TA.11.WN01 Supply Demand Balance
Business Case

September 2018
Version 1.0

Southern Water

Contents

1. Executive Summary

Name of Technical Annex	WN01 Supply-Demand Balance		
Context	We are committed to ensuring a resilient water future for the South East. We are facing the combined challenges of growth, climate change and the need to reduce the environmental impact of our abstractions. The total amount of water we put into supply in 2017-18 was 541 Ml/d of which 185 Ml/d was supplied in the Western area. Between now and 2030 the water available for our customers in a drought could reduce by 294 Ml/d; which equates to 54% of our total supply in 2017-18. 188 Ml/d (64%) of this reduction will be in Hampshire (Western area). The reductions have already been implemented but we will be able to use Drought Orders/Drought Permits – which temporarily relax licence conditions – until 2030 by which time we will have developed the options to meet the deficit.		
Scope of this Technical Annex	Investment required over AMP7 to maintain the supply-demand balance throughout Southern Water's supply area.		
Customer and stakeholder views	Our customers and stakeholders expect us to provide clean, safe, high quality water, whilst helping to protect the environment. We have extensively consulted with our customers and solicited their views on levels of service and options for maintaining water supplies. Customers ranked their preferences as follows: Underground water storage (aquifer recharge) Catchment management Helping people to use water more wisely (water efficiency) Reducing leaks Water saving devices Surface water reservoirs Water re-use Water trading Tariffs (financial incentives) Desalination (use of sea water) We have taken account of customer preferences in selecting our options for maintaining supply-demand balance in AMP7 and beyond. Due to the scale of the reductions, we have had to include solutions from all the above categories. We undertook a further customer and stakeholder consultation after the publication of our draft Water Resources Management Plan and have incorporated feedback into our plans.		
Our aim	Our customers have told us that they do not want any reduction in the resilience of their water supplies. We therefore aim to ensure that our customers do not experience severe restrictions in a drought event unless the severity of the drought exceeds that of a 1-in-200yr drought event. We may need to implement Drought Orders/Drought Permits up to 2030 while we develop permanent solutions.		
	Botex	Enhancement	Total
Totex (£m)	-	459.2	459.2

Opex (£m)	-	46.6	46.6
Capex (£m)	-	412.5	412.5
Residual, post-AMP7 capex (£m)	-	672.8	672.8
20 year whole life totex	-	-	-
20 year cost benefit (£m)[1]			
Materiality (% of the overall plan)			WR 13.7% WN+ 37.1%
Relevant business plan table lines	-	WS2 lines 7, 8, 10, 11, 12, 49	WS2 lines 7, 8, 10, 11, 12, 49
Enhancement			
Need for enhancement / investment	We need to develop water supplies across our region in order to meet our future supply-demand deficit. Under a severe drought scenario we may lose 54% of the total water that we supplied in 2017-18. In the Western area, this equates to 64% of the 2017-18 total supply. Our customer base is forecast to grow by 20% during 2020-45 which has a significant impact on the amount of water that we would need to provide. Climate change may also lead to additional demand for water. However, sustainability reductions have by far the biggest impact on our supply-demand balance. In addition to the reductions we have already agreed with the Environment Agency, there may be further reductions in the future, especially in the Central area. We have accounted for these potential reductions in our plan.		
Overview of AMP7 proposals	We have a triple track approach to maintaining the supply-demand balance as follows: Demand side solutions: Reduce demand by 38 Ml/d by 2025 as part of our industry leading transformational programme Target 100 which will reduce average per capita consumption in our supply area to 100 litres/head/day by 2040 (See Section 5.2) Reduce leakage by 15.1% over AMP7 and by 50% by 2050 (see TA.11.WN04 Water Networks). Supply side solutions: Increased internal transfers to mover water from areas of surplus to areas of deficit Inter-company transfers (up to 52 Ml/d); including collaborative working with Portsmouth Water on Havant Thicket surface water reservoir Water re-use (47 Ml/d) Desalination (85 Ml/d). Catchment solutions:		

[1] Our whole life costs and cost benefit figures have been calculated by extracting a 20 year portion of costs/benefits from a 60 year model. Further details are included in the Optioneering technical annex

	To improve the resilience of our catchments to water quality risks and low flows to protect the environment and ensure we can maintain our abstractions (see TA.11.WR03 Catchment Management Solutions).
Why the proposals are the best option for customers	We have developed a 'best value' plan for our customers using a 'no regrets' approach through an extensive options appraisal process as opposed to a purely 'least-cost' plan. A list of nearly 600 scheme options were generated through consultation with customers and industry experts across a number of categories (unconstrained list). These options were subjected to two rounds of multi-criteria assessment which first produced the constrained options list and finally the feasible options list. The number of options in each category are shown below.

Option category	Number of unconstrained options	Number of constrained options	Number of feasible options
Demand management	48	29	19
Water reuse	63	56	32
New supplies	217	128	65
Catchment management	71	66	37
Asset Enhancement	190	117	38
Total	589	396	191

Our plan has been developed such that it is adaptable to a range of supply-demand scenarios taking into account uncertainties related to sustainability reductions, growth, climate change and customer behaviour.

Customer and stakeholder support	Customer and stakeholder input and support has been sought throughout the water resources planning process and is evidenced through the engagement and consultation processes.
Need for a CAC (if relevant)	N/A
Extent of management control (if relevant)	Growth and climate change impacts are outside of management control. We have been working closely with the Environment Agency on sustainability and have agreed significant reductions to the amount of water we can abstract in the Western area. Similar reductions may be agreed in the Central area.

Robustness and efficiency	<table><tr><th>Option category</th><th>Enhancement (Ml/d)</th><th>Cost per Ml (£m)</th></tr><tr><td>Demand management</td><td>50.2</td><td>1.75</td></tr><tr><td>Water reuse</td><td>46.5</td><td>2.11</td></tr><tr><td>New supplies</td><td>110.0</td><td>4.50</td></tr><tr><td>Asset Enhancement</td><td>25.0</td><td>2.52</td></tr><tr><td>Total</td><td>231.7</td><td>3.21</td></tr></table>
Customer protection (if relevant)	We need to deliver the WRMP as part of our statutory duty to maintain supply-demand balance. We predict needing to invest £1.1bn in supply-demand by 2030 to ensure we are able to maintain our current level of service to our customers. Any under or over spend in AMP7 will be reconciled through AMP8.
Affordability considerations	The investment that is proposed in this technical annex will increase average customer bills by 4% over the course of AMP7.
Board assurance (if relevant)	This enhancement technical annex has been externally reviewed by Jacobs, with no material exceptions identified. The water resources management plan that underpins this technical annex has also been reviewed by Jacobs.

Performance Commitments supported by this technical annex		
PC	How relevant is this technical annex?	Comment
Drought resilience	High	Investment in this area provides new resources to address the future supply-demand deficit.
Water supply interruptions	Medium	Provision of new resources will reduce the risk of supply interruptions during drought events

Schemes and scheme-level options				
Schemes over £10m	Options			
	Description	AMP7 cost	Total cost	Selected option and rationale
Metering	This option will increase domestic meter penetration to 92% in the Central area.	£13.2m	£14.3m	This option is part of our Target 100 transformational programme to promote water efficiency and increase resilience in the Central area.
[redacted]	[redacted]	£4.9m	£24.4m	This scheme is part of our portfolio of

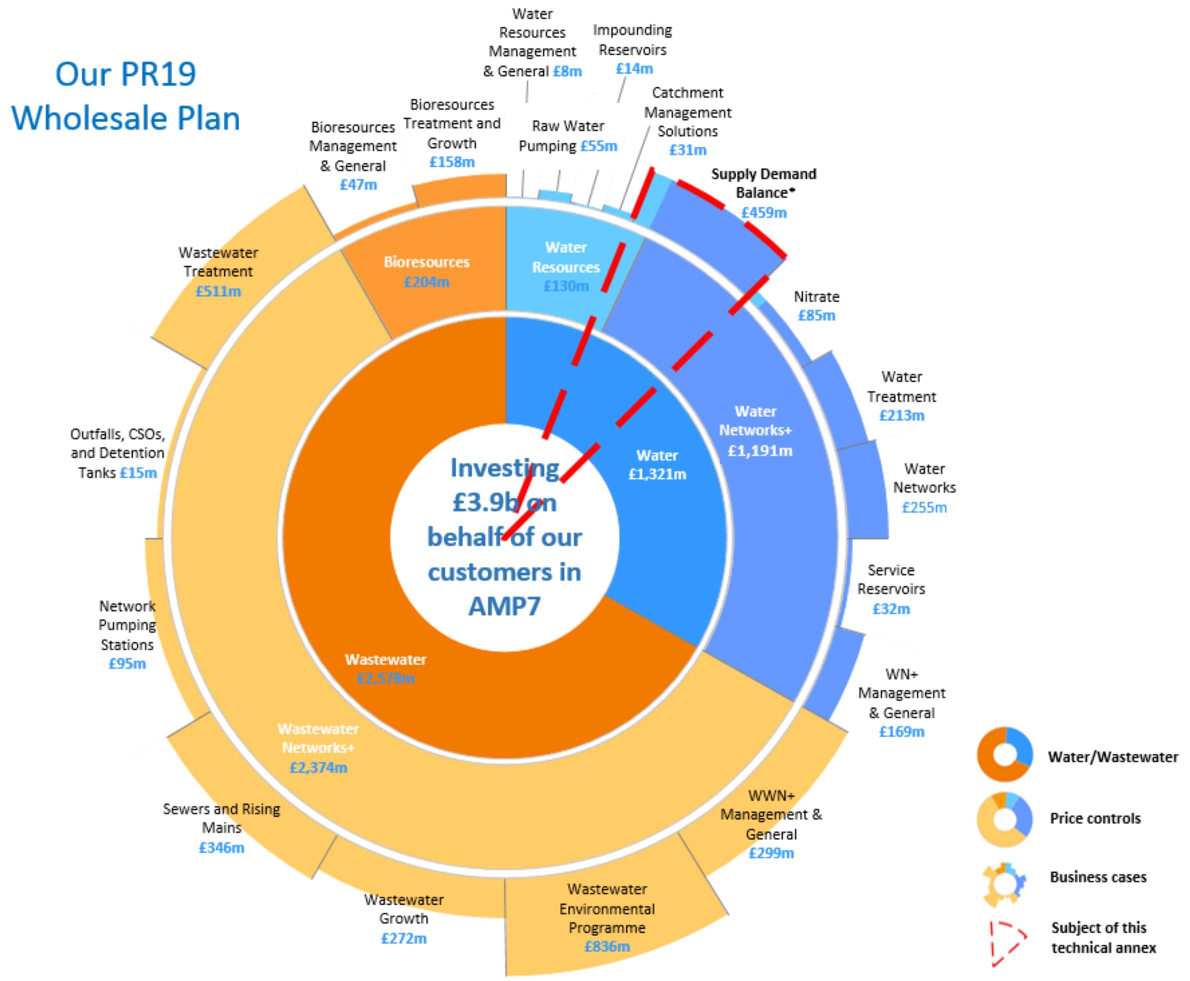
	[redacted]			schemes required to make up for loss of supplies in the Western area due to sustainability reductions.
[redacted]	[redacted]	£9.6m	£48.1m	This scheme is required to increase drought resilience in the Central area.
[redacted]	[redacted]	£5.1m	£25.7m	This scheme is proposed to maintain supply-demand balance in the Eastern area.
[redacted]	[redacted]	£70.7m	£78.4m	This scheme is selected to improve resilience in the Western area by enabling transfers from areas of supply-demand surplus to areas of deficit.
[redacted]	[redacted]	£5.0m	£75.5m	This scheme is part of the portfolio of schemes required to make up for loss of water supplies due to sustainability

				reductions in the Western area.
[redacted]	[redacted]	£35.2m	£37.5m	This scheme is part of the portfolio of schemes required to make up for loss of water supplies due to sustainability reductions in the Western area.
[redacted]	[redacted]	£3.4m	£3.4m	The scheme is selected to improve resilience in the Eastern area.
[redacted]	[redacted]	£1.8m	£12.4m	This scheme is required to maintain supply-demand balance and increase resilience in the Central area.
[redacted]	[redacted]	£2.4m	£11.8m	This scheme aims to improve drought resilience in the Central area.
[redacted]	[redacted]	£89.4m	£255.0m	This option is part of portfolio of schemes required to make for the loss of water supplies due to sustainability

	[redacted]			reductions in the Western area.
[redacted]	[redacted]	£8.7m	£43.8m	This option is required to maintain supply-demand balance and improve resilience in the Central area.

2. Scope of Technical Annex

Our PR19 business plan is valued at £3.9 billion. This technical annex describes £459 million investment to maintain supply-demand balance for our water supplies, funded from the Water Networks+ and Water Resources price controls as shown below (Figure 1).



*Total funding for **Supply Demand Balance** is £459.2m split between the Water Networks+ (£441.3m) and Water Resources (£17.9m) price controls

Figure 1 – The areas of spend in our business plan and the proposed investment in each area

Table 1 – AMP7 Price Controls

TOTEX (£m)	459.167
Water Resources	17.851
Water Networks +	441.316

This document identifies and assigns the investment needed to maintain a supply-demand balance throughout our supply area during AMP7. It reflects those schemes in our current Water Resources Management Plan (WRMP) identified for the next five years, as well as programming the investment required during AMP7 for schemes that will come into effect from AMP8 onwards.

Taken together, the proposals represent the first AMP of our 50-year strategy to ensure water supplies are available to meet every demand scenario in each of our water resource zones (WRZ).

