce the resilience risk to an acceptable level. This process follows the Cabinet Office guidance for the 4 Rs (Section 4.7) of resilience, aiming to offer solutions across the 4 Rs.

We are currently undertaking customer research to understand the level of support for further risk mitigation to improve the resilience of the aqueduct system (Section 4.7.3). A breakdown of the

unconstrained options types is shown in Table 15, and the process for identifying options and solutions to manage the risk is laid out below in Figure 29.

Further detail on the options identification process for Manchester and Pennines resilience is included in the *Draft WRMP19 Technical Report – Water supply resilience* (and specifically Appendix A within that document).

Table 15 Summary of the number of options developed at the unconstrained stage

Option category	Unconstrained options
Demand management	38
Distribution	118
Operational intervention and optimisation*	35
Quality	117
Resource	88
Total	**396**
*This includes a wide range of operational response / recovery options to allow us to respond effectively if the risk arises and return relevant assets to operation, coupled with an agreed contingency plan	

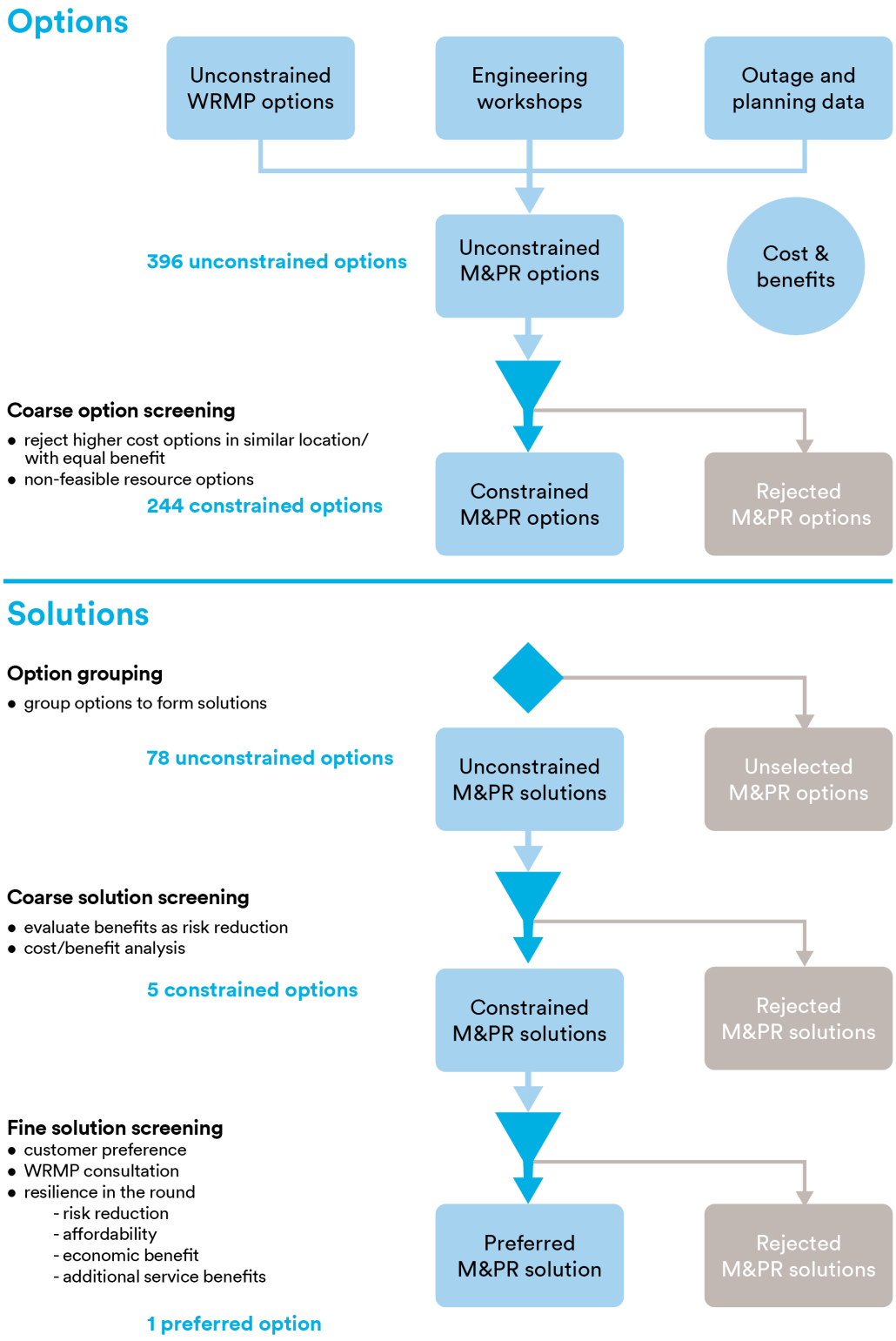


Figure 29 Manchester and Pennine Resilience (M&PR) Option and Solution Selection process

6 Strategic choices for our region

Key points

- **Our baseline position shows we maintain a surplus in all of our resource zones, but this is only part of the picture**
- **We also consider the opportunity to make some 'strategic choices' to protect and, where possible, benefit customers and the environment**
- **The strategic choices have been developed principally in response to the views of customers, regulators and other stakeholders. They include: enhanced demand management, improved level of service, improved water supply resilience to non-drought hazards, and the potential for water trading**
- **Viable strategic choices that have customer support are taken forward to develop a series of alternative plans**

6.1 Overview of strategic choices

In this Water Resources Management Plan we have forecast available supply and future demand for the 25 year period to 2045. Our analysis has demonstrated that we are unlikely to experience a supply-demand deficit in any of our resource zones. However, we have taken the opportunity to consider a number of 'strategic choices' in order to help protect and, where possible, benefit customers and the environment. The strategic choices are related to:

- Enhanced leakage reduction;
- Improved levels of service;
- Increased water supply resilience to non-drought hazards; and
- National water trading.

The strategic choices have been developed principally in response to the views of customers, regulators and other stakeholders. In the remainder of this section we set out the rationale behind each choice and explain how it has been defined. The strategic choices are then combined into a series of 'alternative plans' before we complete an options appraisal process to determine which interventions are required and the necessary level of investment (Section 7).

6.2 Enhancing leakage reduction

Demand management is a significant component of our approach to safeguarding the future of our water supply and the environment. It is a key government priority as, for example, set out in Defra's guiding principles. Our baseline demand management activities are defined in Section 4.2.

Of areas in which we can manage demand, there are particularly strong feelings around leakage; it is consistently raised as a key concern when we consult with customers and stakeholders. Our regulators have set out a clear requirement to further reduce leakage, and in its recent draft methodology for PR19 Business Plans, Ofwat challenged companies to make a further 15% reduction during the period 2020-2025.

It is important to reiterate that if we maintain leakage at existing levels, as per our baseline activities (Section 4.2.2), we will be operating well below the sustainable economic level of leakage. This means that any further reductions will have an associated cost which needs to be taken into account as we define the strategic choice. This cost has the potential to impact customer bills and our ability to address customers' other priorities; we need to ensure that all changes we make are overall affordable to customers. Also, as we don't have a supply-demand deficit to address (Section 4.6.2) there is no general requirement for options. If this had been the case we could have included the leakage reduction options and therefore offset some of the cost in this context. We therefore need to consider our supply-demand position and the affordability to customers in the scale of our proposals.

We have conducted a wide range of specific customer research on leakage, as outlined in our *Draft WRMP19 Technical Report - Customer and stakeholder engagement*. This has shown that, as always, there is very strong support for leakage reduction. It also shows, however, that there are limits and any willingness to pay for leakage reduction is finely balanced with the corresponding costs as shown by the customer panel leakage survey. In our latest and most advanced piece of research, the Programme Customer Choice experiment[59], an average reduction of 44 Ml/d was selected by customers once costs and other potential water resource type priorities such as level of service (Section 2.5) were taken into account. This amount corresponds to around 10% of our current leakage level and, along with the Ofwat methodology, sets some bounds to help define the strategic choice.

In addition to the total level of leakage reduction we also need to consider the pace at which it can be delivered, both in terms of affordability and technical feasibility. In particular, our options identification process has indicated some innovative leakage reduction solutions that require more investigation. Reducing leakage progressively therefore potentially allows us to make these savings in a more cost effective manner for customers. We have considered this in defining our preferred plan, as set out in Section 7.

Our *Draft WRMP19 Technical Report - Demand for water* provides an explanation of how we are constrained in this regard and our *Draft WRMP19 Technical Report - Options appraisal* sets out several other choices that we explored, including a scenario with 15% reduction during 2020-25. As part of the consultation on this draft Water Resources Management Plan we are very keen to gather views on how far we should go with this strategic choice and achieving the right balance. For our draft plan, we have included the profile shown below in Table 16.

Table 16 Proposed enhancement for demand management – regional leakage reduction

Year	2020 25	2025 30	2030 35	2035 40	2040 45
Baseline position (Ml/d)	448.2				
Further leakage reduction (Ml/d)	-30.0	-20.0	-10.0	-10.0	-10.0
Proposed leakage level (Ml/d)	418.2	398.2	388.2	378.2	368.2

At a total of 80 Ml/d, this level of further leakage reduction reflects an 18% change from our baseline commitment. A reduction of 30 Ml/d during 2020-25 is around 7% of the baseline amount; this seeks to balance the pace of reduction against customer priorities and affordability, as well as practical

[59] This is an interactive game to allow customers to 'build their own' Water Resources Management Plan.

considerations and recognition of our supply-demand balance position. Overall affordability with other customer priorities will be fully tested as part of the business planning process in winter 2017/18 to inform the final plan.

The costs associated with this further leakage reduction were defined as part of the options appraisal process and are described in Section 7.4, along with the programme of necessary activities (i.e. the options). There is significant focus on innovation and the involvement of specialist third parties. We have also simulated the specific benefits of additional leakage reduction to customers and the environment using our sophisticated new 'extended methods' process (Section 7.2), to demonstrate the extra value realised from these activities.

6.2.1 Future reporting of leakage

Water companies have been working together, co-ordinated through Water UK, to improve the consistency of reporting of definitions of key measures of performance, so that performance can be compared between companies more easily. This work is supported by Ofwat, the Environment Agency, Natural Resources Wales and the Consumer Council for Water, and further information can be found here https://www.water.org.uk/.

Companies need to make changes to their current reporting to align with the new, more consistent, reporting definitions, and for some of these changes it will take some time to have robust data.

One of the measures of performance this applies to is leakage, and each company's draft Water Resources Management Plan explains how the company is implementing the new reporting definition for leakage and the extent to which it might impact on their future plans for balancing supply and demand for water. The change in reporting of leakage is purely a change in reporting; it does not affect the actual amount of water lost through leakage.

Each company will be making different changes to their current reporting to come into line with the more consistent definition, so the impact will be different for each company. For United Utilities, the changes and their potential impact are explored in our *Draft WRMP19 Technical Report – Demand for water*[60].

This project is referred to as 'leakage convergence'. As a methodological adjustment, it does not affect actual leakage levels, and hence the way this strategic choice is defined. The proposed level of leakage reduction would be of the same scale, relative to any new baseline leakage calculation. Leakage convergence has been considered in the scenarios that we have used to test our plan, and further detail can be found in the *Draft WRMP19 Technical Report – Options appraisal*.

[60] Detail on leakage convergence and what this means for us is included in Section 4.8 of our *Draft WRMP19 Technical Report – Demand for water.*

Consultation question – leakage reduction

- **Do you support our proposal for further leakage reduction? Yes or No. Please state why.**
- **Do you agree with the targeted leakage reduction, and the timeframe that we have set out to achieve it? Yes or No. Please state why.**
- **Have we achieved the right balance between customer, economic, and regulatory factors in our proposals? Yes or No. Please state why.**

6.3 Improved level of service for drought permits and orders

All companies have stated levels of service which stipulate the frequency at which they expect to apply supply restrictions or apply for drought permits and orders during dry weather. Our previous plan sought to maintain our current level of service as shown below[61]:

- Temporary use bans and drought permits/orders to augment supply once in 20 years on average (5% annual average risk);
- Drought orders to ban non-essential water use once in 35 years on average (2.9% annual average risk); and
- No rota cuts or standpipes even during extreme drought conditions.

As part of the planning process we have explored the possibility of changing these levels of service based on the following considerations:

- Customer, regulator and other stakeholder views;
- The impact of the change on the supply-demand balance; and
- Any associated costs

As outlined in our *Draft WRMP19 Technical Report - Customer and stakeholder engagement*, customer research in this area presents a mixed response between different surveys. Quantitative research to assess customer acceptability at different level of service levels[62] assessment indicated a high level of acceptability for the status quo, with only marginal differences in acceptability between service levels. However a willingness to pay assessment completed as part of the same survey suggests very high willingness to pay for improvement once valuations are aggregated across the whole customer base[63]. This is particularly true for drought permits and orders to augment supply once the cost to implement is taken into account (refer to our *Draft WRMP19 Technical Report – Options appraisal*). Similarly, our customer choice experiment indicated customers might tolerate marginally worse levels of service for water use restrictions, and marginally better levels of service for drought permits/orders to augment supply at an average of 1 in 24 years (4.2% annual average risk). Overall, we have interpreted this research as showing that customers do

[61] For WRMP19 Defra provided The Water Resources Management Plan (England) Direction 2017 (Defra, 2017). Section 3 refers to water use under different sections from the Water Resources Act 1991. These are included below for reference:
Section 76 – Provisions of drought order restricting use of water. Referred to in this plan as a temporary use ban;
Section 74(2) (b) – Provisions and duration of ordinary drought order. Referred to in this plan as an ordinary drought order to ban non-essential water use; and
Section 75 – Provisions and duration of emergency drought order. Referred to in this plan as rota cuts and standpipes.

[62] This has been completed using a technique called 'Gabor Granger' analysis.

[63] It is important to note that customer valuations were higher to avoid deterioration in levels of service.

place some value on improved levels of service, but not to the extent that this would be a priority investment driver in its own right.

Some of our stakeholders have particularly strong views about the planned frequency of drought permits to augment supply and would like to see an improvement in this area. In addition to the general expectation of all companies to explore different levels of service, as part of the Water Resources Management Plan pre-consultation process, the Environment Agency specifically requested that we explore the possibility of making drought permit applications only once we have implemented a temporary use ban (i.e. a hosepipe ban). In practice this would mean implementing the drought permit/orders to augment supply later and, therefore, at a lower frequency than a temporary use ban.

Research presented in our Water Resources Management Plan 2015 led us to the conclusion that customers would be willing to pay for an improvement in the level of service for drought permits and orders to augment supply, but not temporary use bans. We said that we would continue to explore this in the next plan and, taken on balance, our new research points us to the same conclusion. Therefore, the definition of this strategic choice is to reduce the stated frequency of drought permits/orders to augment supply from 1 in 20 years on average to 1 in 40 years on average (from 5% to 2.5% annual average risk). We are not proposing to change the frequency of temporary use bans at this stage as there is no evidence to demonstrate customer support of changes in this area.

We have used our water resource models to estimate the size of supply-demand enhancement required to reduce the frequency of drought permits/orders to augment supply to this level. We did this by looking at the benefit we get from them during a severe drought, and considering how we might replace them with other types of options to avoid a loss of resilience. This process is explained in our *Draft WRMP19 Technical Report - Supply forecasting* and the required enhancement is estimated to be around 10 Ml/d.

Given the results of our customer engagement, rather than invest directly in new options to facilitate this strategic choice we have decided to link it to the previous choice to enhance leakage reduction, as a supplementary benefit of these activities. There is a supply-demand benefit of 30 Ml/d from leakage reduction by 2025, which exceeds the requirement to move to a 1 in 40 year frequency for drought permits and orders to augment supply (2.5% annual average risk). Therefore, the timing of this strategic choice is to state the improved level of service from 2025 onwards. This is consistent with the outcomes of our customer engagement, whereby customers do place some value on improvements in this area, but do not consider it a strong relative investment priority in its own right. It also means that from 2025 we would be able to implement temporary use bans before applying for drought permits/orders to augment supply.

At this stage this is only a draft proposal for consideration and consultation. If we were to take this forward then further work would be required to consider how it would work in practice, for example, detailed derivation of new drought triggers. Drought permits/orders to augment supply would likely be implemented at a new lower 'drought trigger 5' rather than the current drought trigger 4. This would be reported and represented in a future Drought Plan upon implementation of the change in level of service.

As part of this Water Resources Management Plan we have also explored how our system performs under extreme drought. To do this we used a range of sophisticated new tools and techniques such as synthetic hydrology; these are all described in Section 4.4.8 and our *Draft WRMP19 Technical Report - Supply forecasting*. We have been able to more reliably consider the level of service for non-essential use bans and emergency droughts orders (i.e. rota cuts, standpipes or bowsers). The analysis demonstrated that we are

resilient to extreme drought and we are able to state improved level of service without requiring any additional investment.

For non-essential use bans we are able to improve the stated expected frequency from no more than 1 in 35 years on average to more than 1 in 80 years (moving from 2.9% to 1.25% annual average risk), reflecting the point at which we would expect these to be implemented in line with our Drought Plan. For emergency droughts orders we can demonstrate that we are able to meet a frequency of no more than 1 in 200 years on average (0.5% annual average risk), Defra's new reference level of service, and this is expanded upon in the next section. This does not constitute an improvement in the level of service statement as such, but adds context to our existing position that they are unacceptable, even in extreme droughts. These changes will apply from 2025 along with the changes to drought permits and orders. Our proposed future level of service with our preferred plan in place is shown in Section 7.7.

? Consultation question – level of service for drought permits and orders

- **Do you support our strategic choice to improve levels of service for drought permits and orders from 1 in 20 years (5% annual chance) to 1 in 40 years on average (2.5% annual chance)? Yes or No. Please state why.**

6.3.1 Investing to increase resilience to extreme droughts

In Section 4.4.8 we outlined how we have tested the resilience of our supply system to more extreme droughts than those in the historic record. This demonstrates that we already have a resilient system that is able to withstand at least a 1 in 200 year event (that has 0.5% annual average risk), correlating with Defra's reference level of service for emergency drought orders (standpipes, rota-cuts and bowsers).

As part of this strategic choice we considered improving resilience to droughts even further. However, given that we are already resilient to extreme droughts there is no significant reason to improve. This position was reinforced by our research that indicated there was no customer support to invest to improve further. Level of service acceptability surveys indicated that the level of acceptance of different drought severities between 1 in 100 year (1% annual average risk) and 1 in 1000 years (0.1% annual average risk) didn't vary significantly, a theme that was also consistent when tested with a small number of stakeholders in our Technical Stakeholder Group.

In advance of considering whether to improve our resilience to extreme droughts, and in line with the planning guidelines, we developed drought resilience options mirroring all of the supply measures in our drought plan. These correspond to actions linked to levels of service such as implementing drought permits and orders to augment supply, but also include disused sources that we don't include in our deployable output calculation (Section 4.4.2). Whilst these measures would be implemented in a repeat of some of the historic droughts that have traditionally been covered by the Water Resources Management Plan process, their role is to protect us if the drought develops into something more severe than we have experienced in the historic record.

Any exercise to improve resilience to extreme droughts should therefore include the existing measures in the same format as any new options, so that we can ensure that the overall supply configuration is

appropriate. The development of the drought resilience options is described our *Draft WRMP19 Technical Report - Options identification* and our *Draft WRMP19 Technical Report - Supply forecasting* outlines the benefits of drought plan measures in droughts of different severities, linked to the population of the Drought Links table detailed in Section 4.4.8.

Whilst at this stage we are not considering further improving our resilience to extreme droughts, the information provided by this process has allowed us to consider whether our existing configuration is the most effective way to maintain drought resilience. We focused on the largest drought permits at Windermere and Ullswater, and compared their average incremental and social cost (AISC) against those for other types of options. AISC is a whole-life (80 year) cost which, in addition to capital and operating costs, includes environmental and social costs, as outlined in Section 7.2. As the AISC of these drought permits was much lower than our other options this exercise confirmed that it would be inappropriate, even in the long-term, to make significant investments in other types of options to replace them[64]. The case is significantly further strengthened once the likely frequency of use is taken into account (not included in AISC).

Our proposed future levels of service with the preferred plan in place is shown in Section 7.7.

? Consultation question – drought resilience

Our demand management plan provides some improvement in resilience to drought, which we believe to be robust. Do you;

- **Support our conclusion that we already have an appropriate level of resilience to extreme droughts? Yes or No. Please state why.**
- **Agree that there is no further immediate need to invest and improve our resilience position further? Yes or No. Please state why.**

6.4 Resilience to non-drought hazards

Our baseline resilience position to non-drought hazards is detailed in Section 4.7. In this section we outline how we consider future resilience to non-drought hazards as a strategic choice.

6.4.1 Customer and stakeholder views

We have carried out a number of targeted assessments of customer and stakeholder views and opinions of water service resilience, including:

- Five events to understand customer and stakeholder priorities;
- Traditional willingness to pay stated preference surveys around water service failures;
- Natural experiments using operational data reflecting customer contacts and attitudes during interruptions;
- Innovative immersive surveys to expose customers to long duration supply failure issues; and
- Comparative online surveys to evaluate customers' views around water service failures.

[64] This conclusion is based on our assessment of drought risk and drought permits as options, but does not pre-empt the conclusions of mitigation studies for the more severe drought permit option at Windermere currently underway.

Resilience has been consistently ranked as a high priority by the majority of our stakeholders. Whilst there is little appetite for increasing water bills, there is wide support to prioritise resilience expenditure within existing budgets. We are confident from our research that customers support our strategy of achieving long term water supply resilience, delivered at a pace that is affordable, wherever this is economically feasible. Further detail on how we have assessed our water supply resilience needs can be found in our *Draft WRMP19 Technical Report – Water supply resilience.*

6.4.2 25 year resilience programme

Through our risk assessment process we have identified our largest resilience risks for priority investment. This is detailed in Section 4.7 along with the current risk position across our region. During the 2015-2020 period we are already investing around £220 million in targeted resilience improvements. For the future, we are working to define a programme of resilience investment to be delivered at a pace customers support and can afford as part of our business planning processes. We are currently undertaking further customer and stakeholder engagement, including through the consultation on this plan.

Future investment will be targeted on addressing risks associated with our regional aqueduct system, some of our most vulnerable treatment works and major supply mains. In early parts of the planning horizon, investment will mainly be associated with our regional aqueduct system. Over the longer term we will prioritise investment to address other risks. The interventions will be across all four 'R's and will increase our water service resilience. Managing all of the currently identified resilience risks to meet the current service level target of very infrequent large scale service failures that exceed 12 hours is expected to take up to 20 years of future investment. The pace of investment will reflect customers' risk appetite coupled with water bill affordability.

This strategic choice is focussed on our approach to manage the highest risk area (Manchester and Pennines resilience), and described further below.

6.4.3 Prioritising resilience expenditure within existing budgets

As shown in both the previous section and in Section 4.7.3, Manchester and Pennines resilience is a key resilience focus area. In light of the customer research we are improving our capability to monitor and respond through a number of improvements that will benefit resilience to Manchester and the Pennines, and across our region:

- Failure contingency planning, including assessment of additional supply, re-zone and alternative water supplies, and water treatment works contingency plans;
- A new 24/7 Integrated Control Centre Network response team is in place to coordinate operational responses to water treatment work, aqueduct and network failures;
- Additional Alternative Supply Vehicle (ASV) provision, to accelerate operational responses;
- On-line monitoring and enhanced laboratory analysis;
- Installation of ultraviolet rigs for microbiological treatment;
- Automated facilities that divert short term deterioration of water quality to waste;
- Agricultural land management to protect water quality; and
- Progressing a project to address the highest risk section of one of our aqueducts.

These interventions have been made through prioritising within existing budgets in the current investment period and are already reflected in the baseline Manchester and Pennine Resilience risk explained in Section 4.7.3.

6.4.4 Considering further risk reduction

Through the options process explained in Section 5.6, we have identified five alternative solutions to further reduce the future Manchester and Pennine resilience risk. These represent a strategic choice between different levels of investment and residual risk. Broadly there is a choice between investing to address only the highest risks relating to deterioration of some tunnel sections of the aqueduct, or to address a wider range of risks.

The two figures below compare the five alternative solutions and through the consultation we would like views on these, to inform our selection of one solution to take forwards into our final plan. In parallel to the consultation we are conducting in depth qualitative and quantitative customer research to inform the selection. The final choice will also be supported by further economic analysis of the options.

Figure 30 Five solutions for improving Manchester and Pennine resilience showing pros (green boxes) and cons (red boxes) for each solution

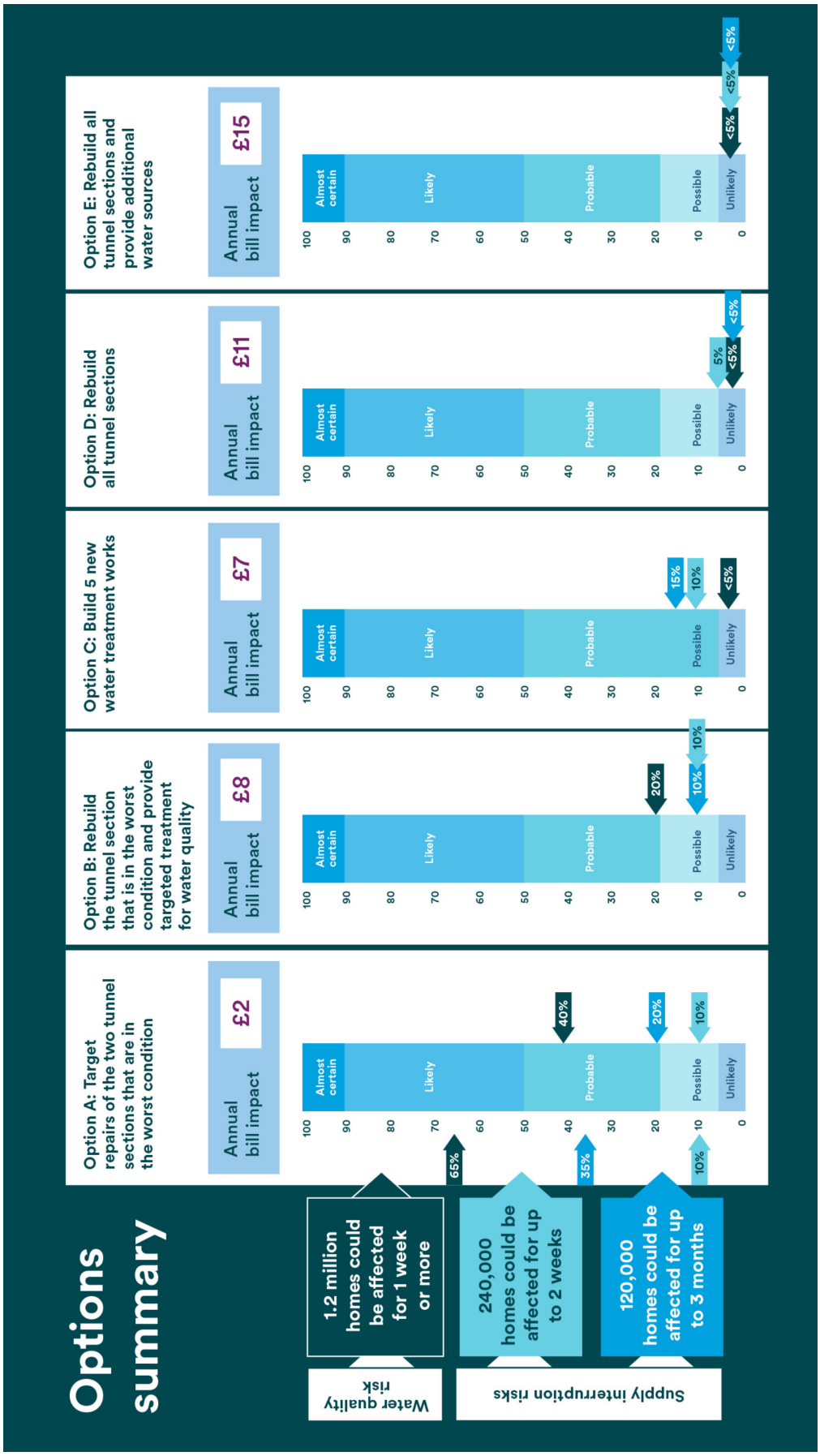


Figure 31 Five solutions for improving Manchester and Pennine resilience showing likelihood of associated risks to customer supply and estimated annual bill impact of executing each solution. Note that the arrows on the right of each bar denote different risk levels for each solution. These correspond to the colour coding on the arrows to the left of the diagram. These arrows to the left of Option A on the diagram show the baseline risk position and the nature of the risk to customers.

Further option specific detail on these five solutions for Manchester and Pennines resilience is included in the *Draft WRMP19 Technical Report – Water supply resilience* (and specifically Appendix A, Section A6, within that document).

? Consultation question – resilience to other hazards

- **In the plan we identify the need to mitigate resilience risks to water supplies in Manchester and the Pennines. We outline five alternative ways of addressing this, with different costs and benefits for each alternative. Which proposal do you think we should prioritise and develop? Please state why.**

6.5 National water trading

In line with the planning guidelines and the Water UK long term water resources planning study this strategic choice relates to national water trading. In our 2015 plan we identified technically feasible export options in conjunction with other water companies, and explored the potential impacts at high-level as a scenario test within the plan. There was a 'high' impact on our supply-demand balance of significant new exports up to 180 Ml/d from our Strategic Resource Zone. This means that options would need to be implemented to maintain resilient supplies to customers. There would be a national benefit to such an arrangement if it allowed resilient supplies to other areas at lower cost and there would be a benefit to the North West due to the revenues paid by the importing company. We have a strategic choice as to whether such exports should feature in this plan.

Due to uncertainty around a potential trade and dependencies on the Water Resources Management Plans from other water companies we cannot commit in isolation to an export (Section 7.6). Rather, we must have an adaptive plan which allows us to prepare for potential trades. Investment would be triggered only if and when the needs of the importing company is confirmed. We have assumed that any trade would occur from the mid-2030s onwards[65]. As we were finalising this draft plan, Thames Water advised us that in the current Water Resources South East regional strategy the water would instead be needed from the late 2040s onwards. The timing of and need for any trade is subject to confirmation through completion of other companies Water Resources Management Plans, which is why we are adopting a pathway approach (Section 7.7). For a trade of this scale to progress there would be significant further investigation and analysis work. The results of such work will feed into any decisions to progress the trade and feature in the next Water Resources Management Plan in 2024.