This document reflects our Business Plan commitments to cut leakage by 15.1% over AMP7 and to roll out '**Target 100**', our industry-leading transformational programme to support our customers' efforts in reducing their consumption to 100 litres per person per day by 2040. Further details about **Target 100** are included in Section 5.2.

This document sets out how we will maintain supply without the use of Drought Orders and/or Drought Permits, except where there is drought more severe than a 1-in-200 event. A 1-in-10 year event will trigger Temporary Use Bans, while a 1-in-20 year event will require the use of non-essential use bans. We have also tested our plan against a 1-in-500 year drought by allowing the benefits of Drought Orders and Drought Permits to be included in our assessments of the supply-demand balance, both now and in the future.

If forecast demand in any WRZ exceeds available supply, we are ready to bring forwards remedial options. An economic least-cost model (the 'investment model') is used to select the option(s) best placed to maintain a supply-demand balance at least whole life cost. We have also used other criteria, including customer preferences, environmental assessments and regional planning initiatives in selecting our options.

Our water supply area consists of three sub-areas (Western, Central and Eastern) and fourteen WRZs (Figure 2). We have developed a separate strategy for each of the three sub-areas. Annex 8 in our revised draft WRMP covers our water resources strategy in detail.

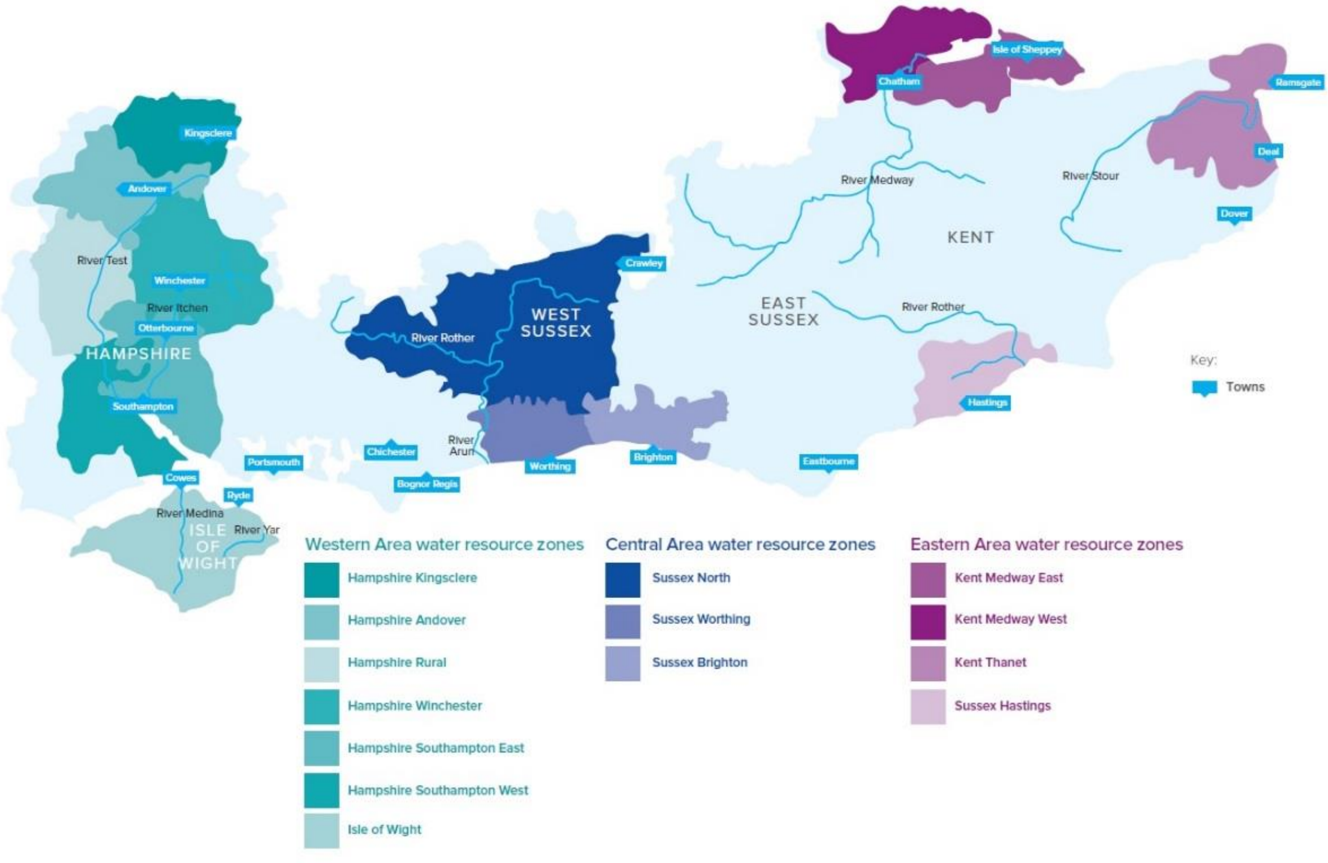


Figure 2 – Our supply area showing the three main sub areas and the associated water resource zones.

Some key elements of our strategy are covered in technical appendices. These are:

- TA.11.WN04 Water Networks – for reducing our leakage by 15.1% over AMP7.
- TA.11.WR03 Catchment Management Solutions – for our new environment friendly and cost-effective long term strategy for protecting water resources.

3. AMP6 Strategy

Our AMP6 strategy, confronts the three central challenges of the South East:

1. How to reduce the environmental impact of our abstractions
2. How to support strong economic and population growth
3. How to address climate change impacts

The Environment Agency classifies our supply area as being under 'Serious Stress'[2] meaning there are limited options to increase supply in response to growing demand. We have worked with the Environment Agency to agree changes to our abstraction licences in the Western area. The implementation of the agreed sustainability reductions in abstractions from the river Itchen and river Test in Hampshire will push the Western area into supply-demand deficit for the first time. Before the introduction of the sustainability reductions, the total Deployable Output[3] in the Western area was 334 Ml/d. As result of the notified changes to our licences, this will drop by ca. 170 Ml/d (51%) during a severe drought. To put this reduction into context, the total volume of water we put into supply in the Western area during 2017-18 was ca. 185 Ml/d.

Growth is the second key factor driving possible deficits. AMP6 growth is forecast to be higher than AMP5, with AMP7 growth likely to be significantly higher still (see Section 5.1). Because of this, we have long recognised the importance of reducing demand. In AMP5 we significantly reduced demand among our domestic customers by increasing meter penetration from 41% to 87%.

The increase in frequency of extreme droughts and flood events resulting from climate change is the third key factor influencing both supply and demand. These distinct weather patterns reduce the reliance we can place on historical rainfall data to predict future droughts. We therefore developed a weather generator model based on research by Newcastle University[4] to stochastically model a 2,000-year time series of daily rainfall data. This allowed us to identify more severe (e.g. 1-in-200 year) drought events, with greater confidence than using historic data alone. We used this in our water resources models to assess the volume of water we can abstract (i.e. the Deployable Output of our sources) under more severe conditions than we have experienced in the past.

Our supply-side options for maintaining supply-demand balance over the 2010-35 and 2015-40 planning periods include innovative solutions such as Aquifer Storage and Recovery (ASR) and water reuse. These have lower environmental impacts than new reservoirs and abstractions, but will not be sufficient to meet forecast demands over the 25-50 year time horizon.

3.1. Investment Strategy

Our Universal Metering Programme (UMP) was the key element of our supply-demand strategy. Over 450,000 domestic meters were installed as part of the programme at a cost of £124m,

[2] Environment Agency, 2013. Water stressed areas – final classification. Cat code: LIT 3230.
[3] Deployable Output is the output of a commissioned source or group of sources or of bulk supply subject to one or more constraints, such as environment, licence, hydrological/hydrogeological conditions, infrastructure and water quality.
[4] Serenaldi, F. and Kilsby, C.G., 2012. A modular class of multisite monthly rainfall generators for water resources management and impact studies. Journal of Hydrology 464-465, p. 528-540.

accompanied by a sustained media campaign to inform and educate our customers about the importance of reducing water consumption. Ahead of the UMP, we estimated that 60% of our customers would pay less via metered billing, with 40% likely to pay more. We also offered customers identified as vulnerable home audits and tips to keep their bills down.

As a result of this programme, total household consumption in 2017-18 (274 Ml/d)[5] was lower than in 2009-10 (322 Ml/d) despite an 11% increase in household population over the same period. Average PCC in our supply area fell from 145 litres per person per day to 129 litres per person per day (Figure 3), or more than 11% - and is now among the lowest in the industry. A study by Southampton University[6] estimated that customers who switched to metering reduced their consumption by 16.5% on average.

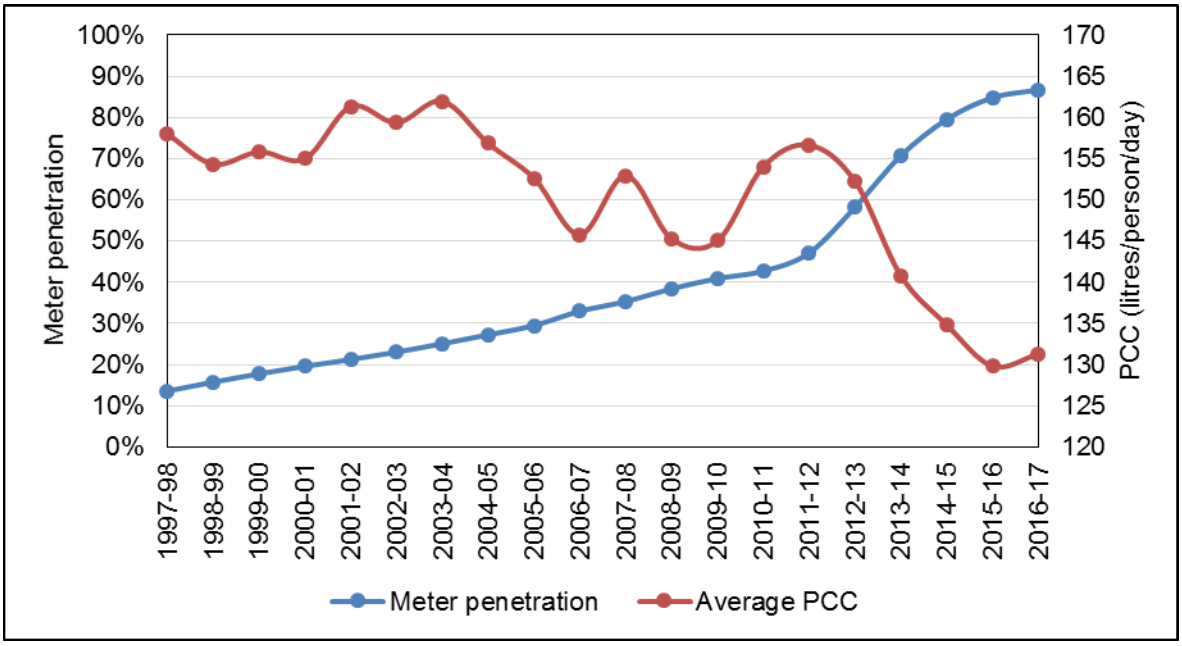


Figure 3 - The change in average PCC and domestic meter penetration over the last 20 years.

We continue to promote water efficiency. Some of our key initiatives in this regard are as follows:

- Planning 28,000 home visits where we will provide our customers with advice on saving water and installing water-saving devices such as low-flow shower heads and tap inserts. Over 13,000 such visits have already been carried out.
- Offering discounted water butts for garden watering and other outdoor activities.
- Planning 234 school visits to fit water saving devices and educate pupils – our future customers – to value water as a scarce source. 156 such trips have already been carried out
- Offering water saving help and advice to 120 small businesses.
- Incentivising communities to reduce their consumption and working with Local Authorities to promote water efficiency among social housing residents. We have offered up to £50,000 for community projects in selected villages around the rive Itchen in Hampshire if they can reduce consumption by 25%. We are also working with Brighton and Hove City Council to

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[5] PR19 Data Table WN02 Line 23

[6] Ornaghi, C. and Tonin, M. 2015. The effects of metering on water consumption – policy note. University of Southampton. Project supported by ESRC grant ES/K01210X/1.

visit 1,000 social housing homes, helping some of our most vulnerable customers save on their water bills.

- Working with developers building 15,000 homes in Ebbsfleet (Kent) and 1,500 homes at Fawley (Hampshire) to build more sustainable homes.

Our leakage performance is industry leading and we will deliver a 2 Ml/d further reduction over AMP6.

Our AMP6 supply schemes are primarily aimed at finding innovative ways of managing existing resources and improving yield and resilience while still operating within our existing licence conditions. These include reconfiguration of our existing well field at Hardham in Sussex (Central area) to allow us to recover over 4 Ml/d of yield lost due to deteriorating well conditions. We have implemented a licence variation on our abstraction from the river Medway in Kent (Eastern area). The variation allows us to abstract more water from the river during the winter months, when flows are high, to fill the [redacted] and reduce abstraction during the summer months to support wildlife. This change allows us to abstract nearly 7 Ml/d more than otherwise, without exceeding the licence limit or causing a detrimental environmental impact.

We are installing nitrate removal plants in Sussex and Kent and investing £8m in catchment management schemes to protect our sources through more sustainable farming and land management practices instead of purely engineering remedies. We currently have catchment management schemes in Brighton and Worthing in Sussex (Central area) and Medway in Kent (Eastern area) to protect our supplies from the use of fertilisers and pesticides. Our catchment management activities are covered in Technical Annex TA.11.WR03 Business Case - Catchment Management Solutions.

With water scarcity affecting the whole of the South East of England, we are working with other regional companies to find solutions. As part of resource sharing, we supply up to 6 Ml/d to South East Water and have built a pipeline to receive up to 15 Ml/d from Portsmouth Water.