A number of stakeholders raised specific water trading points in their pre-consultation feedback. While there was understanding why it was being considered, there were some important aspects highlighted for consideration:

- Cost and benefits in terms of the environment;
- Modelling of impacts on water resources in the North West and implications for droughts;

[65] Our assessment is based on 2035, however, it may be considered as representative of a trade occurring at any point in the 2030s. It is unlikely that any trade will be required before this date based on discussions with Thames Water. If the trade is at a later date, defined by Thames Water's own draft Water Resources Management Plan and/or subsequent work, we will reassess our plans accordingly in future.

- A need to significantly increase the North West's resilience and resources to enable the trade - particularly with the future uncertainty and likelihood for more regular and increasingly extreme events;
- Steps taken by importing companies to minimise their call on north west resources;
- The potential to negatively impact on vulnerable water bodies and Water Framework Directive objectives;
- Potential to impact negatively on customers, in terms of cost. Alternatively any service benefits should go to local residents (for example a reduction in water bills, direct re-investment in local infrastructure, improved resilience or improved natural capital);
- Impact on lake levels for environmental and amenity use;
- The need for a national and balanced framework; and
- The risk of transferring invasive non-native species from one area to another.

In our customer research we identified the following views:

- Overall support that water trading should be considered – only 7% of customers said that this was not an important area for us to consider;
- The view of many people when it comes to the idea of water trading is that it is good in principle, but there is a natural concern of the implications and consequences to ensure that the North West does not suffer as a result;
- There were some concerns that if contractual agreements were put in place to provide water to other parts of the country when they were in need, then what would that mean for the North West if that region was also suffering from a deficit?;
- It was clear that there would need to be safeguards put in place, so that the North West region did not suffer if it were to enter into a contractual obligation to provide water to other areas;
- There were also some isolated views that the water in the North West belongs to the region and should not be exported at all – however this does not represent the views of the majority;
- Many participants felt the water in the North West region is of superior quality to the rest of the UK. Some had fears that water transported into the region might be of a lower quality than the region has become accustomed to having 'on tap';
- Some participants had concerns over the potential costs of transporting the water. Does new infrastructure need to be built? Will this cost be passed onto the customer?; and
- Some felt that there might be an environmental impact, including upsetting the ecosystem, should new infrastructure be put in place; this was a concern for a number of participants.

In developing these proposals we have taken the concerns raised into account. We have developed the extended methods (sophisticated and improved options appraisal) process (Section 7.2) specifically to address the concerns. This allows us to select options to enable an export which at least maintain resilience at the levels expected by customers, and protect the environment (this is shown in Section 7.6). We have also worked with Thames Water to set out a 'heads of terms' which could form the basis of future contractual protections for both parties.

As outlined in our *Draft WRMP19 Technical Report - Options identification* we have engaged with a number of companies about potential exports. Thames Water is the only company to confirm that an import from

United Utilities is a candidate for their preferred plan to date[66]. The export to the South East would be from Vyrnwy reservoir, *via* the River Severn, a new raw water transfer pipeline and the River Thames. This export could be up to 180 Ml/d, although it would be used relatively infrequently, during periods when dry weather meant there was a need for the water in the South East (less than 15% of the time on average). We have tested a larger trade with the 180 Ml/d export used more extensively (Section 8.2) and we have completed some preliminary work on exports of smaller volumes. Whilst we have not reported the details here, it is important to note that we can facilitate different sized trades, i.e. release smaller volumes from Vyrnwy with a lower level of investment required, and that this could be explored further at a later date.

This proposed export has been set in the context of a national assessment of water resources need (Water UK 2015), which sets out a balanced approach between demand reductions, new resource development across England and Wales, and strategic transfers of water. The proposed export from Vyrnwy was identified in this work as a cost effective and resilient way of meeting the national need. Water UK will carry out further work on the extent to which companies have been able to take account of this national framework in their plans.

? Consultation question – national water trading

- **What is your view on our proposal to work towards exporting water to other parts of the UK in future?**
- **If we are to progress our proposals for water trading, would you like to be consulted as we explore delivery plans in more detail? In developing our delivery plan, we would like to collaborate further with our stakeholders to explore areas of mutual benefit. Would you welcome this and if so why?**

6.6 Strategic choices summary

We have outlined a number of strategic choices and described their benefits in the sections above. We are proposing the following strategic choices and would like to hear your feedback and thoughts in particular about:

- Enhanced leakage reduction – 80 Ml/d by 2045;
- Improved level of service for drought permits/orders to augment supply;
- Increasing our resilience to non-drought hazards, in particular asset failure; and
- Continuing to explore national water trading.

These strategic choices will be considered in different combinations that form alternative plans in Section 7. Finally, to reiterate, our strategic choices have been developed based on customer and stakeholder views; this process is summarised below in Figure 32.

[66] This statement is based on the position at the time of developing our draft Water Resources Management Plan. We understand other companies may be considering export options from our region for their draft Water Resources Management Plans. The outputs of other company plans are not available in time to incorporate into this plan, but we will consider this further at revised draft plan based on the options selected and the timescale required for implementation.

Enhancing leakage reduction

Customer and stakeholder research has shown that this is considered a priority area and they want us to do more. There is customer willingness to pay for leakage reductions, but these are finely balanced with corresponding costs. Our customer 'programme choice experiment' showed a 44 Ml/d willingness to pay on bills.

- We set out long-term aspirations to reduce leakage further by 80 Ml/d over the next 25 years, but at a pace customers can afford. We propose reductions of 50 Ml/d by 2030, with 30 Ml/d of these by 2025. Completing the reductions in stages allows us to achieve this in a more cost effective manner by allowing us to implement new innovations over time.

Improved level of service for drought permits and orders to augment supply

Customers show some customer willingness to pay for reducing drought permit/order frequency. However, this is seen as a lower priority area for investment and acceptability of current service is high. There are higher valuations to avoid deterioration in performance. This level of service area is of key concern to some stakeholders.

- Given customer feedback, our plan does not invest in this area in its own right, but improvements are unlocked by other investment to reduce leakage. We therefore propose to move to a better 1 in 40 year (2.5% annual average risk) level of service by 2025 for drought permits (currently this is 1 in 20 years on average (5% annual average risk)).

Resilience to non-drought hazards

This is a high priority area for customers there is high willingness to pay in this area. Our 'immersive' workshop on long-term supply interruptions found that customers deemed long-term interruptions intolerable and placed a high value to avoid such events. However, there is little appetite for increasing water bills.

- There is little appetite for increasing water bills, so we are working to define a programme of resilience investment in future at a pace customers support and can afford. This will be completed as part of our business planning activities. However, in this plan we have identified a salient and priority risk area, and would like your views on alternative plans to address this.

Water trading

In research, customers typically place a higher value on the service they receive, and to avoid deterioration. Whilst there is generally support for water trading in principle, both customers and stakeholders do raise some concerns and want the North West to be adequately protected. Ensuring water quality, resilience and the environment is protected is key.

- We have proposed a plan which protects the resilience, level of service, water quality and the environment in the North West.
- Recognising concerns raised by customers and stakeholders, we consult upon water trading in this plan with a view to completing further, more detailed investigations or studies in future planning cycles.

Figure 32 Summary of how strategic choices are derived from customer and stakeholder views

7 Preferred plan and alternatives

Key points

- We have created four alternative plans by combining the strategic choices
- For each plan we have completed an options appraisal process
- For water trading we used our sophisticated options appraisal process (known as 'extended methods') to ensure that customers and the environment are protected
- In developing these alternative plans we have included innovative solutions and involved third party providers
- We have selected a preferred plan and demonstrate that it is both 'best value' and sustainable
- We'd like to hear customer and stakeholder views on our preferred plan objectives and the options selected to meet them. We will take feedback on board and continue to revise the plan ahead of publishing our revised draft Water Resources Management Plan in summer 2018.

7.1 Overview of alternative plans

As outlined in the previous section we have identified and defined four strategic choices. In this section we consider what options (interventions or solutions), and therefore level of investment, are required to realise these choices. We also measure the impact of making these changes on the performance of the system using our new 'extended methods' process (Section 7.2). In the case of water trading we use the process to ensure that we select options that will properly protect customers and the environment.

We could have assessed each of the strategic choices separately, however this would have prevented us from identifying in-combination impacts and benefits. Therefore, we decided to aggregate the strategic choices into 'alternative plans'. To include every possible combination of strategic choice would have resulted in 16 alternative plans, which we think would have made the plan difficult to digest and consult upon[67]. This also would have overly constrained the amount of analysis that we could have completed, as well as complicated the decision making process. Therefore, we have created four alternative plans in an additive manner, with all four strategic choices appearing in the final plan. These are outlined in Table 17 below.

[67] This was a consideration learning from our discussions with regulators and stakeholders as part of developing the plan.

Table 17 The alternative plans formulated using different combinations of strategic choices

		Strategic choices			
		Enhanced leakage reduction	Improved level of service – frequency of drought permits and orders to augment supply	Water supply resilience to hazards other than drought	National water trading
Alternative plans	Plan 1 Continued demand management	✗	✗	✗	✗
	Plan 2 Plan 1, plus enhanced leakage reduction, with improved level of service for drought permits/orders to augment supply	✓	✓	✗	✗
	Plan 3 Plan 2, plus resilience to other hazards	✓	✓	✓	✗
	Plan 4 Plan 3, plus national water trading	✓	✓	✓	✓

These four alternative plans should not necessarily be considered as the only possible outcomes; the approach is intended as a helpful way to test and present information. We are keen to receive feedback on individual strategic choices, and how they could fit together into our final plan. Note, however, that we have linked enhanced demand management and improved level of service as the leakage reduction allows us to make this change without any additional investment (Section 6.3). As outlined in Section 6.4, all content related to resilience to other hazards will continue to be developed through to the final Water Resources Management Plan. Detailed performance metrics and costs are calculated in the following sections. However, we first outline the options appraisal techniques that we have employed.

7.2 Options appraisal process

This section summarises the options appraisal process, which is detailed further in our *Draft WRMP19 Technical Report - Options appraisal* and a high level overview is shown in Figure 33.

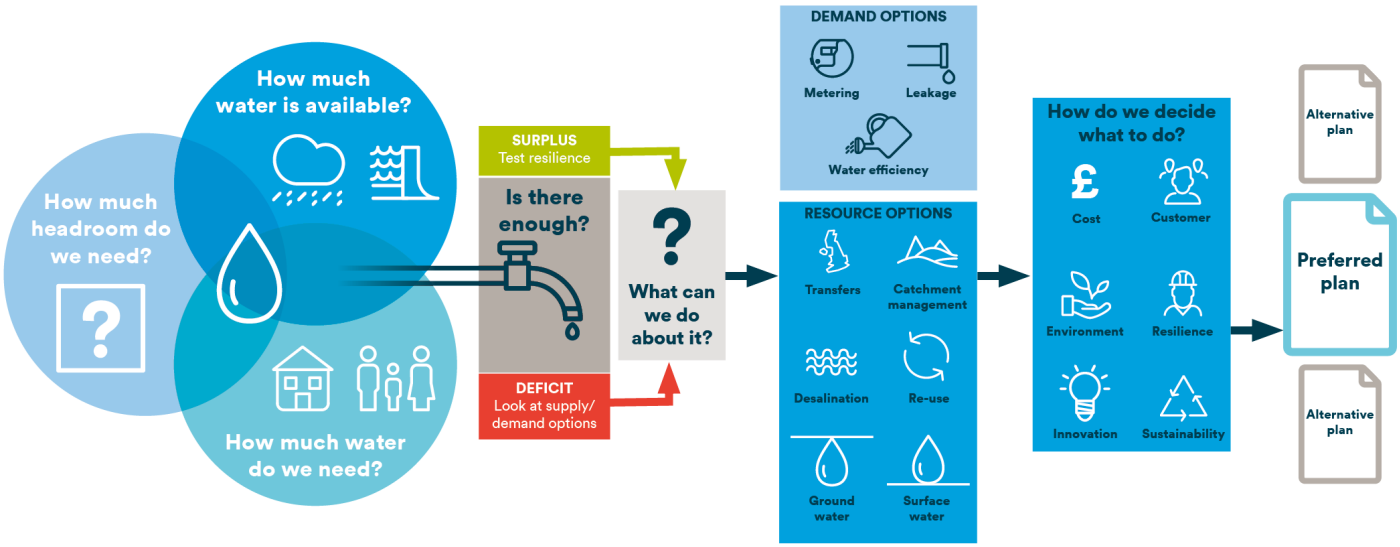


Figure 33 Overview of how we have developed our alternative plans

This process has been developed over a number of successive water resources management plans. For this plan we have used three different complementary options appraisal techniques, which can be summarised as follows:

Average Incremental Social Cost (AISC) – in simple terms, a way to rank options according to their cost by unit volume (pence per cubic metre). AISC includes monetised environmental and social costs and can be used to apply options to a supply-demand deficit at a single point in time.

Economics of Balancing Supply and Demand (EBSD) – using AISC as an input, this modelling approach is used to apply options to a time varying (i.e. 2020-2045) supply-demand balance. It generates an optimised 'lowest cost' portfolio of options to address any supply-demand deficit. We used EBSD to help define the leakage reduction programme (Section 7.4) and examine a range of scenarios (Section 8), however, options for water trading were defined using our extended methods process.

Extended methods – a new sophisticated approach developed in conjunction with one of our water resource service providers; Atkins. As described in detail in our *Draft WRMP19 Technical Report - Options appraisal*, this method represents a move away from the traditional supply demand balance approach to explore wider aspects of water resources performance. It allows us to answer a number of pertinent questions:

- How does a portfolio of options perform under a wide range of future conditions such as extreme droughts or climate change? What if we look a long way into the future, for example, the 2030s or even the 2080s?
- Can we alter a portfolio to increase its value under these conditions, as measured by a range of performance metrics which have been agreed with stakeholders?
- Do we need further or different options to protect customers and the environment from the wider impacts of water trading?

Our metrics were defined in discussion with a range of internal and external stakeholders. For the assessment we arranged them into two groups as shown in Figure 34 below. In the following sections we refer only to the primary metrics to help us to present a clear picture of impacts. However, it should be noted that when defining any portfolios for water trading (Section 7.6) both the primary and contributory

metrics were used; i.e. we were looking for portfolios of options that did not compromise performance in any of these areas. The full set of results can be found in our *Draft WRMP19 Technical Report - Options appraisal*.

		Primarily measures the impact on:				
	Metric	**Customer**	**Cost**	**Environment**	**Resilience**	**Sustainability**
Primary metrics	Change in the likelihood of temporary use bans	✓				
	Change in drought resilience	✓		✓	✓	✓
	Change in river flows and implementation length of drought permits			✓		✓
	Portfolio cost, including environmental and social valuation	✓	✓			✓
Contributory metrics	Change in abstraction from sensitive groundwater sources			✓		✓
	Change in spill from reservoirs			✓	✓	✓
	Climate change resilience	✓		✓	✓	✓

Figure 34 Metrics used to indicate the performance of our alternative plans

7.3 Alternative plan 1 – continued demand management

This plan maintains our baseline supply demand balance position as outlined in Section 4. As such, no options are required and there is no further investment. However, it should not be considered a 'do nothing' plan, as a range of demand management activities are required to maintain the supply-demand balance. These are defined as part of the baseline in Section 4.2 and account for:

- Maintaining leakage levels at 448.2 Ml/d based on our three-year average from 2014/15 to 2016/17;
- Water efficiency activities achieving, as a minimum, an annual saving of 1 litre per property per day; and
- Installing a total of around 180,000 water meters between 2020 and 2025. By the end of the planning horizon in 2045, we forecast that we will reach 76% meter penetration.

This alternative plan provides a useful comparator for assessing the others below.

7.4 Alternative plan 2 – plan 1 plus enhanced leakage reduction and improved level of service for drought permits/orders to augment supplies

As described in our *Draft WRMP19 Technical Report - Options appraisal* we have used a combination of AISC and EBSD to define a leakage programme over the 2020-2045 planning period for the purposes of consultation. The total level of leakage reduction proposed (Section 6.2) is challenging and as such we have sought to employ innovative techniques and involve specialist third parties. At the same time we are acutely aware that many of the newer approaches are not yet fully proven. If we are to make shorter-term commitments on leakage we need to ensure that we can deliver them.

Therefore, we have decided to split the leakage programme into three distinct phases, as also illustrated in Figure 35 below:

- In the first five years from 2020-2025 there will be a larger dependency on the leakage options that we are confident can be delivered, with only a small reliance on innovative approaches;
- During 2025-2030 we have an even balance of reliable and innovative solutions; and
- Beyond 2030 we have removed this constraint and focussed on low cost and innovation by selecting options solely on AISC.

Starting now we have the opportunity to work closely with third party suppliers to further develop and trial these options. We should of course recognise that by 2030 some of the newer approaches may already have been displaced by technologies that are yet to be invented; this is natural for a long-term strategic planning process like the Water Resources Management Plan. Our future forecasts will be reviewed fully in each planning round.

Finally, it is important to point out that any third party contributions implemented in the future will be subject to an appropriate procurement process taking account of any legislative requirements. This applies to any trials or pilot studies that fall within the legal requirements.

2020-25 Focus on reliability with some innovation	• Leakage reduction through additional find/fix and pressure optimisation	28Ml/d *(UU)*
	• Reduce leakage and improve water efficiency by identifying customer side leakage and use patterns	2Ml/d *(third party)*
2025-30 Balance of reliability and innovation	• Pressure reduction in distribution network resulting in leakage reduction and reduced open-tap demand	10Ml/d *(UU)*
	• Reduce leakage and improve water efficiency by identifying customer side leakage and use patterns	10.5Ml/d *(third party)*
2030-35 Innovation	• Temporary logging of large customers	4Ml/d *(UU & third party)*
	• Proactive monitoring of all household meters to identify and fix supply pipe leaks	4Ml/d *(UU & third party)*
	• Splitting DMAs	2Ml/d *(UU & third party)*
2035-40 Innovation	• Reduce leakage and improve water efficiency by identifying customer side leakage and use patterns	10.5Ml/d *(UU & third party)*
2040-45 Innovation	• Enhanced logger verification	8Ml/d *(UU & third party)*
	• Temporary logging of large customers	1Ml/d *(UU & third party)*

Figure 35 Details of our proposed leakage reduction programme

The costs (programme and bill impact) and relative performance of this plan are shown in Table 18 below. As outlined in Section 6.3 and presented in Figure 38, the assumed date for changing our level of service is 2025[68], following the first five-year tranche of leakage reduction (30 Ml/d). There is a total of 80 Ml/d leakage reduction across the planning period, 60 Ml/d of which has been applied in 2035 for the extended methods simulation.

[68] This would also be incorporated into a revised Drought Plan around that time to reflect this change.

Table 18 Details of cost, bill impact and metric scores for alternative plan 2 (note the blue row relates to this alternative plan)

#	Description	Cost Cumulative cost 80 year NPV including environmental and social costs (£m)	Cost Estimated bill impact (£/annum)	Customer Change in the likelihood of temporary use bans	Customer Change in drought resilience	Environment Change in river flows and implementation length of drought permits to augment supply
1	Continued demand management	0	0	NSC	NSC	NSC
2	+ enhanced leakage reduction and improved LoS for drought permits to augment supply	46.7	0.68	+++	+	++
3	+ resilience to other hazards	TBC	TBC	Not tested with extended methods for draft Water Resources Management Plan 2019 (scheduled for completion following the draft plan consultation period).		
4	+ water trading	306.6	-0.40 (saving)	+++	+	++

NSC no significant change +/++/+++ favourable -/--/--- unfavourable

As outlined in Section 6.3 the main driver behind this alternative plan is customer and stakeholder views. The extended method process allows us to measure the benefits of this alternative plan to customers and the environment. Looking at the metric columns in Table 18 improvements in customer level of service, drought risk and environment are all apparent. Further results and a full explanation of the process are included in our *Draft WRMP19 Technical Report - Options appraisal*.

7.5 Alternative plan 3 – plan 2 plus resilience to other hazards

As outlined in Section 6.4, we have identified five potential solutions to mitigate the risk to water supplies in Manchester and the Pennines. We propose to take forward one solution following consultation and customer research. We wish to use this draft plan to provide an opportunity, as part of the consultation process, to collate customer and other stakeholder views on the type of solution that we should select to mitigate this risk. A brief description of the options under consideration is included in Section 6.4. An appraisal process is being conducted as part of our wider business planning process to prioritise investment in addition to Manchester and Pennine resilience. This will define a programme of risk reduction interventions based on stakeholder and customer views and affordability. We aim to incorporate this into the final plan following consultation.

These options comprise either rebuilding or repairing aqueduct sections, new water treatment works for operational use, or some new assets to provide redundancy for outages or failures. At this stage we have assumed that there is no material impact of these options on the supply-demand balance position, noting that these are being defined to address a different resilience driver. Once the options to address this risk have been further established we will be able to examine if this interacts with other elements of the preferred plan and whether there are any resulting changes to the final supply-demand balance position. We therefore aim to incorporate this element further into the final plan following consultation if necessary. However, it should be noted that this is not expected to impact on the water trading options covered in the next section (Alternative Plan 4, see Section 7.6); these options are designed to protect customers and the environment from the impacts of water trading.

7.6 Alternative plan 4 – plan 3 plus national water trading.

As outlined in Section 6.5 and our *Draft WRMP19 Technical Report - Options identification*, we have explored a number of potential water trades. Our strategic choice relates to a national water trade involving Thames Water. In order to maintain supplies to customers when exporting from Lake Vyrnwy we will need to make modifications to our supply system. This will include developing new sources of water to ensure there is no impact on customers or the environment, taking into account the benefits of our leakage reduction programme.

Our proposed options are shown in Figure 36 below. The new supplies will provide water to offset that which would normally come from the River Dee and Vyrnwy. These options have been selected to maintain resilience and maintain environmental standards. For any new supplies, or changes to existing supplies, we would ensure that there is no deterioration to drinking water quality (Section 8.5).

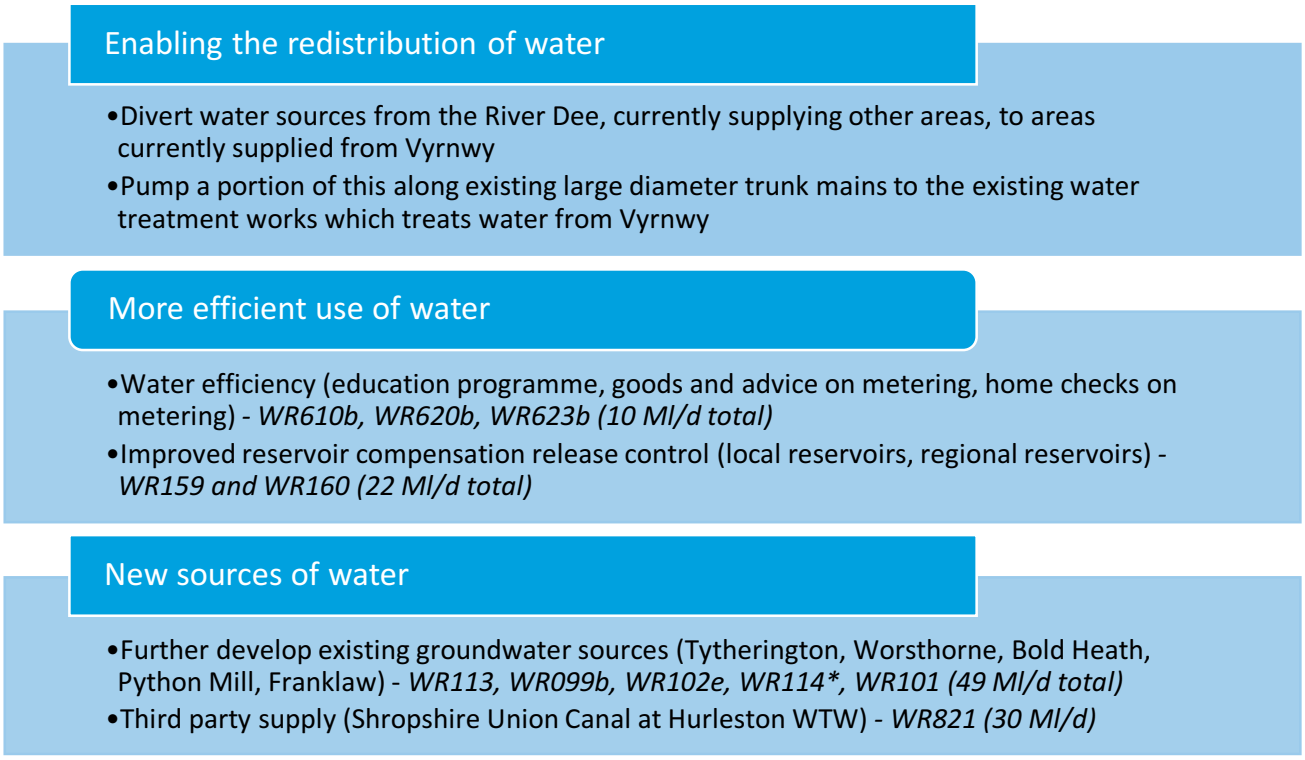


*Figure 36 Details of our proposed option for water trading (includes options ID for cross-referencing to our Draft WRMP19 Technical Report - Options identification, sizes refer to capacity) *Substitute option identified*[69]

The export is designed to operate during times of relatively dry weather in Thames Water's areas. Therefore the redistribution of water and the new sources will only need to be used relatively infrequently. Stochastic analysis that we have commissioned jointly with Thames Water indicates that this is less than 15% of the time on average.

The export with these options in place has been tested in our extended methods process to ensure that they do not result in additional risks to supplies or the environment during drought events in the North West. The results are shown in Table 19 below. In terms of drought risk and impact on the environment there will be no impact in 2035 relative to the position with the leakage reduction program (Section 7.4) in place. There is an indicated further improvement in customer level of service; this is a coincidental benefit of the requirement to maintain performance across all metrics. This is the lowest-cost portfolio of options that we could identify which satisfied our objectives to protect customers and the environment; further information on the selection process is provided in our *Draft WRMP19 Technical Report - Options appraisal*. We have also tested the implications for drinking water quality, this work is outlined in Section 8.5.

[69] As outlined in Section 7.7.1 a groundwater abstraction at Barrow in Furness (WR100) was identified as a substitute option for Python Mill (WR114). Potential risks were identified with WR114 as part of the Habitats Regulation Assessment. If these cannot be effectively mitigated in the future a substitute option will be required.

Table 19 Details of cost, bill impact and metric scores for alternative plan 4 (note the blue row relates to this alternative plan)

#	Description	Cost Cumulative cost 80 year NPV including environmental and social costs (£m)	Cost Estimated bill impact (£/annum)	Customer Change in the likelihood of temporary use bans	Customer Change in drought resilience	Environment Change in river flows and implementation length of drought permits to augment supply
1	Continued demand management	0	0	NSC	NSC	NSC
2	+ enhanced leakage reduction and improved LoS for drought permits to augment supply	46.7	0.68	+++	+	++
3	+ resilience to other hazards	TBC	TBC	Not tested with extended methods for draft Water Resources Management Plan 2019 (scheduled for completion following the draft plan consultation period).		
4	+ water trading	306.6	-0.40 (saving)	+++	+	++

NSC no significant change +/++/+++ favourable -/--/--- unfavourable

The direct costs of these new water resources and associated works will be recovered from Thames Water under a bulk supply contract. In addition, because the bulk supply contract will also cover a proportionate contribution to the general costs of running a water company, bills for customers in the North West will be slightly lower as a result of the trade. This bill reduction is estimated to be around 40 pence per annum for every household (Table 19).

For the purposes of preparing water resources management plans, we have agreed with Thames Water that any environmental impacts downstream of Vyrnwy in the Severn and Thames catchments will be assessed in its Water Resources Management Plan process. So for example, the risk of transferring invasive non-native species from the River Severn to the River Thames has been assessed in Thames' plan and mitigation included. Thames Water has also considered through its Water Resources Management Plan, a range of other options against which this trade is assessed in terms of environmental impacts, resilience, costs etc. This process means that the export is being progressed only after other schemes, for example steps to reduce demand, have been completed.

7.7 The preferred plan

We have selected alternative plan 4 as our preferred plan, incorporating all four of the strategic choices:

- Enhance leakage reduction by a total of 80 Ml/d over the planning period (noting that the benefits of the leakage reduction programme would be protected under national water trading);
- Improve level of service for drought permits and orders to augment supply from 1 in 20 years to 1 in 40 years (moving from 5% to 2.5% annual average risk);
- Increase resilience to others hazards, specifically for our regional aqueduct system associated with Manchester and Pennines resilience; and
- Continue to explore national water trading.

In combining the strategic choices as a coherent plan, we have ensured that we have considered in-combination impacts and opportunities. In simple terms, Alternative Plan 4 was selected as the preferred plan because it contains all of the strategic choices we have proposed to address customer and stakeholder views. Selecting Alternative Plan 3 would not allow us to continue to explore national water trading, thereby failing to meet a potential future national need, and missing the opportunity to provide the associated bill saving to customers. Alternative plan 2, whilst cheaper than Alternative plan 3 (cost to be confirmed), would not allow us to address pressing supply system resilience needs. Alternative plan 2 has an additional estimated cost of £46.7M (net present value including environmental and social costs) compared to Alternative plan 1, but will help to meet customer, stakeholder and regulatory aspirations on leakage reduction, and at the same time provide environmental benefits and allow us to improve our level of service for drought permits in 2025. Alternative Plan 1 has the lowest cost of all plans, but it does not deliver any of these strategic choices.

As previously stated the primary role of the preferred plan is to serve as the focus for consultation on this draft Water Resources Management Plan. The final plan could be based on one of the other alternative plans, or indeed a different combination of the strategic choices. If it were to contain water trading this would still likely be a pathway as the timing of a final decision would extend beyond the production of this Water Resources Management Plan. To be clear, our preferred plan consists of both a trading and a non-trading pathway.