Our total planned AMP6 spend is £84m as shown in Table 2.

Table 2 - AMP6 spend profile

	AMP6 Actual (£m)					
	2015/16	2016/17	2017/18	2018/19	2019/20	AMP6 Total
TOTEX	10.215	14.661	19.518	21.332	18.728	84.454
CAPEX	**10.215**	**14.661**	**19.518**	**21.332**	**18.728**	**84.454**
WRMP Future AMPs Planning	0.162	1.447	1.615	1.644	0.861	5.729
Aggregated WRMP schemes (WN+)	1.464	5.132	5.792	10.068	7.704	30.160
Requisitions	8.396	7.585	11.801	9.619	10.164	47.565
Infra Network Capacity and Growth Resilience	0.193	0.498	0.311	0	0	1.001
OPEX	**0**	**0**	**0**	**0**	**0**	**0**

3.2. Customer Benefits and Resilience

The focus of our water resources strategy during AMP6 has been to maintain our levels of service while protecting the environment. We have done that through a robust re-evaluation of our Deployable Output under more serious droughts than we have experienced in the past and promoting water efficiency, of which the Universal Metering Programme (UMP) was a major part. The result is that domestic consumption in 2017-18 was slightly lower than in 2009-10, before the start of the programme despite an 11% increase in domestic population during this time.

Through our demand management initiatives including leakage reduction, we have been able to commit to not introducing restrictions on activities such as garden water during AMP6 unless we experience two consecutive dry winters[7].

[7] A dry winter for this purpose is defined as a winter during which the total rainfall is less than 85% of the long term average.

4. Drivers for Change

4.1. Customer and Stakeholder Insight

We used insight from our extensive programme of customer and stakeholder engagement to develop a deep understanding of the views and priorities of our customers. This is covered in detail in **Chapter 4 Customer and Stakeholder engagement** of our business plan. Our key findings are as follows.

Customers believe water resilience is a medium priority

Our customers view water as a precious, natural resource that should be looked after and used wisely. They are concerned about their water supply being at risk due to growing population, increasing demand and diminishing resources. They are also concerned about the impact of climate change on their water and wastewater services.

They expect us to ensure that future generations have access to the same level of water services as we do today, and are themselves willing to invest now to ensure that there is no deterioration in services in the future. Our customers prefer approaches that have lower carbon impact and lower environmental impact.

Stakeholders believe water resilience is a high priority

Government and stakeholders want to see long-term strategic water resources plans in place to deliver greater resilience. Stakeholders see us as playing a vital role in delivering necessary improvements, both in terms of lobbying the government and by pioneering new projects.

However, some stakeholders believe that a great deal of the measures required to improve resilience are outside of the scope of our remit, and should instead rest on the shoulders of government and the wider water industry. Nonetheless, stakeholders see us as playing a vital role in delivering necessary improvements, both in terms of lobbying the government and by pioneering new projects.

Customers believe we should be making our network more efficient before we focus on demand management

Customers see conserving water as a partnership issue. In the short term, the majority of customers expect us to focus on reducing leakage, while in the long term some customers want us to help them to use water more wisely. Throughout our customer research, customers generally highlight reducing leakage as a high priority and view it as a moral issue. While they are pleased we are the best performer in this key area, they still consider the leakage level to be too high. Customers expressed a strong preference for us to be a leader in reducing leakage.

While some see saving water as a partnership issue and welcome reducing their own water usage, others are not keen to change their behaviour. For example some customers feel it is not equitable for them to be committing to **Target 100** (reducing their PCC to 100 litres/head/day), while we have “only” committed to reducing leakage by 15.1%. Moreover, some customers believe emerging technologies and innovations will alleviate and facilitate their own personal responsibility to these issues. Consequently customers have put this as a medium priority.

Customers of the future are highly aware of their role in influencing their families to make changes in the way water is used. Moreover they have a high level of confidence that their usage can make a difference and are more willing to change as they see it as a core starting point to make our water sustainable. Their primary focus is to protect and enhance the environment in the short and long term which is why they too put this as a medium priority.

Stakeholders believe demand management should be a high priority

Stakeholders welcome our level of ambition and Environmental groups want to see us reach the target sooner than 2040. Further details of our **Target 100** proposals for AMP7 are included in Section 5.2. provided strong support for demand management over new water supply schemes, in particular for our **Target 100** transformational programme.

Customers believe we should focus on improving our own supply network before using other regions' water supplies

Our customers are strongly against the trading of water. Customers believe we should focus on improving our own supply network in order to meet demand, rather than trading water. Moreover, customers believe water trading could lead to higher prices.

However, stakeholders support water transfers. In particular, the government expects to see companies working together to address drought.

Both customers and stakeholders prefer environmentally sustainable water supply options

Customers prefer water re-use over larger infrastructure options that are not environmentally friendly, such as desalination and abstraction.

Customers believe desalination is a carbon intensive process and produces salt-rich by-products that have a negative impact on the environment. Therefore, they believe we should be using alternative methods where possible.

Customers also have concerns about the impact of locally unsustainable abstraction levels and agricultural runoff on the environment and drinking water quality. In times of drought, customers prefer that we use alternative methods to abstraction.

On the other hand customers are very supportive of the recycling option and not being wasteful with water, as it is a precious natural resource. Customers are supportive of the idea of recycling water for the benefit of golf courses and agricultural land. Customers are also supportive of indirect water re-use to supply drinking water.

Customers indicated they are willing to fund these more environmentally friendly approaches, rather than going for the cheapest approach.

Stakeholders also prefer water re-use over desalination and abstraction

Stakeholders prioritise water re-use over other supply options, including desalination and abstraction and believe technology will be key to enabling water recycling. Sustainable abstraction is an important issue for environmental groups, regulators and government. They want more use of Abstraction Incentive Mechanism (AIM) schemes to reduce pressure around sensitive sources.

However, the National Farmers Union want to create links between water and food security. They want an abstraction system which gives farmers and growers a fair share of water, particularly during times of increased water scarcity

Table 3 summarises our customers' preferred options and their ranking.

Table 3 - Customer preferences for different options types from pre-consultation customer engagement work (1 = most preferred; 10 = least preferred).

Option type	Rank
Underground water storage	1
Catchment management	2

Option type	Rank
Helping people to use water more wisely	3
Reducing leaks	4
Water saving fittings and gadgets	5
Reservoirs	6
Water reuse	7
Trading water	8
Tariffs	9
Sea water (desalination)	10

4.2. Future Trends and Pressures

The key challenges identified in Section 3 remain the most significant, with stronger forecast growth intensifying the scale of challenge (see Section 5.1).

The success of our UMP in reducing domestic consumption may trigger a ‘bounce back’ as customers essentially opt for higher bills and more water, especially as the marginal cost of water remains one of the lowest for all utilities. We therefore need to work harder to maintain and drive down consumption.

The same applies to leakage. In recent years, we have been among the top performers in the industry in this area and have committed to reduce leakage by 2 Ml/d during AMP6. However, we recognise that reducing leakage is a key priority for our regulators and customers. Therefore we aim to reduce our leakage by 15.1% over AMP7.

Our priorities remain to be meeting our service levels, protecting and enhancing the environment, supporting economic growth and ensuring our customers’ bills are good value and affordable. However, as we have increasingly fully exploited the low-cost, environmentally sustainable supply options we need to find alternative and innovative approaches.

5. AMP7 Strategy

5.1. Investment Strategy

Our aim is to ensure there are enough supplies to meet demand under all conditions in an environmentally sustainable manner while keeping customer bills as low as possible. Development of a credible WRMP therefore requires robust estimates of demand and supply.

5.1.1 Demand Forecast

Forecasting demand that we will be required to meet in the future is the first step in planning for water resources. Future demand is impacted by growth in our customer base, technological advances, behavioural trends and climate change.

In order to forecast growth in population and properties for 2019 WRMP and our Plan, we engaged an external consultant (Experian Ltd) as part of a group project with other water companies in the South East. The other companies in the group were Affinity Water, Portsmouth Water, South East Water and Sutton & East Surrey Water (now SES Water). The benefit of this project is to have an aligned view of growth in the South East.

The outputs included annual population, household, property and occupancy forecasts for each year in the period 2015-16 to 2044-45. These forecasts were produced in line with the recommended UKWIR methodology[8] and Environment Agency guidelines[9].

The Environment Agency's guideline states that water companies should base their forecasts on Local Authority local plans. The forecast growth this implies in new connections is much higher than the growth in the previous AMPs (see Figure 4) and exceeds previous forecasts by 46%. The same applies to population which is forecast to increase by 122,000[10]

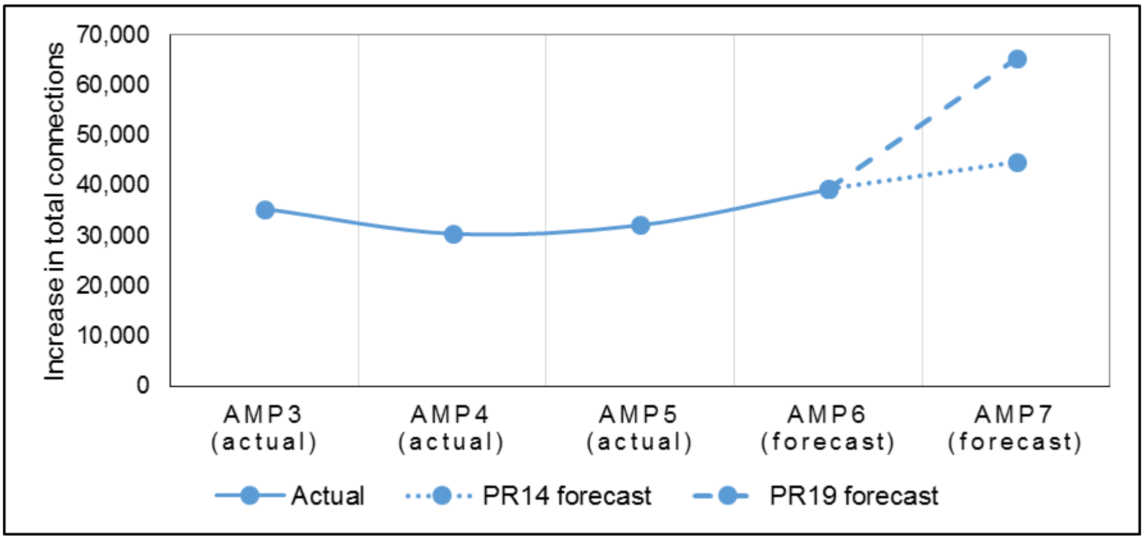

Figure 4 - Increase in total water supply connections since the start of AMP3

Our new connections programme aims to ensure we support the housing development challenge in our supply area. This is split into two requisitions and growth resilience. The requisition cost will be met by developer contributions to our water mains network and from infrastructure charges (i.e.

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[8] UKWIR, 2016. Population, household property and occupancy forecasting. Report no. 15/WR/02/8.
[9] Environment Agency and Natural Resources Wales, 2016. Final Water Resources Planning Guideline, Bristol.
[10] PR19 Data Table WS3 Line 115

payment per connection). The net increase in our customers' bills, will therefore be zero. Growth in our supply area will begin to put significant pressures on our network infrastructure, in particular our water storage assets and vital downstream trunk main systems. To ensure our water transmission infrastructure remains resilient to meet increasing demand, we have undertaken a regional growth study and identified a number of interventions as part of a growth resilience programme. These include:

- Upgrading booster stations (to sustain pressures and continue to maintain stable serviceability).
- New cross connections and minor network modifications (to increase resilience).

The costs associated with requisitions and growth resilience are shown in Table 11.

All other factors being equal, technological advances, leading to the development of more water efficient devices, will result in lower future consumption. Our baseline demand forecast assumes that as a minimum, we will maintain current levels of water efficiency activity which will further lower PCC. We have taken account of climate change impact on household demand but savings due to technological and behavioural changes outweigh potential increases. The overall PCC is thus forecast to decline over time. However, net household demand is still forecast to increase in the 'baseline scenario' as a result of population growth (Figure 5).

Target 100 we plan to significantly increase investment in our water efficiency programme such that by 2040 the total household demand will be lower by 18 Ml/d compared to our current demand instead of being higher by 11 Ml/d – a net saving of 29 Ml/d – under normal year conditions (Figure 5). Further details of **Target 100** are included in Section 5.2.

Demand forecast is subject of a number of uncertainties. We looked at the impacts of uncertainty associated with population growth, behaviour change, non-household demand growth and climate change separately. To capture the full range of demand associated with the uncertainty scenarios, we generated demand profiles for 81 possible combinations of scenarios in each WRZ, for each of the planning scenarios to provide an envelope of possible demand profiles up to 2070. This has allowed us to consider multiple supply-demand balance futures for our planning instead of a single supply-demand balance scenario.