We are committed to ensuring that our preferred plan offers 'best value' as part of ensuring our plan represents the most cost effective and sustainable long-term solution. Our objective has been to ensure that both customers and the environment are protected from the impacts of water trading in the most sustainable way, with the minimum possible overall level of investment. Our *Draft WRMP19 Technical Report - Options appraisal* describes how portfolios of options were selected, tested and optimised to achieve this objective and Table 20 helps to summarise the process.

By 2035, our assumed date[70] to commence trading, customers and the environment will be benefitting from our strategic choice to enhance leakage reduction, as highlighted by the green 'plus' symbols in the second row of the table. However, once we introduce water trading, without options in place there could be a detrimental impact to customers and the environment. Therefore, our preferred plan recovers the performance of the system with the lowest possible level of investment that we were able to find to avoid deterioration against the performance metrics. Furthermore, it provides some additional benefit – the

[70] As we were finalising this draft plan, Thames Water advised us that in the current Water Resources South East regional strategy the water would instead be needed from the late 2040s onwards.

analysis indicates that the actual frequency of temporary use bans in the Strategic Resource Zone could be less than the stated 1 in 20 year level of service (5% annual average risk) – but this is a secondary effect of meeting the objective to protect customers and the environment. The final row is an example of one of the higher cost portfolios that provides some additional benefit in all areas. In this particular case, the portfolio is an efficient way to deliver the additional benefits. However, it does not meet our objective to protect customers and the environment in the most cost effective way.

Table 20 Defining a best value preferred plan

Description	Cumulative supply demand options benefit (Ml/d)	£ Cost Cumulative cost 80 year NPV including environmental and social cost (£o)	£ Cost Maximum bill impact (impact	Customer Change in the likelihood of temporary use bans	Customer Change in drought resilience	Environment Change in river flows and implementation length of drought permits to augment supply
Baseline - Continued demand management	0	0	0	NSC	NSC	NSC
2035 leakage reductions in place	60	46.7	0.68	+++	+	++
Water trading with enabling works only	60	137.1	Not calculated	NSC	-	--
Preferred plan	170.7	306.6	-0.40 (saving)	+++	+	++
Example higher cost, higher performing portfolio	219.7	392.0	Not calculated	+++	++	+++

NSC no significant change +/++/+++ favourable -/--/--- unfavourable

We presented our current levels of service in Figure 6 (Section 1.4), and we have updated this below in Figure 37 to reflect the proposed changes in our preferred plan. Our stated level of service for emergency drought orders (i.e. rota cuts or standpipes) remains unchanged, however, using our sophisticated new tools and techniques (Section 6.3) we have explored the actual expected frequency of implementation. There is a fairly high degree of uncertainty in this assessment but the maximum simulated frequency at any point during the 2020-2045 planning period is 1 in 800 years on average (0.125% annual average risk) with the preferred plan in place (trading pathway). This analysis is outlined in our *Draft WRMP19 Technical Report - Supply forecasting.*

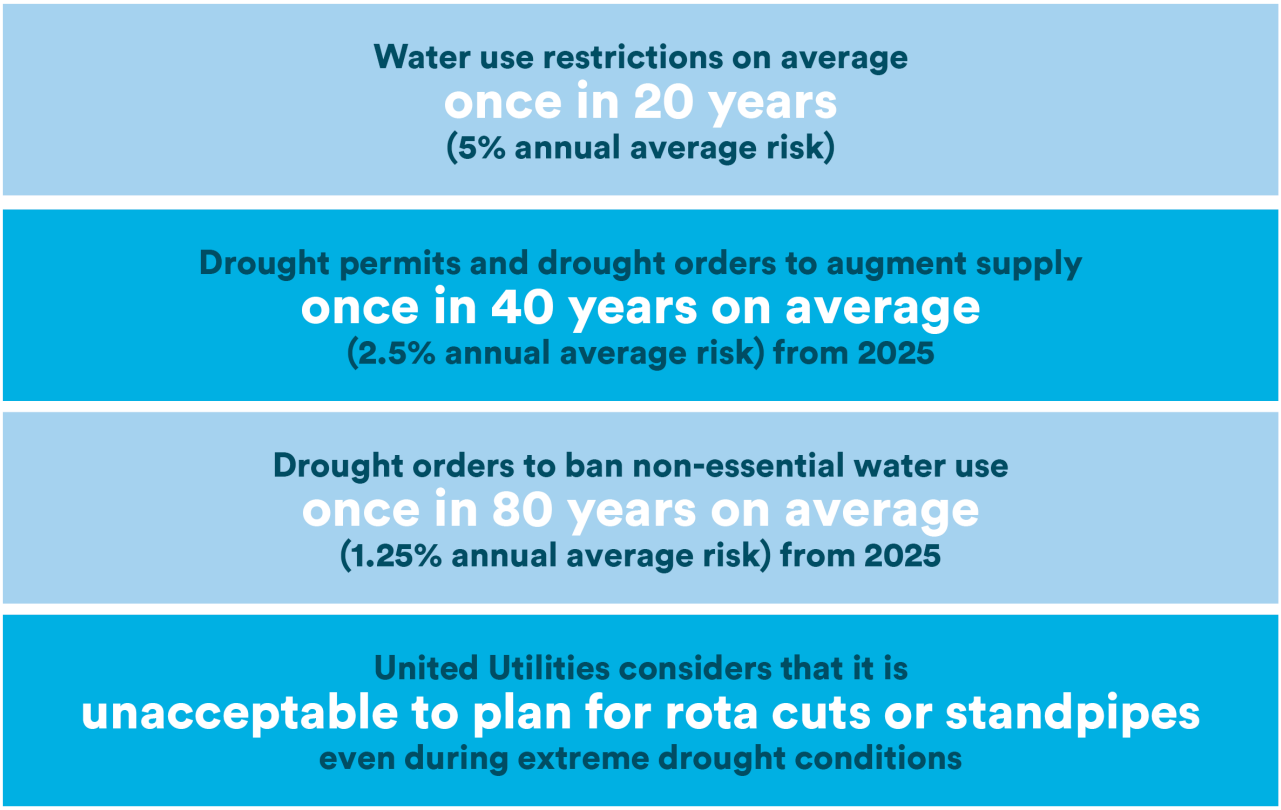


Figure 37 Future levels of service with our preferred plan, from the year 2025 onwards

7.7.1 Environmental appraisal

As set out in the previous sections we will ensure that any future water trading agreement does not negatively impact on customers or the environment. We have selected a plan that is cost effective and sustainable in the long-term. This was in part achieved by employing environmental metrics in the extended methods process, as explained in Section 7.2. However, there is a practical limit to the number of elements of the environment that we can represent this way. Our overall assessment of the environment is much broader; an independent consultant has completed three environmental assessments as required by the regulatory guidelines. These documents have been issued alongside the draft Water Resources Management Plan:

- Strategic Environmental Assessment[71];
- Water Framework Directive Assessment[72]; and
- Habitats Regulations Assessment[73].

We have also completed an initial assessment of the risks from invasive non-native species (INNS) which is outlined in our *Draft WRMP19 Technical Report - Options appraisal*. The determination of environmental and social costs was a key aspect of the options identification process (Section 5.4.1).

These environmental assessments are intrinsic to the water resource management plan process and have informed key decisions along the way. All feasible options were assessed as part of the options identification stage, as outlined in Section 5.4. Options then selected for the preferred plan were assessed

[71] Strategic Environmental Assessment of the Draft Water Resources Management Plan 2019: Environmental Report.
[72] Draft Water Resources Management Plan 2019: Water Framework Directive Assessment.
[73] Draft Water Resources Management Plan 2019: Habitats Regulations Assessment.

in more detail during options appraisal. Our future use of existing sources was also considered, particularly in relation to the Water Framework Directive and the need to avoid deterioration of water bodies in our region. These assessments will therefore ensure that our Water Resource Management Plan as whole is sustainable in the long-term.

The environmental appraisal process will continue way beyond the draft Water Resource Management Plan. At this stage the type of information available is typically 'high-level', as appropriate for the strategic planning problem being explored, and there is a relatively large degree of uncertainty. By the time options in the plan are implemented there will have been a number of iterations to both scheme design and environmental assessment, with each informing the other. This will take place through future successive planning cycles. Due to the inherent level of uncertainty, the nature of the assessments for the draft Water Resource Management Plan is necessarily precautionary. As such we would reasonably anticipate some potential impacts from the implementation of certain options and we recognise the need for further discussions with the regulators, further assessment and possible mitigation. There is sufficient time to do this because none of the resource options are due for implementation until at least after the next Water Resource Management Plan is published in 2024.

If we did not do this, and selected only options with no or very low impact at this early stage, we might end up with a plan that is sustainable, but not cost effective. We cannot reject a cost effective plan based on the potential risk that it might not be sustainable. Now that candidate options have been selected we should firstly aim to explore the risks and mitigate the impacts to make it sustainable. If we do need to alter the plan we are confident that with so many alternative or substitute options to choose from this should be achievable, if the driver for national trading remains. Of course, if at any stage we determine there are high levels of risk associated with an option it will be eliminated from our plans.

The conclusions of each of the assessments are summarised below; the full reports have been published alongside this draft Water Resource Management Plan.

Strategic Environmental Assessment (SEA)

The Strategic Environmental Assessment found that the type, range and magnitude of both positive and negative environmental effects would be likely to increase commensurate with the level of intervention proposed. The programme of leakage reduction would be likely to generate significant positive effects on health and wellbeing, associated with increased investment and continuity of water supply, and water quantity and quality and water resources, as less water would be lost due to leakage thus lowering demand for water abstraction. Mixed significant positive and significant negative effects on climate change and resource use have also been identified, reflecting carbon emissions arising from pipeline repair, but also the expectation that lower levels of leakage (and improved water efficiency) would reduce greenhouse gas emissions and energy use. Consistent with the scale of intervention associated with the preferred plan, no further significant effects would be anticipated.

Through the implementation of the Manchester and Pennine Resilience solution, the preferred plan would be expected to deliver benefits in terms of both levels of investment and continuity of water supply. Additionally, the preferred plan provides national benefits through export to Thames Water, helping to address risks associated with drought beyond the United Utilities region. However, reflecting the increased scale of construction activity and operational impacts associated with the abstraction of water, potential adverse environmental effects are more likely.

Water Framework Directive Assessment

The draft Water Resources Management Plan was found to be in compliance with the Water Framework Directive. In terms of the current abstraction licences, the assessments indicate that although there is some residual risk, which should be mitigatable. Overall, the operation of the licences, the reductions noted by the Environment Agency and the schemes identified for completion by 2020 (Section 4.4.3) should be enough to mitigate against any significant risks to the Water Framework Directive water bodies in future, and are therefore the plan assessment shows compliance with the requirements of the Water Framework Directive.

The assessments for the options that comprise the preferred plan indicate that most of the options could have a medium level of impact against Water Framework Directive objectives, and as such will require further assessment at detailed planning stage. However, the impact assessments were based on a precautionary approach and can be mitigated. As such it will be possible to be compliant with Water Framework Directive objectives.

Habitats Regulations Assessment

The preliminary conclusion of the Habitats Regulations Assessment is that it is likely, based on the available works information, that the resilience options can be delivered with 'no significant effects' on any European sites – although this cannot be confirmed with the information available at this point. With regard to the remaining options in the preferred plan it is clear that the majority of these will have 'no significant effects alone or in combination' if brought forward as projects. Where there are residual uncertainties in the 'plan-level' assessment of these options, mitigation measures have been identified to ensure that the WRMP will not result in adverse effects that cannot be avoided with scheme-level measures.

This includes the identification of a potential substitute 'no significant effect' option for Python Mill (WR114). At this stage there is no need to remove Python Mill from the preferred plan, but we have already identified a groundwater abstraction at Barrow in Furness (WR100) as a suitable candidate for substitution if required (Figure 39). This option has been tested through the full extended methods process to ensure that the adjusted portfolio would still meet all of our objectives. Note that due to the 'conjunctive use' nature of the Strategic Resource Zone substitute options aren't necessarily required to be situated in the same location.

Therefore, the preliminary conclusion of the Habitats Regulations Assessment is that the draft Water Resources Management Plan will have no adverse effects, alone or in combination. This conclusion does not remove the need for a Habitats Regulation Assessment at the project-level, which will be required to address those aspects and uncertainties that cannot be meaningfully assessed at the plan-level, such as potential 'in combination' effects with forthcoming plans or projects that may coincide with option delivery.

Invasive Non Native Species Assessment (INNS)

The national water trading pathway involves the transfer of raw water between the River Severn and the River Thames catchments. The assessment of these elements of the scheme are covered in Thames Water's draft Water Resources Management Plan.

The only option in the preferred plan which involves the transfer of raw water is the abstraction from the Shropshire Union Canal (WR821). If this scheme is progressed it will require a more detailed INNS risk assessment. As the option is associated with national water trading there is sufficient time to undertake

this work in the future and ensure that any risks are mitigated. More details of the preliminary INNS assessment that we have completed are provided in our *Draft WRMP19 Technical Report - Options appraisal.* We also assessed our existing transfers as outlined in our *Draft WRMP19 Technical Report – Supply forecasting.*

7.7.2 Future timeline

This is our view for the draft Water Resources Management Plan and we welcome the views of customers and stakeholders through the consultation process. Following this, we expect to publish a revised draft Water Resources Management Plan in summer 2018. Until then, we will continue to refine our plan as more information comes to light, particularly acknowledging the link with Thames Water for our water trading pathway. As activity for more detailed option design and cost estimation continues, we may be able to refine the portfolio of options to further reduce cost. Once we have published our revised draft Water Resources Management Plan it would subsequently become final pending approval by the Secretary of State.

By selecting the export to Thames Water as part of this preferred plan, it does not necessarily follow that it will be implemented. The export is dependent on a number of factors, including Thames Water selecting it as part of their future plans and progressing to a contract award, further design work and granting of the necessary development consents. Selecting it as part of an adaptive plan will allow further more detailed design work to progress, at a pace tailored to the timing of need defined by other company plans. Given the time needed to progress a scheme of this scale, such work will need to commence in the period 2020-25. However, there will be another Water Resources Management Plan in 2024 before construction is likely to commence, even assuming implementation by the mid-2030s at the earliest. At that point it is possible that timings or requirements may change. See Figure 38 below.

We consider the Vyrnwy export to be resilient and environmentally sound. It brings benefits to customers through lower bills and investment in local infrastructure. It allows us to make a contribution to national needs for the benefit of the UK economy.

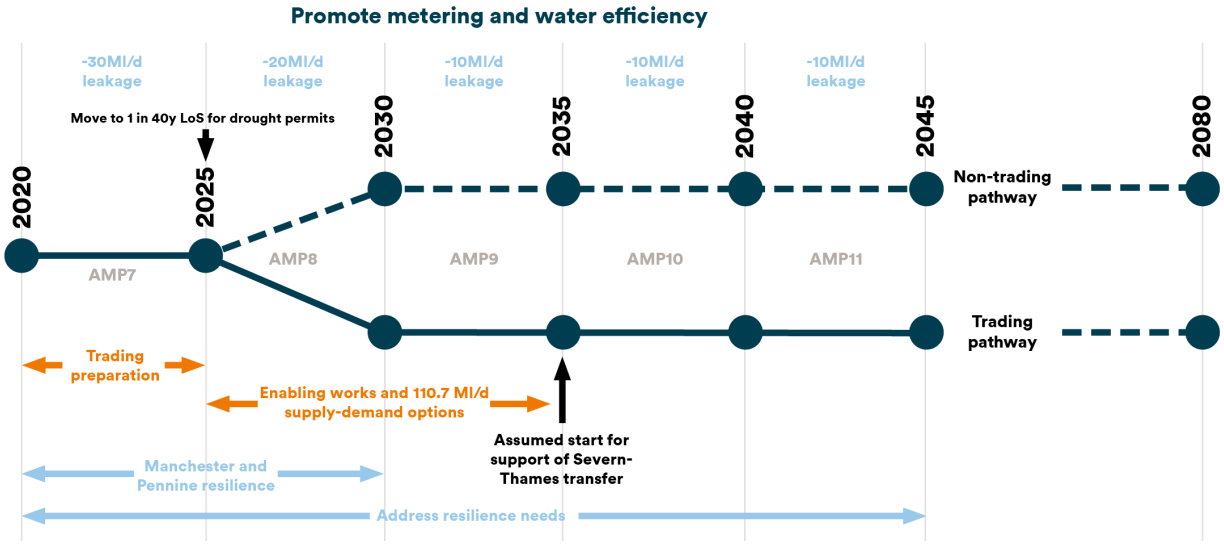


Figure 38 Our preferred plan timeline

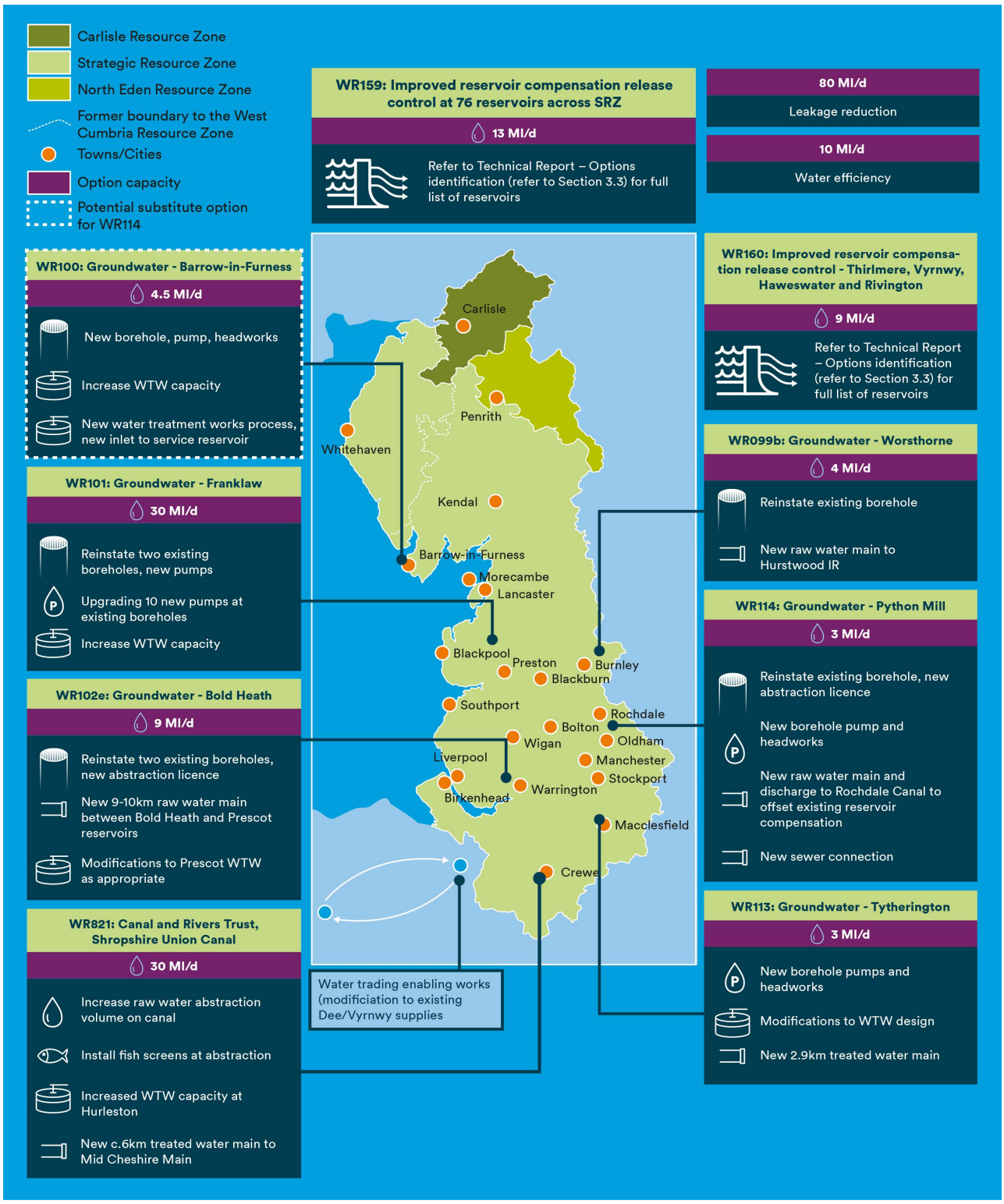


Figure 39 Summary detail of our preferred plan options

? Consultation question – environmental report

We would welcome your views on any aspect of the Environmental Report, together with supporting evidence where appropriate. We are particularly interested to receive your response to the following questions:

- **Do you think that the Environmental Report has correctly identified the likely significant effects of the draft Water Resources Management Plan? If not, what other significant effects do you think we have missed, and why?**
- **Do you agree with the conclusions of the Environmental Report and the recommendations for avoiding, reducing or off-setting significant effects associated with the implementation of the draft Water Resources Management Plan? If not, what do you think should be the key recommendations and why?**
- **Do you agree with the proposed arrangements for monitoring the significant effects of the implementation of the Water Resources Management Plan? If not, what measures do you propose?**

? Consultation question – preferred plan

Our preferred plan is to reduce leakage further; improve levels of service for drought permits and orders; to mitigate the resilience risk to water supplies in Manchester and the Pennines; and explore national water trading.

- **Is this the right combination of strategic choices? Yes or no? Please state why.**
- **Does our portfolio of options demonstrate we are being innovative and providing an appropriate balance of options? Yes or no? Please state why.**
- **Do you have any concerns regarding any of the specific options selected in the preferred plan? Yes or No. Please state option and concern.**
- **Do you agree that our preferred plan meets our objective of the "most cost effective and sustainable long-term solution"? Yes or No. Please state why.**

8 Testing our plans

Key points

- Our preferred plan is robust to a wide range of uncertainties
- It would be inappropriate to invest large sums of customers' money to address all possible eventualities
- We tested a range of scenarios beyond what we have planned for, and set out the scale and cost of mitigation required
- In the event that any of these were to materialise they would be addressed as part of a future Water Resources Management Plan
- We will protect the resilience and water quality of supplies to all customers

8.1 Overview

There are significant uncertainties in water resources planning such as the impacts of climate change, population growth and future customer demand for water. We have incorporated a wide range of these uncertainties into our planning through the application of target headroom (Section 4.5) and use of extended methods (Section 7.2). It would be inappropriate, however, to invest large sums of customers' money to address all of the possible eventualities that we can foresee.

It is nevertheless prudent to 'stress-test' the preferred plan to ensure that in the unlikely event that conditions outside of our planning envelope were to materialise, there are no significant risks to supply that we cannot mitigate. Therefore, we have performed careful scenario testing of our preferred plan, including those resource zones where we are not planning to invest in new options. This work is outlined fully in our *Draft WRMP19 Technical Report - Options appraisal,* which includes, for example, possible impacts on abstraction due to continued compliance with the Water Framework Directive. A summary of the most significant uncertainties (in terms of scale) for each resource zone is provided in the following sections. In all cases we will monitor the future situation carefully, and reassess risks for the production of each five-yearly Water Resources Management Plan, as well as our ongoing Water Resources Management Plan annual review process.

We have tested the impact of the options we have selected in the Strategic Resource Zone on supply system resilience (Section 8.6) and drinking water quality (Section 8.5). We have also completed a number of scenarios around leakage reduction, linked both to leakage convergence[74] and the 15% reduction in 2020-2025 stipulated in Ofwat's draft methodology for PR19 (Section 6.2). None of these leakage scenarios particularly stress the system; they are reported in our *Draft WRMP19 Technical Report - Demand for water.*

[74] Leakage convergence is a methodological adjustment and does not affect actual leakage levels. Further explanation of leakage convergence is included in Section 6.2.1.

8.2 Strategic Resource Zone scenarios

Key scenarios for the Strategic Resource Zone are shown in Table 21 below.

Table 21 Scenarios used to test the Strategic Resource Zone

Scenario	Change	What would we need to do to mitigate this?	How much would this cost through to 2045? (NPV £M)
Demand is much higher than forecast	158 Ml/d increase in demand, leading to 55 Ml/d deficit in 2045 with preferred plan in place (trading pathway)	Develop further options. This would be appraised in a future Water Resources Management Plan if the increase in demand became apparent. The current assessment indicates that options would include re-establishing an abandoned reservoir, developing further groundwater sources and increasing the capacity of an existing water treatment works.	96.5
Climate change impacts are worse than anticipated	Three sets of climate change projections tested through extended methods	Through protecting customers and the environment against the impacts of trading the preferred plan is robust to a range of climate change impacts (up to the 75th percentile). Therefore no mitigation actions are required.	0
A larger trader; in this case a scheme, for example Thames Water, with more extensive use of Lake Vyrnwy (i.e. trading on a greater number of days).	Higher utilisation tested through extended methods	With the preferred plan in place it would be possible to increase the use of Vyrnwy for trading without impacting customers or the environment. No new options would be required, but the level of utilisation of those selected for the preferred plan would be higher. This helps demonstrate a long-term best value plan.	7.8*

*Whilst no further options would be required for these scenarios there would be an increase in the utilisation of the options in the preferred plan; this is reflected by the cost.

We have also taken the opportunity provided by the extended methods process to explore how the preferred plan would perform beyond the 2020-2045 planning period, right out to the 2080s. We used the 2080s UKCP09 climate change projections (Section 4.4.4), extended our demand forecast and included a working assumption that we would continue to enhance leakage reduction by 10 Ml/d every 5 years beyond 2045.

This demonstrated that our preferred plan was relatively robust in the 2080s, and we would only need to invest in some additional groundwater capacity in the south of the region (Cheshire). Analysis showed that the additional capacity was required in the 2080s irrespective of whether we were making releases from Vyrnwy reservoir, i.e. the water trading strategic choice does not introduce a long-term risk in this context. Under all circumstances we would protect the water quality of supplies to all customers.

8.3 Carlisle Resource Zone scenarios

The supply-demand balance in this resource zone is robust. Our current assessment shows that even with the worst climate change impacts we still have a surplus, though this is relatively small at 0.5 Ml/d. All other scenarios tested resulted in a larger surplus, as outlined in our *Draft WRMP19 Technical Report - Options appraisal.*

8.4 Barepot and North Eden Resource Zone scenarios

The supply-demand balance in these resource zones is very robust and none of the scenarios we tested led to a requirement for further investment in new options. In both resource zones supply is constrained by physical assets and abstraction licences rather than hydrological conditions, therefore even the more severe demand or climate change projections do not lead to the need for investment.

8.5 Drinking water quality

Our preferred plan needs to ensure that we continue to meet drinking water quality standards, minimise water quality risks and that the water we supply remains acceptable to customers; there should be no deterioration. This is in line with the latest Drinking Water Inspectorate guidance to water companies including its Long Term Planning guidance published in 2017.

Through the development of our plan, we have considered the potential water quality changes that may occur within our supply system. In accordance with Drinking Water Inspectorate guidance, any changes to the supply will need to ensure that there is no deterioration in the absolute water quality parameters and aesthetic water quality. This is of particular relevance for resilience and water trading drivers where there could be transient changes to how our supply system operates at certain times. There is the potential for increased numbers of customer contacts if these types of scenarios are not correctly managed (for example, due to aesthetic or taste changes).

We have considered this risk of 'deterioration' of water quality in a number of ways:

- All options that we have considered have been designed to ensure that they meet the required drinking water quality standards. This is a regulatory requirement;
- Furthermore, we have also considered whether additional stages of water treatment processes may be required in order to reduce the risks of water quality changes and to ensure that our supplies remain acceptable to customers. This thinking has been built into our Engineering assumptions used to support the development of our feasible options. For example, a water softening process may be required in certain circumstances (for instance if water supplies changed from surface water to groundwater, or from Vyrnwy to Dee). It is recognised that if any of the options are taken forward as part of the preferred plan, then a higher level of design maturity will be required, in conjunction with the regulators to ensure customers are protected; and
- We have completed some provisional analysis of our supply system during a water trading scenario to understand the significance of the changes and where water quality impacts to customers might be observed. This also includes any enabling works that are required to facilitate the water trading scenario.

As part of the preferred plan (with a water trading scenario), we have assessed how the options selected could change the composition of the water supplied in different parts of the supply system. We have done this using our water resources models to indicate what proportion of demand they comprise when in operation during indicative dry and normal demand years. Furthermore, we have also considered the

effects of the water trading 'enabling works' as these would be required ahead of options for water trading coming into operation.

Figure 40 shows how each of the options could potentially change the composition of supplies in the areas which they feed. The key conclusions from this graph are as follows:

- During water trading in a dry year, about 16% of the reduced output demand normally fed from Lake Vyrnwy would be made up from the River Dee;
- Use of the Shropshire Union Canal water may increase to above 40% in a dry year. This would be to provide water to customers in the Crewe area which would normally be fed from canal water sourced from the River Dee catchment. We already have a water treatment works that treats water from this source, but there may be a change in the raw water quality of the source that would need to be understood;
- Existing and normally used groundwater sources at Tytherington (Macclesfield) and Franklaw (Fylde demand) would be utilised more in both normal and dry demand year scenarios during water trading at less than 20% of the total demand for that area; and
- Existing but unused groundwater sources at Bold Heath (Prescot), Python Mill (Oldham) and Worsthorne (Burnley)[75] would be required to provide between 4% and 6% of the demand in dry years. Bold Heath water would be mixed with other regional supplies prior to treatment. Worsthorne and Python Mill are designed to offset compensation from existing impoundment reservoirs and so there would be no change envisaged to the source water for the treatment works water.

[75] Worsthorne is included in our Drought Plan as a supply side option. This WRMP19 option both makes this capacity permanently available as a 'business as usual' source contributing to WAFU, whilst also adding additional asset capacity.