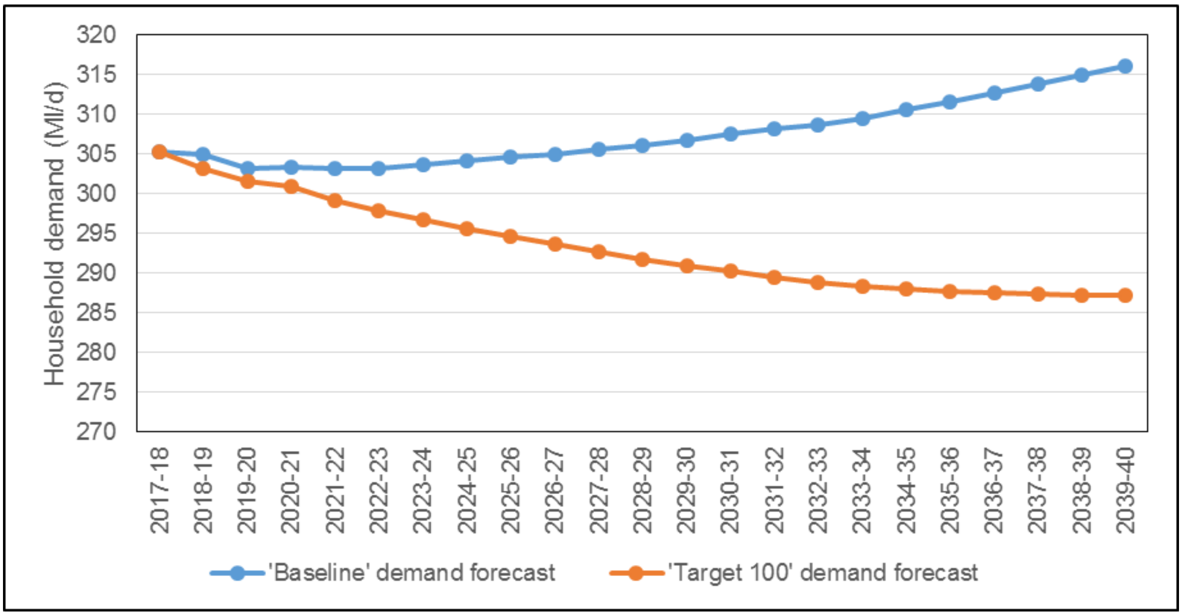

Figure 5 - Household demand forecast comparison for the 'baseline' scenario and the 'Target 100' scenario under normal year conditions.

5.1.2 Supply Forecast

In order to plan effectively to ensure security of supplies, it is important to know the water resources that will be available in the future. We have consequently developed and refined our understanding of the supplies that will be available under a range of drought events.

Our plan is a 'fully risk based plan' reflecting the complexity of the planning challenges we face in our area in accordance with UKWIR risk based planning methodologies[11] and the water resource planning guideline[8].

The total **Water Available for Use (WAFU)** in any WRZ is calculated as:

WAFU = Deployable Output + bulk imports – bulk exports + climate change impacts[12] – sustainability reductions – outage – process losses

In calculating WAFU we have reassessed all of the components that could impact it (see Appendix 2 for details). While there are changes in all components of WAFU, the already notified sustainability reductions have by far the greatest impact on it in our Western area. The same applies in the Central area where potential sustainability reductions pose the biggest risk to maintaining supply demand balance in the future.

As a result of the notified sustainability reductions, the total Deployable Output in the Western area under a severe drought has reduced by 170 Ml/d (51%).

5.1.4 Supply-Demand Balance

The traditional Economics of Balancing Supply and Demand (EBSD)[13] approach used in water resources planning considers a single demand (plus headroom) scenario against a single supply

[11] UKWIR, 2016. WRMP 2019 Methods – Risk Based Planning. Ref 16/WR/02/11.
UKWIR, 2016. WRMP 2019 Methods – Decision Making Process Guidance. Ref 16/WR/02/10.
[12] Climate change impact be positive (increase in supply) or negative (decrease in supply).
[13] UKWIR, 2002. The Economics of Balancing Supply and Demand (EBSD) Main Report. UKWIR Ref. 02/WR/27/3.

scenario and then develops options to meet any supply-demand deficits that may occur at any point during the planning period.

As part of a 'fully risk based' plan, the baseline supply-demand balance forecast has been generated as a series of probabilistic distributions from which we can select different percentiles to represent a range of possible futures. We have then used the baseline supply-demand balances at different percentiles as the input to the Real Options decision-making model. The Real Options approach solves the supply-demand deficits simultaneously for seven different 'states of the world' across up to five different 'futures' or 'branches'.

- '**States of the world**' represent snapshots of different climatic conditions and in-year pressures on water resources and demands, from normal year through to severe and extreme droughts, looking at periods when water supplies are at their minimum, and at periods of peak demand for water.
- Different possible '**futures**' modelled by different 'branches' represent a plausible set of future supply-demand balances for which different solutions may be most appropriate.

The various states of the world allow differing drought conditions to be considered in combination with year on year variability in supplies available to meet demand for water. Each 'state of the world' will therefore have its own supply-demand balance built up from a combination of possible demand growth scenarios, climate change impacts and sustainability reductions. The model must solve each of the 'states of the world' simultaneously (i.e. so that any deficit in any 'state of the world' is solved). Inclusion of the states of the world is useful for a number of reasons:

- It ensures the plan is robust against a range of supply and demand conditions that we could face in any given year across the planning horizon.
- It allows consideration of how the water available from different options may vary in different drought events.
- It ensures the costs are appropriately weighted in relation to how options are likely to be used under each 'state of the world' (known as utilisation). Hence an option that is only required to meet an extreme event is likely, on average, not to have significant total variable operating costs, as it would only be required to supply water very infrequently. However, the capital costs of the option (CAPEX) and any fixed operational costs (fixed OPEX) would still be incurred regardless of how frequently the scheme may actually be used in practice – i.e. these costs are independent of the utilisation.

The states of the world are related to the following climatic conditions, or design drought events:

- **Normal** year – 50% annual probability.
- **Drought** condition – a 1-in-20 year drought, or 5% annual probability.
- **Severe drought** condition – a 1-in-200 year drought, or 0.5% annual probability.
- **Extreme drought** condition – a 1-in-500 year drought, or 0.2% annual probability.

Table 4 shows our supply-demand deficit for Western area under a severe drought for a range of supply-demand deficits, with the 10th percentile branch representing the most severe deficit and the 90th percentile branch showing the least severe deficit.

Table 4 – Supply-demand deficit in the Western area during a severe drought under average demand conditions.

Western area	Initial supply demand deficit (end of AMP) (Ml/d) in a severe drought

	2020-25 (AMP7)	2025-30 (AMP8)	2030-35 (AMP9)	2035-40 (AMP10)	2040-45 (AMP11)	2045-2070
10th %ile branch	-127	-205	-207	-209	-213	-229
30th %ile branch	-127	-196	-197	-199	-202	-216
50th %ile branch	-127	-188	-189	-191	-193	-205
70th %ile branch	-127	-178	-179	-181	-182	-192
90th %ile branch	-127	-146	-147	-148	-150	-158

As can be seen from Table 4, the deficit in AMP7 is entirely due to the 170 Ml/d sustainability reductions which are implemented immediately. If the reductions were not implemented, we would have a surplus water balance in AMP7 and scale of deficit post AMP7 would be much lower.

The supply-demand deficit at the company level is shown in Table 5. The additional deficit at the company level in AMP7 is due to deficit in the Central area. The increase in deficit post AMP7 is primarily due to the potential sustainability reductions that may be required in all areas by 2027, but in particular the Central area.

Table 5 – Supply-demand deficit at the company level during a severe drought under average demand conditions.

Southern Water	Initial supply demand deficit (end of AMP) (Ml/d) in a severe drought					
	2020-25 (AMP7)	2025-30 (AMP8)	2030-35 (AMP9)	2035-40 (AMP10)	2040-45 (AMP11)	2045-2070
10th %ile branch	-152	-374	-380	-389	-398	-442
30th %ile branch	-152	-337	-342	-348	-356	-394
50th %ile branch	-152	-294	-298	-304	-312	-347
70th %ile branch	-152	-248	-252	-258	-265	-298
90th %ile branch	-152	-187	-190	-195	-201	-229

The Real Options approach enables us to understand how a plan would best be varied in light of possible future scenarios, as a result of uncertainty about future forecasts. The outcome from the modelling exercise provides a range of schemes which will be required to maintain the supply-demand balance under different 'futures'. Some schemes will be needed regardless of how the future unfolds, while others will be required only under the more extreme conditions. The objective is to implement the schemes that are common to all scenarios and/or are required in the short term while working to remove uncertainties associated with the other schemes before ruling them in or out.

5.1.5 Options Appraisal

The supply-demand balance forecast identifies deficits that may occur within the planning horizon. These deficits can be met through the introduction of supply side options to increase supplies or demand management options to reduce demand. Options appraisal is the process by which these options are identified, developed and subsequently assessed against each other to bring together the portfolio of schemes that form the strategy for each of our three supply areas. We have followed the Environment Agency guidance[9] while undertaking the options appraisal process. Annex 6 of the WRMP covers our options appraisal process. A summary is presented in Appendix 3.

The process starts off with identifying all possible options that could be used to meet the projected deficit in consultation with customers and stakeholders. We started off by identifying 589 **unconstrained** options covering a range of categories (Table 6).

Table 6 – The number of unconstrained options in each option category.

Option category	Number of options
Aquifer storage and recovery	29
Asset enhancement	21
Borehole rehabilitation	7
Bulk exports	18
Bulk supply	69
Canal Water Abstraction	1
Catchment Management	66
Conjunctive Use	3
Demand Interventions	3
Desalination	67
Drought Planning	8
Inter-zonal transfers (between Southern Water WRZs)	44
Grey Water Reuse	3
Groundwater Abstractions (new)	16
Indirect Potable Water Reuse	53
Industrial Water Reuse	7
Leakage Management	12
Licence Trading	6
Licence Variation	12
Metering/tariffs	16
New Technologies	1
Reservoirs	51
Supply Interventions	21
Supporting River Flows	2
Surface Water Abstractions	17
Water Efficiency	17
Water Treatment Works Enhancement	19
Total	**589**

These options were then assessed against a range of criteria to develop a constrained options list (see Appendix 3). The process is summarised in Figure 6. An example of an excluded option is shown in Table 7.

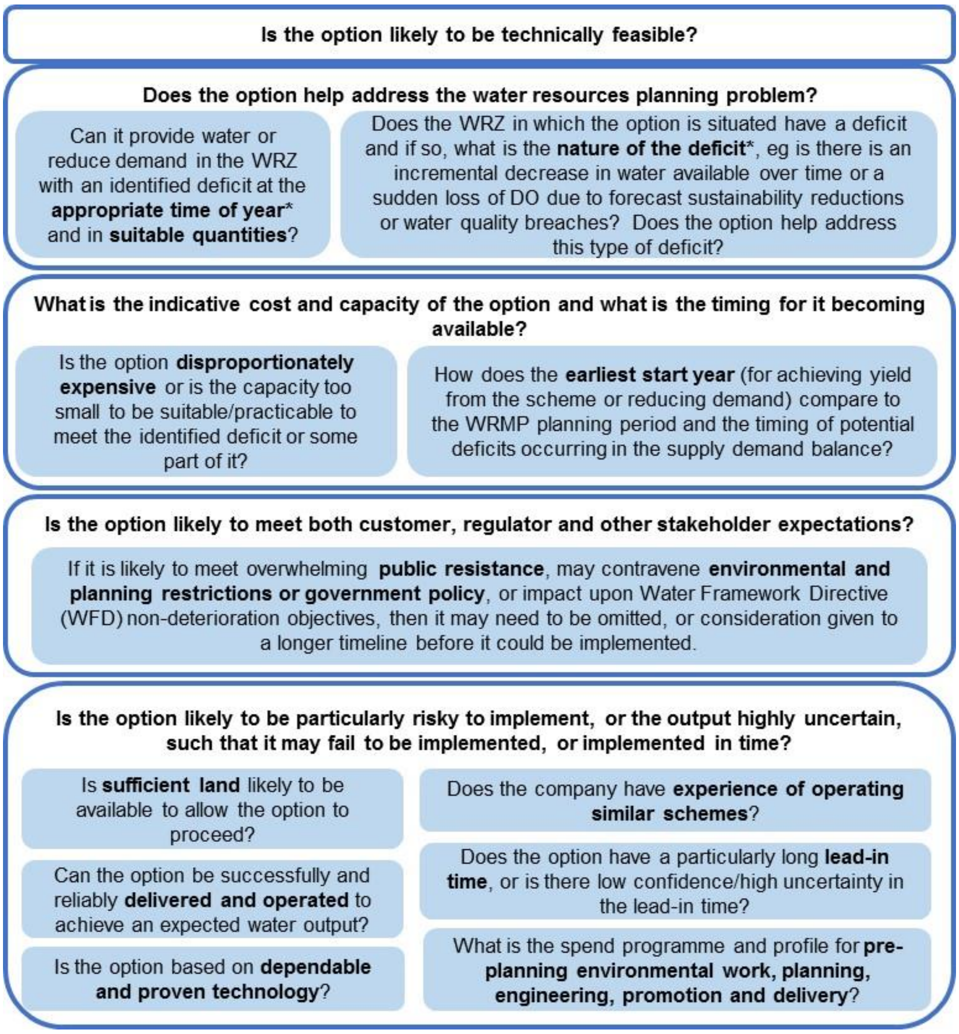

Figure 6 – Screening criteria for the unconstrained options

Table 7 – An example of an unconstrained option that did not progress to the constrained options list.

Option category	Desalination
Option name	Desalination between Sandwich and Kingsdown
Option description	The stretch of coastline between Sandwich and Kingsdown on the East Kent coast has been investigated for potential locations for a desalination plant.
Area	Eastern
Water resource zone	Kent Thanet
Beneficial environmental outcomes?	No

Increased resilience?	Yes
Phased/modular implementation?	Yes
Technically feasible?	Yes
Addresses water resources planning problem?	Yes
Meets customer and regulator expectations?	No
Avoids disproportionate costs and/or delivers appreciable water resource?	Yes
Confidence in implementation/output?	Yes
Include in constrained option list?	No
Comments	The stretch of coastline is subject to several designations (e.g. Site of Special Scientific Interest, Special Area of Conservation, Special Protection Areas etc.) and is either undeveloped or residential in nature. The site is thus unsuitable due to planning/environmental constraints.

A total of 396 constrained options were identified (Table 8).

Table 8 – The number of constrained options in each option category.

Option category	Number of options
Aquifer storage and recovery	3
Asset enhancement	12
Borehole rehabilitation	6
Bulk exports	0
Bulk supply	60
Canal Water Abstraction	0
Catchment Management	63
Conjunctive Use	1
Demand Interventions	1
Desalination	61
Drought Planning	6
Inter-zonal transfers (between Southern Water WRZs)	31
Grey Water Reuse	0
Groundwater Abstractions (new)	4
Indirect Potable Water Reuse	49

Option category	Number of options
Industrial Water Reuse	7
Leakage Management	11
Licence Trading	6
Licence Variation	5
Metering/tariffs	13
New Technologies	1
Reservoirs	16
Supply Interventions	19
Supporting River Flows	2
Surface Water Abstractions	12
Water Efficiency	4
Water Treatment Works Enhancement	3
Total	**396**

The identified constrained options were then subjected to a further screening process to ascertain whether they should be taken forward as **feasible** options that could reduce the supply-demand deficit in their respective WRZs. Screening of the constrained options list was based on the following:

- A Strategic Environment Assessment (SEA) and Habitats Regulation Assessment (HRA) were produced which summarise the environmental and social costs and benefits, and impacts upon European designated sites of each option.
- Links to other options such as mutual exclusivities and dependencies were identified.
- Risks, including vulnerability of the option to future uncertainty relating to climate change impacts and regulatory changes, as well as the sustainability and acceptability of the option.
- Phasing, i.e. whether the option can be constructed in a phased or modular way, which would increase its flexibility to be altered in response to future changes in the forecast supply demand balance.
- Resilience, which is an indication of the confidence that the option will deliver the required reduction in the supply demand balance deficit.

An example of an option that did not meet the screening criteria to progress to the feasible list is shown in Table 9. The feasible options set included 196 options.

The feasible list of options is a final screened list that has been tested on grounds of both monetised and non-monetised costs and benefits. It encompasses the option types listed in Table 9. A SEA and HRA was also produced which summarises the environmental and social costs and benefits, and impacts upon European designated sites.

The feasible list of options was taken forward into the investment model which was used to identify the best value solution in each WRZ. This, and subsequent decision-making processes were used to derive the portfolio of schemes that comprise the strategy for each area.

Table 9 – An example of a constrained option that did not progress to the feasible options list

Option category	New Technologies
Option name	Water from Air
Option description	New Technology which extracts water from the air using a wind turbine to drive a heat exchanger to cool and condense water.
Area	Company wide
Water resource zone	All WRZs
Scheme SEA grade: risk of adverse effects?	-
Scheme SEA grade: opportunity for beneficial effects?	No
Are there mitigation measures to address potential impacts?	No
Are there dependencies or mutual exclusivities with other options or third parties?	No
Is option at risk of climate change impacts or future uncertainty?	No
Can option be implemented in a phased or modular way?	Yes
Does option contribute to overall resilience?	Yes
Include in feasible option list?	No
Comments	Initial desktop studies revealed that this option would be prohibitively expensive to run on a large scale, with much higher operating costs than desalination which itself is already considered an energy intensive technology. Using wind powered turbines as the cooling mechanism would reduce the energy requirements considerably, however, the volume of water produced by this type of device is low, and it would be cost prohibitive to install enough devices, treat the water and distribute to customers. This type of approach is much more suited to small communities in extremely water scarce environments.

Table 10 – Generic option types included in the feasible list of options.

Option category	Number of options
Aquifer storage and recovery	1

Option category	Number of options
Asset enhancement	2
Borehole rehabilitation	4
Bulk exports	0
Bulk supply	13
Canal Water Abstraction	0
Catchment Management	35
Conjunctive Use	0
Demand Interventions	1
Desalination	36
Drought Planning	2
Inter-zonal transfers (between Southern Water WRZs)	12
Grey Water Reuse	0
Groundwater Abstractions (new)	2
Indirect Potable Water Reuse	29
Industrial Water Reuse	3
Leakage Management	8
Licence Trading	1
Licence Variation	4
Metering/tariffs	6
New Technologies	0
Reservoirs	5
Supply Interventions	17
Supporting River Flows	2
Surface Water Abstractions	1
Water Efficiency	4
Water Treatment Works Enhancement	3
Total	**191**

5.1.8 Developing Our Strategy

Our water resources strategy for the three areas reflects the challenges we face in each of them.

Our **Western area** has traditionally not experienced water shortages like our other supply areas, and has not had any restrictions imposed on customers' use as there has been sufficient water available within our abstraction licences to supply our customers.

However, this has fundamentally changed following our agreement with the Environment Agency to fully implement the notified sustainability reductions in 2017 and the potential for further reductions in the future.

This has necessitated the need to promote large-scale new water resource developments alongside demand management measures in order to meet our obligations under the Habitats Regulations, the Water Industry Act and the WRMP Regulations.

The strategy for the **Central area** is also dominated by sustainability reductions. While there is uncertainty regarding the scale and timing of these reductions, we have produced a plan to accommodate any outcome. Both the investigations and the feasibility/design of potential solutions to resolve deficits will be developed at the same time during AMP7.

In the **Eastern area**, we do not currently face any loss in Deployable Output due to sustainability reductions.

We have developed an economic least-cost model (the ‘investment model’) to help select the combination of options (the portfolio of options) which maintains the supply-demand balance at least-cost. The investment model is a decision-making tool to help us identify the optimum set of options based on cost, but it does not necessarily identify the final strategy we adopt in the plan, as there may be other factors that need to be considered and addressed. These factors may include customer preferences, environmental assessments, and regional planning initiatives. We then use the investment model to test the robustness of our final strategy, enabling us to identify key alternative options which may also warrant investigation.

Separate investment models were developed for each of the three supply areas. Although the building blocks for the strategy are the individual WRZs, there are interconnections (either current or potential) between them, and thus actions in one WRZ can affect others. The model takes account of the supply-demand balances for each planning scenario, including transfers and bulk supplies, in all WRZs in each supply area at the same time in order to develop a coordinated solution for the supply area.

Figure 7 presents an overview of the inputs and decision-making tools. The first stage in strategy development was to undertake an initial ‘least-cost’ model run to develop a ‘basic solution’, without further consideration of potential constraints (Figure 8).

This was then tested by modifying assumptions about the availability of certain options such as Drought Orders, to progress our understanding of the impacts that these assumptions might have on the strategy.

We then incorporated policy decisions such as **Target 100,** into the least-cost model to produce the constrained least cost strategy. This demonstrated how customer preferences influenced a least cost plan. The policy decisions applied reflected the inclusion of water efficiency assumptions and the availability of Drought Orders to relax abstraction licence conditions in severe and extreme drought events.

The constrained least-cost strategy was then examined and tested against:

- SEA criteria.
- Outcomes from regional planning exercises as part of the WRSE project.
- The preferences arising from customer engagement activity.

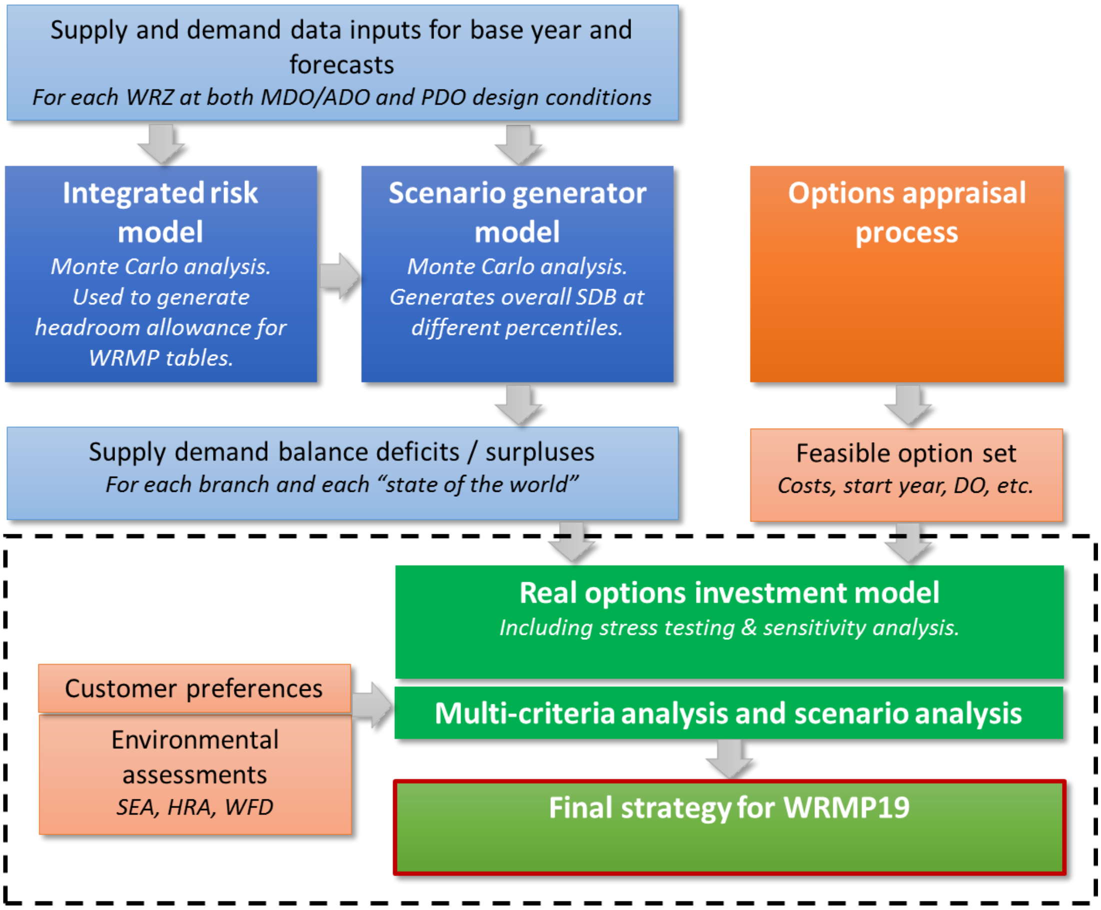

Figure 7 – High level overview of decision making process and inputs.

Overlaying the SEA, regional planning and customer preference considerations on the constrained least-cost strategy does not necessarily imply changes as the strategy may already adequately address key considerations from these tests. While some schemes may be less favoured by the SEA, regional plans or customers, the availability of suitable, better alternatives, or the scale of the deficit faced may mean some options need to be retained in the feasible list.

The initial least cost strategy was then tested against SEA, regional plan outputs and customer preferences to demonstrate how customer preferences influenced a least cost plan. The testing included scenarios to understand how penalty functions assigned to the least preferred option types might affect the constrained least cost strategy. This helped us decide on the option types to be included in the strategy, as well as where other option types should be excluded or minimised. It should be noted that it is not always possible to exclude a least favoured option entirely, if there are limited alternative options to solve a given supply-demand balance deficit.

The strategy was then subjected to scenario and sensitivity testing to understand whether there were key alternative strategies that we should seek specific feedback on during consultation and to understand what alternative strategic schemes may be needed, should the schemes in the preferred plan not be implementable. This is particularly important for those schemes in the strategy that are required in AMP7 or AMP8. This is illustrated in Appendix 4 using an example from our draft WRMP.

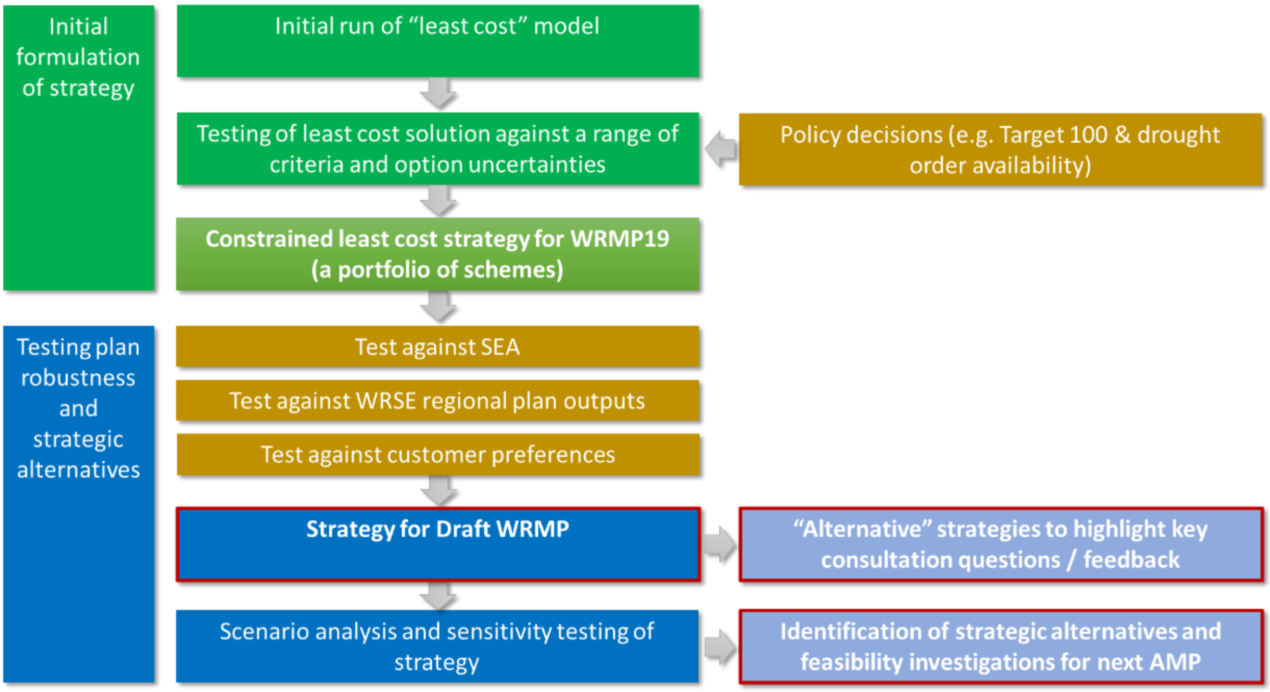

Figure 8 – Stages in the development of strategy for the WRMP

Our AMP7 investment proposals (Table 11) can be divided into the following three key areas. The estimated gain in Deployable Output under a severe drought scenario are also given for each option.