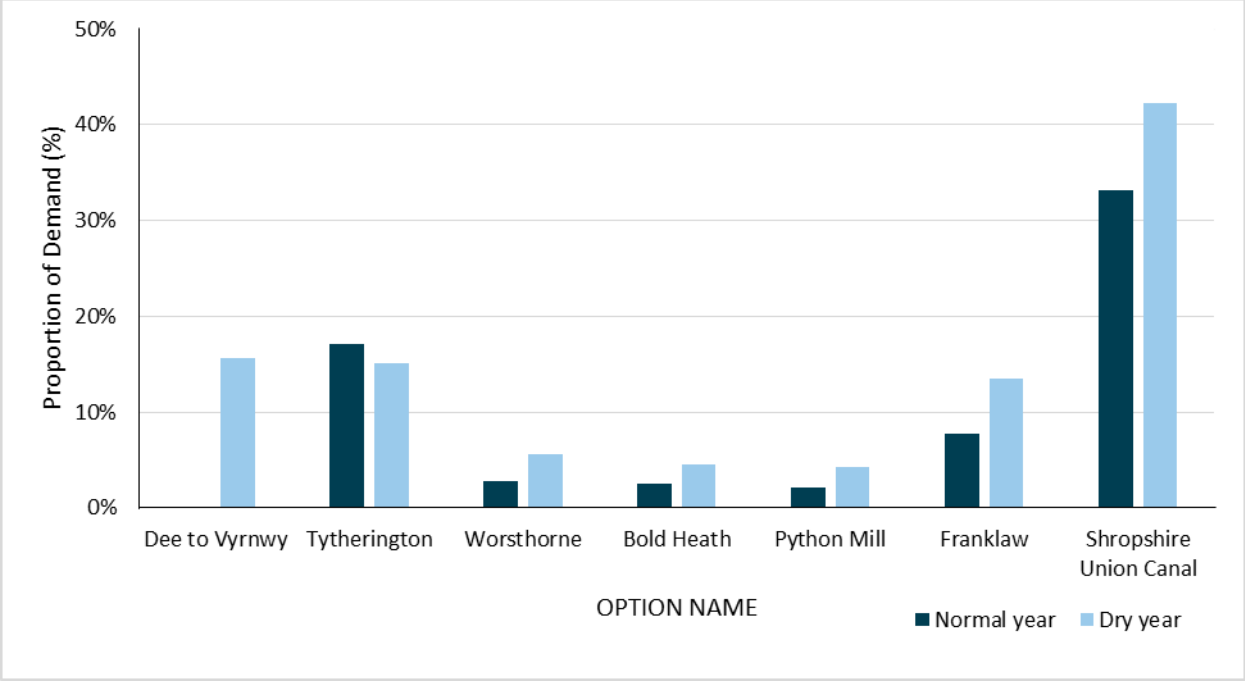


Figure 40 Proportion of water supplied to the nearest demand centre from the new options when used for water trading

In conclusion, there are some potential changes in water source in particular areas. The use of some existing supply sources may change depending on the supply-demand requirements at certain times. We will use this provisional analysis as we develop our long-term plans to understand the significance of these changes, risks to water quality and that our supplies remain acceptable to customers at all times. We would envisage that this would be through more specific assessments of the supply system changes, including a better understanding of the potential risks and required mitigation, particularly where new sources of water are required.

8.6 Assessment of wider supply resilience

The expected effect of the proposed water trading options to our overall system resilience will be to at least maintain the existing level against all significant hazards. Whilst we have not yet carried out all hazard system resilience assessments against the proposed water trading options we have assessed the supply resilience to both drought and freeze thaw hazards. Further detailed option design will address all significant hazards associated with the options.

The modelled effects of the trading options during a drought are reported above. The same freeze-thaw assessment process as discussed in Section 4.7.5 was applied to the system including trading options. In all of the cases assessed the system resilience was at least as high as in the baseline case without the trading options.

9 Assurance and board engagement

Key points

- **We have completed extensive assurance activities as part of developing this plan, and have engaged our Company Board through the process**
- **Our Corporate Audit Team have overseen our assurance activities, supported by an independent third party audit process by CH2M**
- **This ensures that our plan meets the Defra guiding principles and regulatory guidelines, in particular that the plan represents the most cost effective and sustainable long-term solution**
- **Our assurance has also included compliance to the drinking water quality guidance**
- **The Company Board have assured this draft Water Resources Management Plan submission following the outcome of our audit and assurance processes**
- **Following consultation, we will seek final Board assurance for our revised draft Water Resources Management Plan in summer 2018**

9.1 New requirements for Board assurance

We take the development and assurance of our Water Resources Management Plan submission very seriously. Recognising the increasing importance of the Water Resources Management Plan and its links with wider business planning processes, the Defra guiding principles and Water Resources Planning Guideline also advocate some new specific requirements for Board assurance.

There are two key statements:

1. The Defra guiding principles for the Water Resources Management Plan state an expectation that *"with assurance from your company's Board we want to see you collaborate with customers, partners and regulators to develop a strong understanding of future needs, explore every option, and build consensus on delivery plans"*; and

2. The Water Resources Planning Guideline states the need to gain *"assurance from your Board that they are satisfied the plan represents the most cost effective and sustainable long term solution".*

Given the specific requirement defined in the Defra guiding principles, particularly around consensus on delivery plans, following consultation on this draft plan we will seek final Board assurance on the revised draft Water Resources Management Plan in summer 2018. This will allow us to ensure that the consultation period has resulted in an appropriate final plan and to integrate this process into our wider business planning. However, recognising the need for the draft Water Resources Management Plan consultation to be on track to meet these defined objectives, we have gained endorsement on the draft Water Resources Management Plan from the Company Board prior to submission (see Section 9.3).

9.2 Assurance undertaken on the plan

To enable Board assurance, and to ensure submission of a robust plan in line with the regulatory guidelines and Defra guiding principles, we have undertaken an extensive assurance process. This was completed by CH2M and included three phases, as follows:

- **Stage 1 – Preparedness Audit – June 2016:**
  - Confirmed that the Water Resources Management Plan is defined, maintained and tested in line with the relevant water resources planning guidelines. This included a review of the robustness of the water resources management planning methodology and controls over:
    - key inputs;
    - models and outputs; and
    - internal and external approval procedures.
  - Reviewed our readiness to adopt the changes to water resources management planning guidelines, supporting UKWIR methodologies and readiness to assess the key strategic questions impacting the next Water Resources Management Plan.

- **Stage 2 – Water Resources Management Plan Processes and Resilience – June 2017:**
  - Confirmed the definition and maintenance of the Water Resources Management Plan is in line with the latest relevant technical guidelines (e.g. Environment Agency/Natural Resources Wales Guidelines; Defra guiding principles; and supporting UKWIR methodologies).
  - Confirmed the Water Resources Management Plan has been tested against different scenarios.
  - Confirmed governance meetings and communication with key internal and external stakeholders throughout the planning processes is in place.
  - Confirmed implementation of the Water Resources Management Plan options identification process (including incorporation of 3rd party options) and readiness for options appraisal.

- **Stage 3 – Water Resources Management Plan Processes – October 2017:**
  - Confirmed the rationale for Options Appraisal.
  - Evaluation of the options appraisal process; considering the associated costs and benefits; overall need for investment and economic, social and environmental justification for a preferred strategy.

The final stage of the process was also expanded to ensure that compliance to new Drinking Water Inspectorate long-term planning guidance could be evidenced. This ensures that drinking water quality and quantity are given parity during the development of the plan. We have considered the requirements of this guidance and have sought counsel from the Water Quality and Public Health teams within the Company to ensure that our plan is appropriate.

Further information on our governance and assurance activities, and evidence of meeting the relevant regulatory requirements may be found in our *Draft WRMP19 Technical Report - Assurance and governance*.

9.3 Engagement with our Company Board

We originally engaged with our Board early in the process prior to pre-consultation in September 2016. We have subsequently provided regular updates on plan development. In the final phase of plan development this engagement took place on a monthly basis. As well as presenting our proposed plans to the Board, to allow the Board to endorse the plan we have:

- Underpinned Board engagement with extensive governance processes for reviewing and approving the plan, which also integrates into our wider business planning. In particular, our main approvals group for the Water Resources Management Plan comprised Director level representatives, and subsequently fed into Executive level endorsement; and
- Completed an extensive assurance audit process of the Water Resources Management Plan development process, led by our Corporate Audit Team using an independent third party, CH2M (as outlined in Section 9.2 above).

In November 2017 the Board endorsed and subsequently assured that the draft Water Resources Management Plan represents the most cost effective and sustainable long term solution.

10 Conclusions

Key points

- **Our plan accounts for the delivery of the Thirlmere transfer project as defined in the previous Water Resources Management Plan 2015**
- **We have proposed a plan that represents the most cost effective and sustainable long-term solution for consultation. Our plan has been subject to extensive independent assurance and Board endorsement**
- **Our baseline position shows a supply-demand surplus, taking account of our demand management activities**
- **Beyond this, we have explored several key strategic choices to propose further leakage reductions and improved levels of service and resilience as part of our preferred plan**
- **Our preferred plan also proposes that we continue to work towards water trading, as part of a potential future pathway for water resources in the North West**
- **We are committed to sustainably providing high quality, safe, clean and reliable drinking water to customers and ensure our proposed plan helps to deliver this**
- **This draft Water Resources Management Plan has taken on board customer, stakeholder, and regulator feedback in its development. We publish this plan for consultation and will further refine to publish a revised draft plan in summer 2018**

10.1 Summary of our plans

We have carried out detailed analysis to determine the future dry year supply-demand balance and water supply resilience. These include delivery of sustainability improvements as part of the Water Industry National Environment Programme (WINEP), and take account of future climate change and population growth. Our assessments have taken account of the latest regulatory guidelines and incorporate current best practice, applying new and innovative planning methods. We have engaged the market to identify potential solutions from third parties to address any needs in our plan, in addition to options identified by ourselves.

Our baseline plan continues to promote water efficiency, and maintains the benefit of leakage reductions observed in recent years. As part of our plan we will continue to encourage customers to take up free water meters, using our ongoing customer engagement and research insights to allow effective communication and remove disincentives to meter uptake. Our forecasts show meter penetration reaching 76% by the end of the planning horizon. We will continue to target annual savings of 1 litre per property per day through the planning horizon as part of our water efficiency programme.

Accounting for this, our baseline supply-demand position in a dry year is one of surplus across all resource zones. However, we have explored wider strategic choices driven by wider water resources considerations, such as levels of service and the environment. We have also identified resilience needs to reduce risks to

water supply posed by hazards other than drought. We would therefore like to consult upon the following proposals:

- Further leakage reductions of 80 Ml/d over the planning horizon, a reduction of 15% below the baseline position, with 50 Ml/d reductions taking place between 2020-2030;
- Improvement of our level of service for drought permits/orders to augment supplies, from no more than once every 20 years (5% annual average risk) to once every 40 years (2.5% annual average risk) by 2025, enabled by the leakage reductions above;
- Five potential plans to address the most pressing water supply resilience risk, based upon the relative costs and benefits of these proposals. This will allow us to confirm our proposal for the final Water Resources Management Plan in line with our Business Plan submission;
- To continue to work towards a future water trade from our region, enabled by new or enhanced water sources and enhanced water efficiency. This plan will ensure that water quality, resilience and the environment in the North West are protected, whilst delivering bill reductions and performance improvements.

Our plans have been extensively stress-tested beyond the 25 year planning horizon to the 2080s, and have shown to be resilient to future change. We are committed to sustainably providing high quality, safe, clean and reliable drinking water to customers and ensure that our proposed plan helps to deliver this.

10.2 Next steps

This draft plan was submitted to Defra on the 1st December 2017 prior to publication. Water resources planning is a dynamic process, and we would like to consult upon our proposals in this draft Water Resources Management Plan to take account of feedback in developing our final plan. We expect public consultation to start in early 2018, upon being given permission to publish by Defra.

The plan may change as we carry out further activities over the coming months, as improved or more up-to-date information becomes available for use in preparing the final plan. In particular, this will be informed by revisions to our demand forecasts with the latest base data, and taking account of the conclusions of other company draft Water Resources Management Plans with regards to future water trading. We will also further develop our specific water supply resilience proposals.

We will continue to discuss and review the key elements of the plan through our constructive dialogue with the regulators and stakeholders, and take account of further customer engagement as part of our Business Planning processes. We expect to publish a revised draft Water Resources Management Plan in summer 2018, which would then subsequently become final pending approval by the Secretary of State. The final plan will then be reviewed annually, with the annual review published at:

http://www.unitedutilities.com/corporate/about-us/our-future-plans/water-resources/

Our next statutory Water Resources Management Plan is expected to be published in 2024.

Consultation question – developing our plan

- **We have used new and more sophisticated methods for this draft plan, which are summarised in Section 1.3.4. Do you have any views on the tools and techniques that we have used?**
- **Are there any areas of the plan or supporting technical reports that you think are unclear or warrant further explanation?**

Appendix A - List of technical reports

The following technical reports have been written to provide additional detail on the work underpinning this Water Resources Management Plan;

- *Draft WRMP19 Technical Report – Assurance and governance*
- *Draft WRMP19 Technical Report – Customer and stakeholder engagement*
- *Draft WRMP19 Technical Report – Demand for water*
- *Draft WRMP19 Technical Report – Options appraisal*
- *Draft WRMP19 Technical Report – Options identification*
- *Draft WRMP19 Technical Report – Supply forecasting*
- *Draft WRMP19 Technical Report – Target headroom*
- *Draft WRMP19 Technical Report – Water supply resilience*
- *Draft WRMP19 Technical Report – West Cumbria legacy*
- *Amec. (2017). Draft Water Resources Management Plan 2019: Habitats Regulations Assessment.*
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Appendix C - Glossary

Abstraction	The removal of water from any source, either permanently or temporarily.
Abstraction Licence	The authorisation granted by the Environment Agency to allow the removal of water from a source.
AMP	Asset Management Plan: AMP5 covers the period April 2010 to March 2015, AMP6 covers the period April 2015 to March 2020, etc.
AMR	Automated Meter Reading.
Aquator™	The name of a water resources computer modelling system used by United Utilities.
Aqueduct	An artificial channel for conveying raw or partially treated water.
Average Incremental Social Cost (AISC)	The ratio of present Social Costs over Present Net Value of additional water delivered or reduced demand.
Barepot	A small resource zone in the West Cumbria area serving non-potable water to commercial customers only.
Base Year	The first year of the planning period/horizon, forming the basis for the water demand and supply forecasting of subsequent years.
Baseline Demand Forecast	A demand forecast which reflects a company's current demand management policy, but which assumes the achievement of the current agreed target for leakage during the forecast duration, as well as the implementation of the current company water efficiency plans, irrespective of any surplus.
Bristol Water	The licensed water only company for Bristol.
Canal and River Trust	A charitable organisation playing a protective role for waterways in England and Wales.
Catchment	The area from which precipitation (rainfall) and groundwater would naturally collect and contribute to the flow of a river.
Carlisle Resource Zone	The resource zone covering the Carlisle area (see resource zone).
Co-imagine	Where water companies work with customers and/or stakeholders to imagine the future for water.
Co-create	Where water companies work alongside customers and/or stakeholders to create solutions.
Co-deliver	Where water companies work alongside customers and/or stakeholders to deliver these solutions.
Consumer Council for Water	The Consumer Council for Water (Northern), which represents the interests of water customers.
Countryside Council Wales	Countryside Council for Wales. To be replaced by Natural Resources Wales 1 April 2013.
Compensation flow / release	Stored water released from a reservoir to ensure a continuous flow in the downstream watercourse.
Competition / Competitive Markets	A concept introducing customer choice of supplier into a formerly regionally monopolised industry.
Critical Period	The length of time between a reservoir being full and the reservoir reaching minimum storage during the worst drought on record.
DCLG	Department for Communities and Local Government