1. Demand side solutions
   - Reducing leakage by 15.1% over AMP7 (projected to achieve 34 Ml/d saving by 2030). Costs are captured within this technical annex, for details see **TA.11.WN04 Business Case - Water Networks**.
   - Reduce PCC to 100 litres/head/day by 2040 (**Target 100**) (19.2 Ml/d saving by 2030).
2. Supply side solutions
   - Increased transfers to move water from areas of surplus to areas of deficit; including Hampshire water grid to increase resilience and trading.
   - Water trading and transfers including collaborative working with Portsmouth Water on Havant Thicket surface water reservoir (50 Ml/d by 2030).
   - Water re-use (46.5 Ml/d by 2030).
   - Desalination (85.0 Ml/d by 2030).
3. Catchment solutions
   - Improved resilience of our catchments to water quality risks and low flows to protect the environment and ensure sustainable abstractions (127 Ml/d by 2030). See **TA.11.WR03 Catchment Management Solutions** for details.

A high level summary of the options to be implemented as part of our AMP7 plan (excluding leakage and catchment management which are covered in separate technical annexes) is given in Table 11.

Table 11 – Proposed investment over AMP7

Option type	Option	CAPEX £m	OPEX £m	TOTEX £m
Demand management	Target 100		30.000	30.000
	Meter Reads		10.630	10.630
	Meter Install	13.209	0	13.209
	Leakage[14]	19.247	0	19.247
	Intelligent Networks	13.870	0	13.870
Water reuse	Water Reuse	19.646	0	19.646
New supplies	Desalination	98.116	0	98.116
Asset enhancements	Transfers	110.426	0	110.426
	Havant Thicket Reservoir	4.971	0	4.971
	In-stream Activities	4.272	0	4.272
	Other Supply Improvement	19.456	0	19.456
Investigations	WRMP	6.657	6.003	12.660
Growth	Requisitions and New Connections	100.391	0	100.391
	Infra Network Capacity and Growth Resilience	2.273	0	2.273
Total		**412.534**	**46.633**	**459.167**

As mentioned in Section 5.1, we will be supporting increased housing development in our supply area. The forecast number of new water connections during AMP7 will result in £100.4m in capital expenditure. This cost will be met by developer contributions to connect new developments to our water mains network and from infrastructure charges (i.e. payment per connection) with no impact on customer bills. Growth will, however, begin to put significant pressures on our network infrastructure and we will need to increase resilience in our water transmission infrastructure. The cost of the growth resilience programme in AMP7 is £2.3m (Table 11).

Our strategy for the Western area and the company to maintain supply-demand balance up to 2030 under a 50th percentile scenario (see Table 3 and Table 4) are illustrated in Figure 9 and Figure 10 respectively.

[14] See technical annex TA.11.WN04 Networks for details of leakage and Intelligent Networks

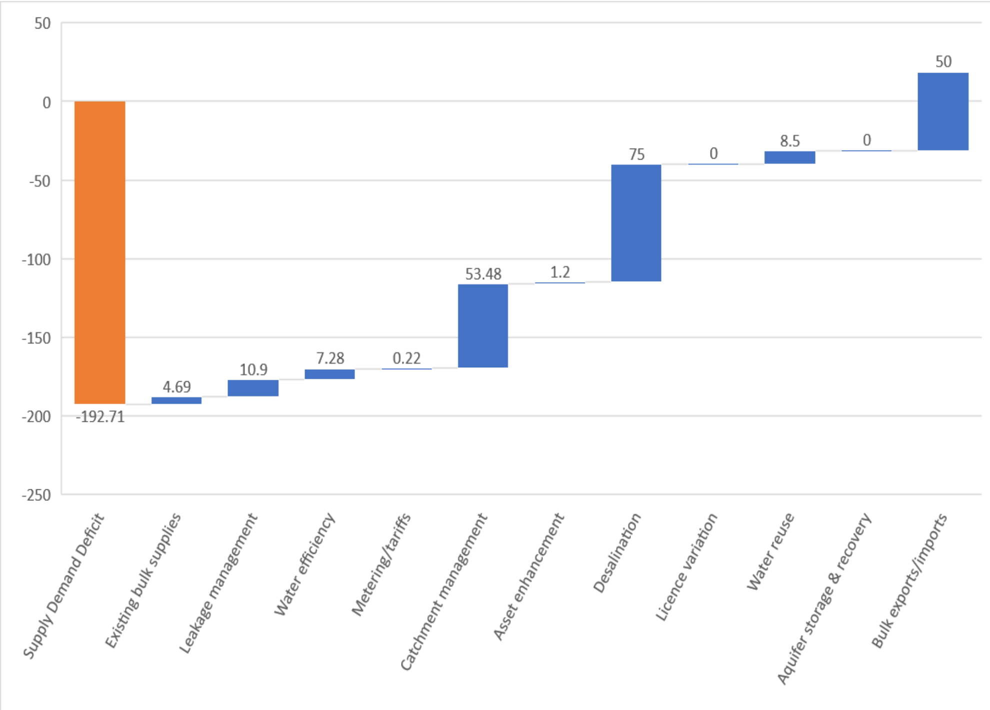

Figure 9 – The contribution our selected options (in Ml/d) to reducing supply-demand deficit in the Western area by 2030; 'Water efficiency' in the figure refers to Target 100.

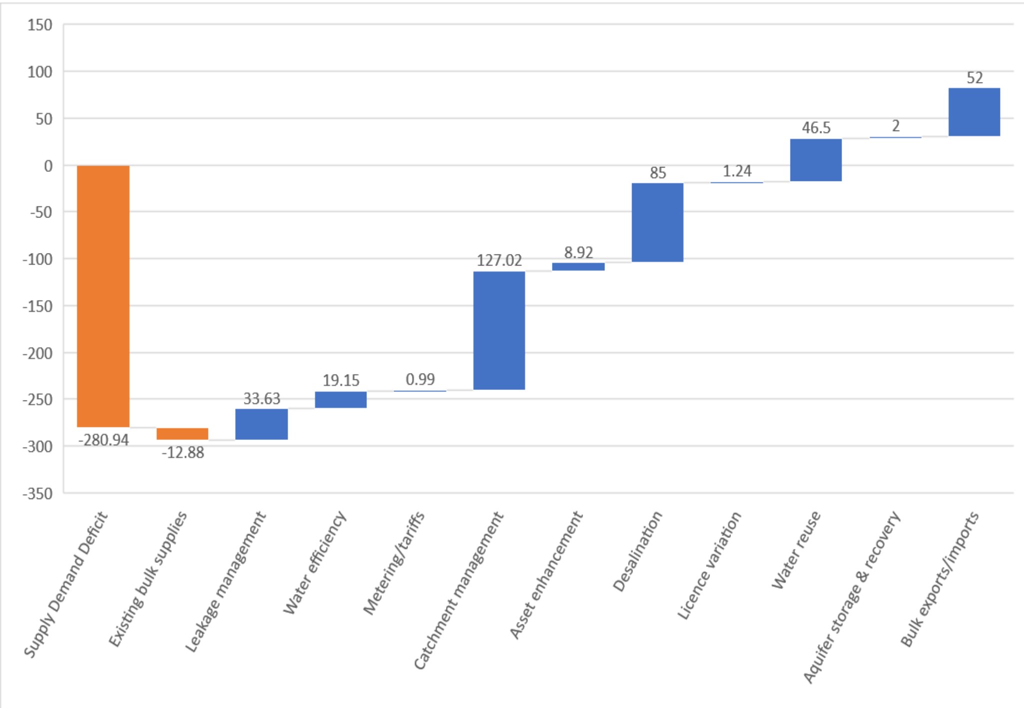

Figure 10 – The contribution of our selected options (in Ml/d) to reducing supply-demand deficit at the company level by 2030; 'Water efficiency' in the figure refers to Target 100.

5.2. Innovation and Target 100

We undertook a 'problem characterisation' assessment at the start of the development of this WRMP. This highlighted a number of complexity factors and concerns in each of our three supply areas and indicated that the plan would benefit from using a more complex 'extended' decision-making approach. As a result of the assessment, we chose to develop a 'fully risk based' plan that uses a Real Options analysis method to recognise risk and uncertainty, and to make appropriate 'no regret' investments.

As part of the development of a 'fully risk based' plan, the baseline supply-demand balance forecast has been generated as a series of probabilistic distributions from which we can select different percentiles to represent a range of possible futures. This represents an innovation in our treatment of risk in the supply-demand balance, commensurate with the strategic challenges and uncertainties we currently face.

The use of different futures in the Real Options approach effectively recognises that the future is not certain, so tries to identify how solutions may change through time in the face of different possible future water resource pressures. This is again an improvement on the standard EBSD approach which seeks to optimise the selection of options to meet a specified deficit on a least-cost basis. The 'standard' EBSD investment model thus only needs to solve a single objective – namely least-cost (which include financial, environmental and carbon costs) – whilst satisfying a single constraint to ensure that supplies would be greater than demand plus headroom in each year of the planning horizon.

Taking account of our customers and stakeholders' views, we will be implementing our industry leading **Target 100** transformational programme from AMP7.

Target 100 (labelled as 'Water efficiency' in the figures) is a core component of our supply-demand strategy; with nearly 40% of the projected savings from the programme in the Western area. The transformational programme has four key strands.

1. **Installation of smart metering** technology: We are currently undertaking trials of devices that can read meters and send the reading to the customers using their Wi-Fi. The aim is to provide customers with near real-time information on their consumption so they can see the consumption associated with various water-using activities and take measures to conserve water where they can. We plan to roll out 100,000 devices over AMP7 at an estimated cost of £2.7m, funded from a reward-only performance commitment.
2. **Home visits:** We currently undertake home visits to promote water efficiency. The programme has a high uptake rate and can result in up to 10% further savings on top the savings achieved through metering. We plan to continue with this programme and combine it with leak detection so that while we offer help and advice on water efficiency, we can also help detect any plumbing losses or supply-pipe leaks. The estimated cost of home visits over AMP7 is £14m.
3. **Proactive customer contact:** We are looking to develop tools and systems that allow us to identify any significant increase in consumption so we can proactively engage with our customers at an early stage to determine if the increase is due to change in circumstances or a leak. This will allow us to specifically target customers or geographical areas for water efficiency messages during periods of high demand. The estimated cost is £3.3m
4. **Incentivising water efficiency behaviour:** Our customers and stakeholders have shown little appetite for seasonal tariffs as a way of managing demand (see Table 2). As an alternative, we are looking to reward customers for conserving

water. Given the sustainability reductions that we have implemented in the Western area, the first scheme will be rolled out in Hampshire in partnership with Eastleigh Borough Council. The scheme will offer rewards to residents for recycling waste and reducing water consumption on a monthly basis. The scheme will be introduced in the Central area towards the end of AMP7 and in the Eastern area during AMP8. The estimated AMP7 cost is £3m.

We estimate an additional spend of £7m over AMP7 in educational programmes, product development and delivery.

Customer outcomes related to **Target 100** in AMP7 are shown in (Table 12).

Table 12 – Target 100 customer outcomes delivered in AMP7.

	Unit	2020-21	2021-22	2022-23	2023-24	2024-25
PCC	litres/head/day	127.0	125.0	122.0	121.0	120.0
Customers achieving Target 100	%	49.0	51.2	53.4	54.4	55.0
Water saved from water efficiency visits	Ml/d	0.5	1.0	1.5	2.0	2.5

5.3. Customer Benefits and Resilience

Our approach to water resources planning is geared towards ensuring we are able to maintain supplies under more severe droughts than we have experienced in the past. The challenge has become greater given the scale of sustainability reductions we face in our Western and Central areas.

Our ‘no regrets’ approach allows solutions to be developed for a range of supply-demand balance futures rather than a single supply-demand balance scenario this means we can continue to implement schemes that are needed in the short term while carrying out work to remove the uncertainties associated with the options needed in the mid to long term and modify our strategy accordingly.

5.4. Value for Customers

As shown in Figure 8, we have not relied on the least-cost option derived from the Real Options methodology to formulate our strategy. We have used a multi-criteria analysis approach to developing a best value plan that considers environmental assessment outcomes, regional planning and customer preferences for different option types, with the objective to derive a best value plan from the initial least-cost solution. As a result, we have adopted a leakage reduction target of 15.1% over AMP7 and plan to reduce PCC to 100 litres/head/day by 2040.

Customers are highly averse to accepting reductions in service in exchange for lower bills, and in general are willing to pay for improvements in service levels (Table 13).

- The total amount that our customers would be willing to pay to see leakage per property per day reduced by 1 litre was £450,305 per year.
- The total amount that SW customers would be willing to pay to see water use per person per day reduced by 1 litre was £94,196 per year.

Our additional research into willingness to pay for service level improvements indicated that our customers demand and are willing to invest in significant improvements to leakage, as well as improvements in effluent re-use.

Southern Water

5.5. Summary of AMP7 Proposals

Table 14 shows the annual spend profile of our AMP7 programmes shown in Table 10.

Table 14 - The options selected for AMP7 and their spend profile. All costs are post efficiency.

		AMP7 Total (£m)
TOTEX		**459.167**
Total CAPEX		**412.534**
Option type	**Option**	
Demand management	Meter installation	13.209
	Leakage[15]	19.247
	Intelligent Networks	13.870
Water reuse	Water reuse	19.646
New supplies	Desalination	98.116
Asset enhancements	Transfers	110.426
	Havant Thicket Reservoir	4.971
	In-stream Solutions	4.272
	Other supply improvement	19.456
	Future AMPs	6.657
Growth	Requisitions and New Connections	100.391
	Growth Resilience	2.273
Total OPEX		**46.633**
Demand management	Target 100	30.000
	Meter reads	10.630
Investigations	AMP7	6.003

[15] See technical annex TA.11.WN04 Networks for details of Leakage and Intelligent Networks

5.6. Medium & Long-Term proposals

The proposed spend over AMP7 and AMP8 is shown in Table 15. Total spend on growth post AMP7 has not yet been determined and is therefore not included in the table below.

Table 15 - The proposed TOTEX spend over AMP7 and AMP8 (excluding growth spend).

Option type	Option	AMP7 (£m)	AMP8 (£m)
Demand management	Target 100 (including enhanced meter reads)	40.630	159.119
	Meter Install	13.209	1.185
	Leakage[16]	19.247	0
	Intelligent Networks	13.870	11.000
Water reuse	Water Reuse	19.646	78.584
New supplies	Desalination	98.116	198.052
Asset enhancements	Transfers	110.426	80.097
	Other Supply Improvement	28.699	34.183
Investigations	WRMP	12.660	6.003
Total		**356.503**	**568.223**

[16] See technical annex TA.11.WN04 Networks for details of Leakage and Intelligent Networks

6. Costing Strategy

6.1. CAPEX

CAPEX for each option was developed from a detailed assessment of project work items required. Asset lives were determined for each project work item. Infrastructure costs were derived using typical water industry unit costs. Non-infrastructure treatment costs were derived from supplier quotes, known out-turn costs and, in the case of desalination plants, a desk study into typical costs over a range of capacities internationally.

6.2. OPEX

OPEX such as fixed and variable costs including power, abstraction, treatment, distribution, labour and any other costs, such as business rates where applicable, have been included.

6.3. Embodied and Operation Carbon

Carbon emissions were calculated for each option, both in terms of embodied carbon (the lifecycle carbon emissions of materials used in construction), and operational carbon (emitted through operation of the scheme over its lifetime). The embodied and operational carbon emissions associated have been quantified in terms of kg CO_2e to allow identification of a least carbon suite of options.

The embodied carbon of each option was calculated using Atkins' Carbon Tool. For this plan the tool was updated to include up-to-date values for the embodied carbon of different construction materials and for the fuel efficiency of transport/plant. Carbon curves provided by Southern Water were used to calculate the embodied carbon of pipes and concrete tanks.

Operational carbon emissions have been calculated based on the operational energy requirements of each option in kWh and the carbon intensity of energy production using published data.

It should also be noted that high energy options are automatically equated with high carbon emissions. However, opportunities to reduce emissions through the supply of energy from renewable sources has been identified in each option fact file.

6.4. Environmental and Social Considerations

We have assessed the environmental and social impacts of each feasible option. We have not quantified the environmental costs and benefits of options in monetary terms, which is in accordance with the Environment Agency's supplementary guidance17 on environmental valuation. Depending on the option, impacts are informed by a SEA, more general environmental assessment, HRA, and its ability to meet WFD objectives. The full methodology by which environmental and social impacts have been considered is set out in Annex 14 of the WRMP.

The climate change impacts on options have been assessed as part of the SEA. However, climate change also formed part of the overall assessment of potential future vulnerability of options within the options screening process (as detailed within the example in Table 8).

Climate change would only affect the few options that are impacted by climatic events. For example, a storage reservoir option would likely be affected by climatic events, whereas desalination and water reuse options would not be affected.

[17] Environment Agency, 2016. Environmental valuation in water resources planning – additional information.

7. Key Risks and Opportunities

7.1. Risks

7.1.1 Leakage

- Our 330km of mains renewal programme in AMP7, required as part of our 15.1% reduction target, may result in a shortage of skilled workforce and increased contractor costs.
- Failure to achieve our leakage target could pose a risk to our level of service in dry years and/or during periods of peak demand. This is because leakage reduction is one of our key initiatives for maintaining supply-demand balance in some WRZs,

7.1.2 Enhanced Meter Penetration

- Problems we are starting to experience in AMP6 in gaining access to properties may prevent us from reaching the 92% meter penetration target in key WRZs during AMP7. This could lead to assumed levels of water efficiency not being achieved.
- The 16.5% savings achieved in UMP may not be sustainable over the longer term as customers become used to metered charges and additional metering may not deliver the expected savings.

7.1.3 Target 100

- The customer benefits from **Target 100** may be less than detailed above in Table 12. This is because while the costs of activities aimed at behaviour change (home visits, media campaigns, more frequent meter reads) can be estimated with a high degree of confidence, the PCC reductions of these initiatives, in terms of volume of water saved, are much more difficult to estimate. If PCC reduction is not achieved then in some WRZs, our level of service could be at risk during a dry year and/or during periods of peak demand.
- Large-scale installation of meter read devices could lead to an increase in customer contact and negatively impact our CMEX score.

7.1.4 Catchment Management

- The assumed benefits of catchment management work will not be realised in the timescales assumed. This is because the outcomes of catchment management initiatives take years to materialise and the extent to which our catchment management initiatives are successful in meeting our targets is uncertain and dependent on the future behaviours of others.
- Farming and land-use practices can change in response to factors beyond our control. These include government policy, economic factors, climate change etc. This may mean that our strategy is no longer fit for purpose.

7.2. Opportunities

7.2.1 Leakage Reduction

- The installation of a leakage management and reporting system could considerably reduce data processing time and human error to a greater extent than we have assumed, leading to quicker and more accurate reporting of leakage figures on daily, week, monthly and annual basis.

7.2.2 Enhanced Meter Penetration

- Further increasing meter penetration could allow us to engage and influence a greater proportion of our customers. In addition there is the opportunity that we can start to engage with the minority of customers who in the past have been unwilling or unable to engage with us on these issues.

7.2.3 Target 100

- Proactive customer engagement, with tangible benefits to customers and ultimately to the natural environment, could improve our customers' view of us as a customer-focussed service provider.
- By better understanding the way our customers use water could allow us to better segment our customers into different groups. This will help us to find better ways of encouraging and supporting our customers to reduce consumption.

7.2.4 Catchment Management

- By promoting environmentally sustainable farming and land-use in our catchments we may be able to reduce the risk to our water supplies to lower levels than we have assumed.
- Our catchment management work may be able to reduce our reliance on expensive end-of-pipe solutions for water quality to a greater extent than we have assumed, leading to increased benefit to our customers through lower bills.

Appendix 1: Schemes and Projects in AMP7

Table 1A: The schemes selected for implementation or investigations during AMP7 excluding catchment management schemes (detailed in Technical Annex TA.11.WR03 Business Case - Catchment Management Solutions).

Schemes	Area	AMP7 spend (£m)	Total Spend (£m)	Lead in time (years)	Operational year	Deployable Output by 2030 (Ml/d) (average demand conditions)
Demand management – Total		**86.956**	**258.260**			**19.2**
Target 100 (incl enhanced meter reads)		40.630	199.749			
Target 100 activities including enhanced meter reads	Western	15.671		0	2020	7.3
Target 100 activities including enhanced meter reads	Central	12.555		0	2020	5.8
Target 100 activities including enhanced meter reads	Eastern	12.404		0	2020	6.1
Meter installs		13.209	14.394			1.0
Increase AMR household meter penetration to 91%	Western	2.546		0	2020	0.2
Increase AMR household meter penetration to 91%	Central	10.663		0	2020	0.8
Leakage[18]		19.247	19.247			
Intelligent Networks		13.870	24.870			
Water reuse – Total		**19.646**	**98.230**			**46.5**
[redacted]	Western	4.879	24.396	7	2027	8.5
[redacted]	Central	9.635	48.174	6	2027	20.0
[redacted]	Eastern	5.132	25.660	4	2027	18.0
New Supplies – Desalination – Total		**98.116**	**296.168**			**85.0**
[redacted]	Western	89.364	252.409	8	2027	75.0

[18] See technical annex TA.11.WN04 Water Networks for details of Leakage and Intelligent Networks

Schemes	Area	AMP7 spend (£m)	Total Spend (£m)	Lead in time (years)	Operational year	Deployable Output by 2030 (Ml/d) (average demand conditions)
[redacted]	Central	8.752	43.759	6	2027	10.0
Transfers		110.426	190.523			50.0
[redacted]	Western	65.776	73.082	4	2023	
[redacted]	Western	4.971	75.514	4	2029	21.0
[redacted]	Western	4.459	4.459	3	2023	9.0
[redacted]	Western	35.220	37.468	5	2027	20.0
Other supply improvements – Total		28.699	62.882			25.0
[redacted]	Western	1.114	1.114	2	2024	2.0
[redacted]	Western	1.249	5.959	5	2027	1.0
[redacted]	Western	4.272	5.357	0	2019	
[redacted]	Central	0.681	0.681	1	2021	1.0
[redacted]	Central	1.855	12.365	5	2027	2.0
[redacted]	Central	4.190	4.190	4	2025	4.0
[redacted]	Central	3.365	3.365	4	2025	2.0
[redacted]	Central	2.363	11.816	6	2027	2.0
[redacted]	Eastern	3.425	3.425	5	2027	3.0
[redacted]	Eastern	5.504	12.669	4	2025	5.0
[redacted]	Eastern	0.681	0.681	3	2021	1.0
[redacted]	Eastern	0	1.260	3	2030	2.0

Schemes	Area	AMP7 spend (£m)	Total Spend (£m)	Lead in time (years)	Operational year	Deployable Output by 2030 (Ml/d) (average demand conditions)
Investigations – Total		**12.660**	**18.663**			
	Western	2.222		0	2020	
	Central	5.219			2020	
	Eastern	5.219		0	2020	
Growth – Total		**102.664**	**205.328**			
Requisitions and New Connections	SWS	100.391	100.391	0	2020	
Growth Resilience	SWS	2.273	4.546	0	2020	
Total		**459.167**	**1130.054**			

Appendix 2: Estimating the Total Water Available for Use

The total Water Available for Use (WAFU) in a WRZ consists of the following elements (Figure 2A):

- Deployable Output
- Bulk imports and exports
- Climate change impacts on supply
- Sustainability reductions
- Outage
- Treatment works losses

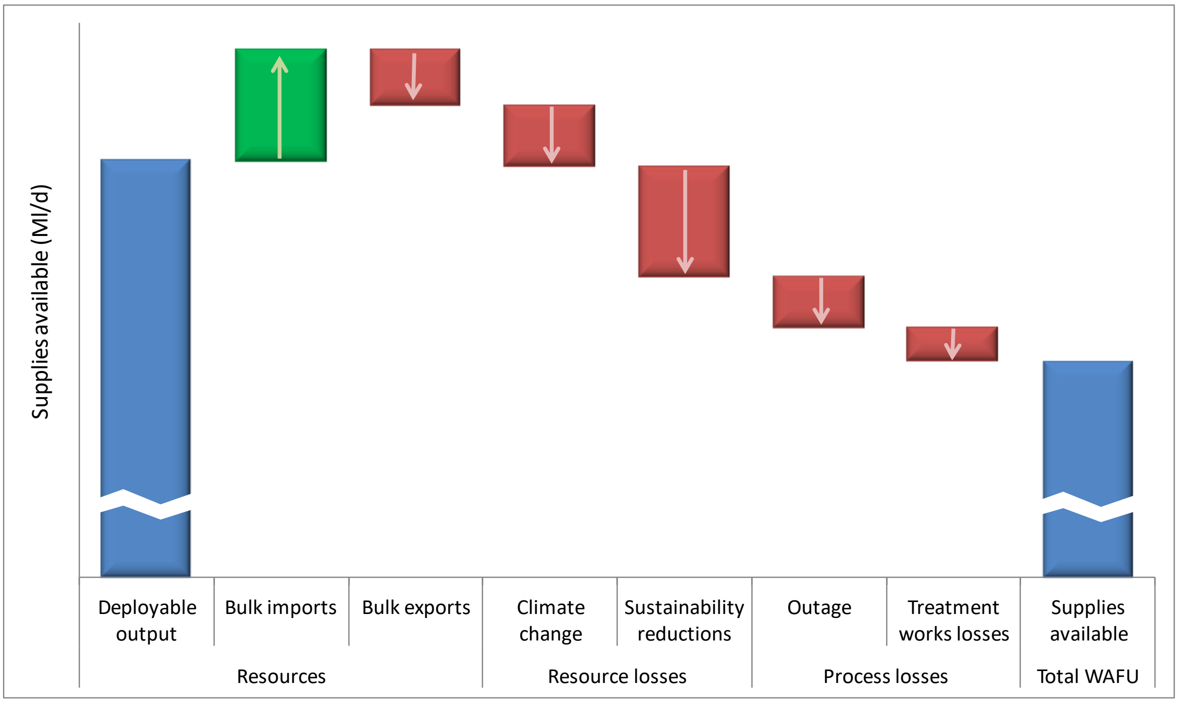

Figure 2A - Components that make up Water Available For Use in each WRZ.