Dee Valley Water	The licenced water only company serving Chester and Wrexham areas, now part of Severn Trent PLC.
Defra	Department for Environment, Food and Rural Affairs.
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 a bulk supply as constrained by: the environment; abstraction licences; water quality; existing water treatment and supply system capacities.
DETR	Department of the Environment, Transport and the Regions (which no longer exists and many of its functions are now completed by the new department Defra).
Distribution Input	The amount of water entering the distribution system at the point of treated water production.
Distribution Losses	Comprises water lost from trunk mains, service reservoirs, distribution mains and communication pipes. Distribution losses = distribution input less water taken.
DMA	District Meter Area – an area (of up to 3000 properties) where the supply to it is continuously monitored, and there is a defined and permanent boundary. DMAs were set-up for leak detection prioritisation. Guidance states that DMA's should typically have, under normal operation, a single supply inlet.
DMZ	Demand Monitoring Zone. There are currently 33 DMZs in our region, which are areas used to monitor demand and losses. All supply inputs and outputs are metered around the boundary of a DMZ. A DMZ is built up of a number of smaller units; however, these are predominantly for water quality and leakage detection purposes.
Dead Water	The part of a reservoir's total storage volume that is not usable for water supply purposes. Often the dead storage of a reservoir is required to store sediment accumulation during the life of the reservoir. In some cases, a portion of the dead storage may be recoverable through engineering works.
Dry Year	In water resources modelling, a period of low rainfall from which future demand is forecast. For this plan we have used 2016.
Dry Year Annual Average Daily Demand	The level of demand, which is just equal to the maximum annual average, which can be met without the introduction of demand restrictions at any time during the year. This should be based on a continuation of current policies regarding demand management. The dry year demand should be expressed as the total demand in the year divided by the number of days in the year.
Droughts (severe, extreme)	A prolonged dry period potentially leading to scarcity of water. Severe and extreme droughts are defined by Defra return periods of 1:200 years and 1:500/1000 respectively.
Drought Order	The Water Resources Act 1991 gives the Secretary of State or the National Assembly for Wales the power to grant ordinary and emergency drought orders to water undertakers or the EA. Ordinary drought orders can include the same powers to abstract water as drought permits, but they can also authorise water undertakers to take other actions. In this plan the term 'drought permit/order' is used to differentiate these from drought orders for non-essential use. An emergency drought order gives water companies complete discretion on the uses of water that may be prohibited or limited, and they can authorise supply of water by standpipes or water tanks, or impose rota cuts.
Drought Permit	Schedule 22 of the Environment Act 1995 amended the Water Resources Act 1991 to give the EA the power to grant drought permits. Drought permits can only authorise a water

	undertaker to 'take water' from specified sources or modify or suspend restrictions or obligations relating to a water undertaker's existing powers to 'take water' from a source. In this plan the term 'drought permit/order' is used to differentiate these from drought orders for non-essential use.
Drought Plan	A statutory document written every 5 years, detailing company strategy to maintaining water supplies during periods of drought.
Dŵr Cymru Welsh Water	The licensed water and sewerage company for wales.
Emergency Storage	A reserve water storage capacity aimed at accommodating the operational uncertainty for the duration of a particular drought. The value of the reserve store should be agreed with the regulators and should be reflected in the level of risk a water company is taking across the planning period.
Environment Agency (EA)	One of our regulators. The Environment Agency (EA) is a non-departmental public body, established in 1995 and sponsored by the United Kingdom Government's Department for Environment, Food and Rural Affairs (Defra), with responsibilities relating to the protection and enhancement of the environment in England (and until 2013 also Wales).
EBSD	*Economics of Balancing Supply and Demand* – a key methodology document published by UKWIR in 2002.
ELL	Economic level of leakage, which is being superseded by the concept of 'sustainable economic level of leakage' (SELL).
Final Planning Demand Forecast	A demand forecast that reflects a company's preferred policy for managing demand and resources through the planning period, after taking account of all options through economic analysis.
Freeze-thaw	Freeze-thaw events relate to peak demands caused by rapidly increasing leakage levels. These normally occur during the winter months, when changes in temperature can cause the ground to freeze and then thaw relatively quickly. This can result in pipes or mains cracking or bursting.
Habitats Directive	The European Union Habitats Directive (92/43/EC) is the instrument through which Member States must identify and protect as 'Special Areas of Conservation' (SAC) certain sites that are representative of specified habitats for specific species which are of European importance. It also covers 'Special Protection Areas' (SPA) but none are identified as being affected by United Utilities abstractions
Habitats Regulation Assessment (HRA)	Habitats Regulations Assessment is a process for identifying the implications of the drought plan options for European designated sites (SAC, SPA, and Ramsar). If likely significant adverse impacts are predicted, then a detailed Appropriate Assessment of the option is required
Hands-off flow	A hands-off flow (also known as a prescribed flow) is normally associated with a river abstraction and is the flow above which abstraction can occur. The purpose of a hands-off flow is to ensure a given flow of water continues in the river prior to abstraction.
Headroom	Available headroom is the difference (in Ml/d or %) between WAFU (including imported water) and demand at any given point in time. See also Target Headroom.
Hosepipe Ban / Temporary Use Bans	Section 36 of The Flood and Water Management Act 2010 replaced the original Section 76 of the Water Industry Act 1991. The original legislation only allowed water undertakers to prohibit or restrict the use of hosepipes (or similar apparatus) for the purposes of watering private gardens and the washing of private motor cars, commonly known as a hosepipe ban. The new legislation gives water companies further powers to restrict water use by customers. Therefore this plan refers to 'water use restrictions' rather than hosepipe bans.
Household	A property used as a single domestic dwelling as defined by Ofwat.

Impounding Reservoir	A man made store of water featuring a dam wall, often the result of damming a river or stream.
Initial Supply-Demand Balance	The difference between WAFU and baseline demand forecast (including target headroom) before any additional demand management measures or source enhancements.
Inset Appointee	The inset appointment process is the route by which one company replaces the incumbent (i.e. United Utilities for the North West) as the appointed water and/or sewerage company for a specified area. As such the replacement appointed water company will have all of the same duties and responsibilities as the previous statutory water company for the specified area. UNITED UTILITIES's only inset appointment is for Peel Water Networks Ltd. who supply water to Media City, Salford. Peel are not a licensed supplier as they do not hold a Water Supply Licence
Integrated Resource Zone	A term used in our Water Resources Management Plan 2015 to describe our largest resource zone covering most of North-West England. For this plan we now refer to the Strategic Resource Zone.
Integrated Asset Planning (IAP)	An internal process used to identify future investment needs at our treatment works and network assets.
l/hd/d	Litres per person per day
l/prop/d	Litres per property per day
LeakLine	A free telephone number for the public to report leaks to United Utilities.
Level of Service	Reliability of water supply to customers expressed as the frequency of the imposition of water use restrictions.
Met Office	The United Kingdom's national weather service.
MISER	A water network management advisory tool for operational resource planning, widely used in the UK water industry
Ml/d	Megalitres per day (million litres per day).
Natural England (NE)	A non-departmental public body in the United Kingdom sponsored by the Department for Environment, Food and Rural Affairs. It is responsible for ensuring that England's natural environment, including its land, flora and fauna, freshwater and marine environments, geology and soils, are protected and improved.
Net Present Value (NPV)	Net Present Value of a schedule of costs for a programme. NPV is a very widely used method to combine various costs occurring over a period of time into a single value for comparison with the NPV of an alternative programme.
Non-essential Use Ban	Also known as a prescribed uses order. The Drought Direction 2011 sets out the 'non-essential' uses of water that can be prohibited or limited by an ordinary drought order. It is more restrictive than Section 76 of the Water Industry Act 1991 (as replaced by Section 36 of The Flood and Water Management Act 2010) and can impact particularly on car washing businesses, building cleaning businesses and those businesses with private swimming pools.
Non-household	Properties receiving potable supplies but which are not occupied as domestic premises, i.e. factories, offices, commercial properties, and cattle troughs. They also include properties containing multiple households, which receive a single bill (e.g. block of flats).
Normal Year Annual Daily Demand	The total demand in a year with normal or average weather patterns, divided by the number of days in the year.
North Eden Resource Zone	The water resource zone covering the North Eden area, comprised mainly of borehole sources.

Northumbrian Water	The licensed water and sewerage company for Northumbria.
NRA	National Rivers Authority, which was replaced by the Environment Agency (EA) in 1996.
ODPM	Office of the Deputy Prime Minister.
Ofwat	The public name of the Water Services Regulatory Authority, previously called Office of Water Services (the economic regulator of the water industry in England and Wales).
ONS	Office for National Statistics.
Outage	A temporary loss of deployable output due to planned or unplanned events. An outage is temporary in the sense that it is retrievable, and therefore deployable output can be recovered.
PCC	Per capita consumption (in litres per person per day)
Peak Demand	In water resource modelling, the time at which demand for water is at its highest.
Peel Water Networks Limited	A water supply and wastewater drainage service provider owned by The Peel Group.
Price Control	A method of separating out the regulation of prices charged by water companies.
Price Review or Periodic Review	A review (normally every 5 years) conducted by Ofwat of water tariffs, price limits, water company investment plans and service levels to customers.
PR14	Price review at 2014 to determine water prices, water company investment plans and service levels for the period 2015-20.
PR19	Price review at 2019 to determine water prices, water company investment plans and service levels for the period 2020-25
Point of Production	The point where treated water enters the distribution system. Defined as raw water into treatment less treatment works operational use and treatment works losses.
Potable /Non-Potable	Drinking water / non drinking water
Ramsar	Ramsar sites are wetlands of international importance designated under the Ramsar Convention. More formally known as 'The Convention on Wetlands of International Importance especially as Waterfowl Habitat' it is an intergovernmental treaty signed in Ramsar, Iran, in 1971.
Raw Water	Water direct from the source, which has yet to be treated.
Rateable Value	A value ascribed to a domestic or commercial building based on its size, location, and other factors, used to determine the rates payable by its owner.
Reservoir	An impoundment with natural or pumped inflows
Resource Zone	The largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which all customers should experience the same risk of supply failure from a resource shortfall.
Review of Consents	The EA process by which abstraction licences (and other consents such as discharge consents) that have the potential to adversely affect SAC and SPA sites are being reviewed by the EA to determine if they need to be altered. This process will result in changes such as increases to compensation or prescribed flow requirements and reductions to the volume of water that can be abstracted.
RDM (Robust Decision Making)	A planning framework that helps in making decisions when dealing with a very uncertain future, sometimes referred to as 'deep' uncertainty, where the probabilities of future events are unknown or cannot be agreed upon. Solutions from RDM are considered to be robust as they perform well over a wide range of future conditions, rather than optimally in a few.

SAC	Special Area of Conservation designated under the EU Habitats Directive
SEA	Strategic environmental assessment – see Section 8.5.
SELL	Sustainable economic level of leakage, a concept introduced by Ofwat in 2007.
SELWE	Sustainable economic level of water efficiency, a concept introduced by Ofwat in 2010.
Secretary of State	The Secretary of State for Defra (Department for Environment, Food and Rural Affairs).
Service Reservoir	A holding tank for treated water prior to distribution into the network.
Severn Trent Water	The licenced water and sewerage company serving the majority of the midlands (England).
South Staffordshire Water	The licensed water only company serving parts of Staffordshire and the west-midlands.
Sustainability Reductions	Reductions in deployable output required by the Environment Agency to meet statutory and/or environmental requirements
SPA	Special Protection Area, as designated under the EU Directive on the conservation of wild birds (also known as the Birds Directive). Together with SAC's these form the Natura 2000 network of protected sites
SSSI	Site of Special Scientific Interest
Statutory Water Use Restrictions	Statutory Water Use Restrictions would be implemented approximately 28 days following the introduction of Voluntary Water Use Restrictions. The Statutory Water Use Restrictions are as set out in Section 76 of the Water Industry Act 1991 (as replaced by Section 36 of The Flood and Water Management Act 2010)
Stochastic	A process incorporating an element of randomness, the evolution of which can only be predicted within a range of values of the uncertain variables
Strategic Resource Zone	The largest water resource zone, covering the majority of the North-West of England. Formerly the Integrated Resource Zone, but including West Cumbria also.
Supply-demand balance	The difference between total water available for use (as supply) and forecast distribution input (as water demand) at any given point in time over the Water Resources Management Plan's planning period/horizon.
Supply Pipe Losses	Losses that occur from pipes which are the responsibility of the customer.
Sustainability Reduction	Reduction in deployable output of a water source, or group of water sources, due to change in abstraction licence conditions imposed by the Environment Agency to ensure more environmentally sustainable water abstraction.
Target Headroom	Target headroom is the threshold of minimum acceptable headroom, which would trigger the need for total water management options to increase WAFU or decrease demand.
Telemetry	Telemetry is an automated communications process by which measurements and other data are collected at remote or inaccessible points and transmitted to receiving equipment for monitoring.
Thirlmere transfer scheme	A large scale capital project to enable transfers of water from West Cumbria into Thirlmere reservoir. This was defined in our previous Water Resources Management Plan. It is expected to be implemented by March 2022 at the latest.
Total Leakage	The sum of distribution losses and customer supply pipe losses.
Total Water Management	All water management activities from source to end use (i.e. resource management, production management, distribution management and customer-side management)
Tripartite Report	The short name often given to the Ofwat, EA and Defra (2002) report: *Future Approaches to Leakage Target Setting for Water Companies in England and Wales*

UKCIP	United Kingdom Climate Impacts Programme.
UKCP	United Kingdom Climate Projections
UKWIR	United Kingdom Water Industry Research Limited.
United Utilities	United Utilities Water Limited, the licensed water and sewerage company for North West England.
Wastewater	The commercial and domestic sewage that is collected and treated by United Utilities.
Waterbody	A body of fresh or salt water e.g. a lake or a river
Water Resources North group	A multi-company forum for discussing water resources activities in the north of England.
Water Available For Use (WAFU)	The value of Ml/d calculated by the deduction from deployable output of allowable outages and planning allowances in a resource zone.
Water Framework Directive	The European Union Water Framework Directive (2000/60/EC) establishes a strategic 'river basin planning' approach to managing the water environment, including achievement of good ecological status in water bodies by 2015. It provides a consistent approach for ensuring compliance with standards and objectives set for protected areas, and implementation of programmes of measures to meet those objectives.
Water Network Plus	An internal term to describe the business area responsible for water treatment and treated water distribution.
Water Resource Zone	See Resource Zone.
Water Taken Unbilled	Water supplied to customers for legitimate purposes which is unbilled and water taken illegally.
Water Trading	The concept of transferring water between the incumbent areas of water companies.
Water UK	An organisation which represents and works with the major water and wastewater service providers in England, Scotland, Wales and Northern Ireland.
West Cumbria Resource Zone	A term used in our Water Resources Management Plan 2015 to describe the water resource zone covering West Cumbria. For this plan West Cumbria is now part of the Strategic Resource Zone.
WINEP	Water Industry National Environment Programme.
WRc	Water Research Centre
Yield	A general term for the reliable supply of water from a source. More specific, defined terms are used in this document – see Water Available For Use and Deployable Output.

United Utilities
helping life flow smoothly

About us

United Utilities is the North West's water company. We keep the taps flowing and toilets flushing for seven million customers every day. From Crewe to Carlisle, we work hard behind the scenes to help your life flow smoothly.

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