Our supply forecast, with the exception of bulk imports and exports, is covered in detail in Annex 3 of the WRMP; bulk imports and exports are covered in Annex 5.

Deployable Output

Deployable Output comprises the majority of WAFU in all of our WRZs. Deployable Output is defined as the water available from a source after taking account of:

- Source characteristics (e.g. hydrological or hydrogeological yield).
- Physical and infrastructure constraints (e.g. aquifer properties, pump capacity, distribution networks).
- Raw water quality and treatment constraints.
- Licence and other regulatory constraints on water abstraction.
- Demand constraints and levels of service.

We have considered the following scenarios in our Deployable Output assessments:

- **Minimum Deployable Output (MDO)**. This is the volume of water available from a source during the period of minimum resource availability. It is most commonly determined in the late autumn following the summer recession and prior to the onset of winter rainfall and recharge.
- **Peak Deployable Output (PDO)**. This is the volume of water available from a resource during the period of maximum demand. Typically demand peaks in early to mid-summer and thus the PDO reflects the ability of a source to meet demand during this period.
- **Average Deployable Output (ADO)**. This reflects the annual average Deployable Output from a source and is most useful for reflecting the yield drawdown from high storage systems such as reservoirs.

Our estimates of Deployable Output have been determined through the development and application of advanced mathematical models to determine hydrological and hydrogeological yields of our surface water and groundwater sources respectively. We have used stochastically generated, but historically plausible, time series of weather to consider water resource availability under very severe droughts including those that may not have been captured by historical record. We have consequently derived probabilistic estimate of Deployable Output under a range of drought severities and durations. Our estimates of Deployable Output for a 1-in-200 year drought event are shown in Table 2A - Comparison of Deployable Output assessments at the start of AMP7 under a 1-in-200 year drought scenario (draft WRMP).2A. ***Detailed assessment of Deployable Output is given in Annex 3 of the WRMP.***

Once Deployable Output has been determined, planning allowances (outage, process losses etc.) and net exports are subtracted, and net imports are added, to calculate WAFU (Figure 2A - Components that make up Water Available For Use in each WRZ.2A).

Table 2A - Comparison of Deployable Output assessments at the start of AMP7 under a 1-in-200 year drought scenario (draft WRMP).

Scenario		Deployable Output (Ml/d)			
		Western area	Central area	Eastern area	Total
MDO / ADO	WRMP19	113.3	191.8	244.0	549.1
	WRMP14	309.1	193.6	236.9	739.6
	Change	-195.8	-1.8	+7.1	-190.5
PDO	WRMP19	144.7	243.6	306.1	694.4
	WRMP14	372.7	251.2	319.1	943
	Change	-228.0	-7.6	-13.0	-248.6

Bulk Imports and Exports

Bulk imports and exports are used to maintain supply-demand balance by transferring water from an area of surplus water to an area of water deficit. Such transfers can either eliminate or delay the need to implement a new scheme and are a key component of building resilience at a regional level. We currently transfer water between our WRZs and also have agreements in place with Portsmouth Water and South East Water to both import and export water. The net benefit from our existing imports and exports are shown in Table **2B - Net benefit from import/exports at the start of AMP7 for PDO conditions under 1-in-200 year drought scenario (draft WRMP)**2B. ***Our assessment of bulk transfers is detailed in Annex 5 of the WRMP.***

Table 2B - Net benefit from import/exports at the start of AMP7 for PDO conditions under 1-in-200 year drought scenario (draft WRMP)

	Western area	Central area	Eastern area
Net benefit from imports/exports (Ml/d)	4.6	9.6	-34.9

Climate Change

Current projections of climate change impacts on the UK suggest that South East England is most likely to experience warmer and wetter winters, and hotter, drier summers. However, the probabilistic nature of climate change forecasting means there is a relatively wide range of uncertainty in the outcomes. In the context of water resources, the impacts of climate change vary from possible drier futures in which water resources will become more scarce, and wetter futures where increased winter rainfall translates to increased resource availability. We have consequently assessed climate change impacts on supply using Environment Agency guidance[19] for three different scenarios using the national UK Climate Projections (UKCP09) at a river basin scale. The results are shown in Table 2C.

The magnitude of climate change impacts in the WRMP are generally larger than for our previous plan. This reflects the change in the forecasting period and projecting climate change forward to the 2080s where the effects are more keenly felt, compared to the previous cycle where we were only required to forecast to the 2040s.

[19] Environment Agency, 2013. Climate Change Approaches in Water Resource Planning – Overview of new methods.

Table 2C - Climate change impact on Deployable Output under a 1-in-200 year drought scenario (draft WRMP)

Scenario	Climate Scenario	Western area impact	Central area impact	Eastern area impact
MDO / ADO	Dry	-21.5 Ml/d (-19%)	-36.0 (-19%)	-7.9 (-3%)
	Wet	36.3 Ml/d (32%)	24.1 (13%)	21.6 (9%)
	Medium	4.4 (4%)	7.1 (4%)	6.2 (3%)
PDO	Dry	-37.3 (-26%)	-41.7 (-17%)	-8.9 (-3%)
	Wet	74.1 (51%)	-20.0 (-8%)	1.4 (0.5%)
	Medium	28.1 (19%)	-26.1 (-11%)	4.2 (1%)

Overall, our most vulnerable resource zones are those where we have large surface water abstractions constrained by 'hands off flow' licence conditions i.e. Hampshire Southampton East, Hampshire Southampton West and Sussex North WRZs.

Sustainability Reductions

Over the last 20 years we have undertaken investigations and implemented schemes to improve the environmental sustainability of our abstractions. We have been an active partner in supporting delivery of the Restoring Sustainable Abstractions (RSA) and Water Framework Directive (WFD) programmes. Both programmes aim to establish a sustainable abstraction regime.

In recent years we have revoked an abstraction licence in Hampshire (Test valley), reduced licence volumes at a source in Sussex (North Arundel) and implemented a river restoration scheme on the Isle of Wight (Lukely Brook). We are currently delivering a number of investigations, options appraisal and implementation schemes as part of AMP6 National Environment Programme (NEP).

We believe it is in the best interest of customers and the environment to address unsustainable abstractions as quickly as possible and to look beyond the five-year NEP/business planning cycle to ensure that future risks are addressed. Optimal solutions can then be implemented taking account of the long-term availability of supplies. As well as being supportive of the Environment Agency's 2016 'sustainable catchments' plan, which has influenced the Water Industry National Environment Programme (WINEP) for AMP7, we are also developing a long term environmental forecast. This will consider future scenarios taking account of climate change and its impact upon sustainable abstraction as well as other drivers such as behavioural change.

The Environment Agency[20] has categorised measures to be taken under WINEP as follows (Table 2DTable 2D - PR19 approach to managing uncertainty for Water Industry National Environment Programme.).

Table 2D - PR19 approach to managing uncertainty for Water Industry National Environment Programme.

Colour	Status of Measure	Justification
Green	Certain	Evidence that water company action is needed, there is clarity on the required measure, the measure is considered cost beneficial and affordable (where applicable).
Amber	Indicative	Evidence that water company action is needed, there is clarity or developing clarity on the required measure, the measure is considered cost beneficial but awaiting decision on affordability. May turn green during the AMP period.
Red	Unconfirmed	Evidence that water company action is needed but the measure is not yet clear. May turn amber during the AMP period.

[20] Environment Agency, 2017. Sustainable abstraction. A supporting document for the Water Resources Planning Guidance.

Purple	Direction of travel	We know that the water company will need to do this work in the future, e.g. potential change to revised Common Standards Monitoring Guidance but we don't have scheme level evidence.

The guidance requires that companies consider three sustainability reduction scenarios:

- A **lower scenario** that includes only green sustainability changes.
- A **middle scenario** that includes green and amber sustainability changes and a pragmatic estimate of the red sustainability changes.
- An **upper scenario** that includes green, amber and red sustainability changes and a pragmatic estimate of any further sustainability changes that may be required following investigations and options appraisals, or driven by future legislation or requirements.

In view of Environment Agency guidance, we developed an approach to assess potential sustainability reductions. Our results show that:

- For the **Western area**, the full implementation of proposed licence changes, as agreed with the Environment Agency, results in immediate reductions in PDO of 174 Ml/d rising to 223 Ml/d after 2027. The immediate MDO impacts are 184 Ml/d rising to 220 Ml/d after 2027.
- For the **Central area**, there are no sustainability reductions in the lower and middle scenarios. For the upper scenario, estimated sustainability reductions from 2029, are 74.9 Ml/d for PDO and 53.1 Ml/d for MDO/ADO conditions.
- For the **Eastern area,** there are no sustainability reductions in the lower and middle scenarios. For the upper scenario, the estimated sustainability reductions from 2029 are 28.6 Ml/d for PDO and 23.0 Ml/d for MDO/ADO conditions.

Outage

In order to enhance resilience cost effectively and protect services, we need to include an allowance for temporary loss of Deployable Output from a source i.e. outage. This allowance covers both unplanned outage (e.g. mechanical failure) and planned outage (e.g. to perform maintenance). To develop our outage allowance for each of our WRZs, we have followed the recommended UKWIR methodology[21] using data from 1992 to 2017.

Overall there has been an increase in the total outage allowance in all WRZs increasing from 27.15 Ml/d at the company level in WRMP14 to 41.29 Ml/d under MDO conditions and from 39.16 Ml/d to 51.14 Ml/d under PDO conditions. The higher outage level than set out in WRMP14 is in part due to deteriorating raw water quality at a number of sites.

As part of assessing options for maintaining supply-demand balance we have looked at the cost effectiveness of reducing outage in preference to building new schemes.

Process Losses

We have updated our analysis of process losses i.e. the volume of water we lose between abstraction from the environment and distribution due to water treatment processes. To update these data we have revisited the assumptions we have made around losses at specific sources and used the most recent data available.

Overall these updated figures have led to an increase in the amount of process losses we are forecasting in many of our WRZs compared to our previous plan. In our Western area, process losses have increased by around 9.5 Ml/d. In our Central area, process losses are stable except for the Sussex North WRZ where they have increased by 1-2 Ml/d. In the Eastern area, they have increased by 3-4.5 Ml/d. Generally process losses are smaller at critical periods than during the rest of the year.

WAFU at the start of AMP7 in each of our three areas under PDO conditions for a 1-in-200 year drought scenario is shown in Figures 2B – 2D. There are a few things to note while looking at these figures.

- The **DO write-downs** are the result of nitrate and pesticide impacts on sources of supply.
- Three climate change scenarios were used in the uncertainty modelling process: 'dry', 'medium', and 'wet'. These are calculated for each individual WRZ, and are expressed as a

[21] UKWIR, 1995. Outage allowances for Water Resource Planning. Ref: WRP-0001/B.

change in Deployable Output. The medium scenario is considered to represent the most likely impact on Deployable Output, whilst the ‘dry’ and ‘wet’ scenarios represent the 90th and 10th percentiles of the distribution of UKCP09 scenario impacts respectively. Figures 2B – 2D show the ‘medium’ impact. Where this is positive, this means that there is a gain in water.

- **Three sustainability reduction scenarios** have been developed for this plan (‘Lower’, ‘Middle’ and ‘Upper’). The sustainability reductions shown in this section are those that are in the Lower scenario only.

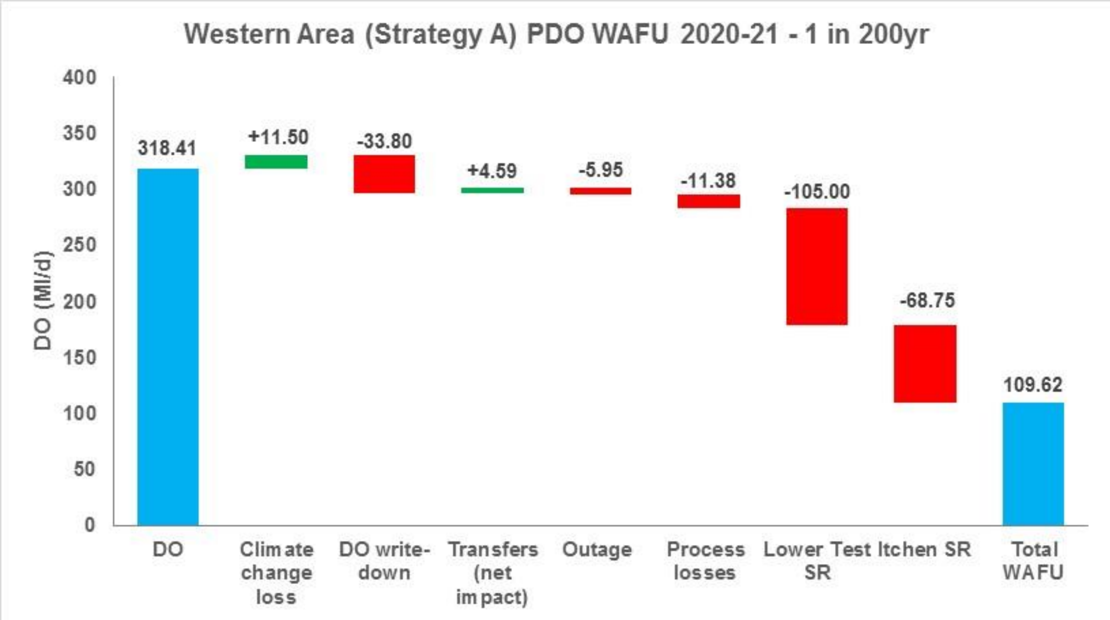

Figure 2B - Water Available for Use in the Western area at the start of the planning period for a 1-in-200 year drought at PDO. Strategy A refers to full implementation of sustainability reductions in 2017.

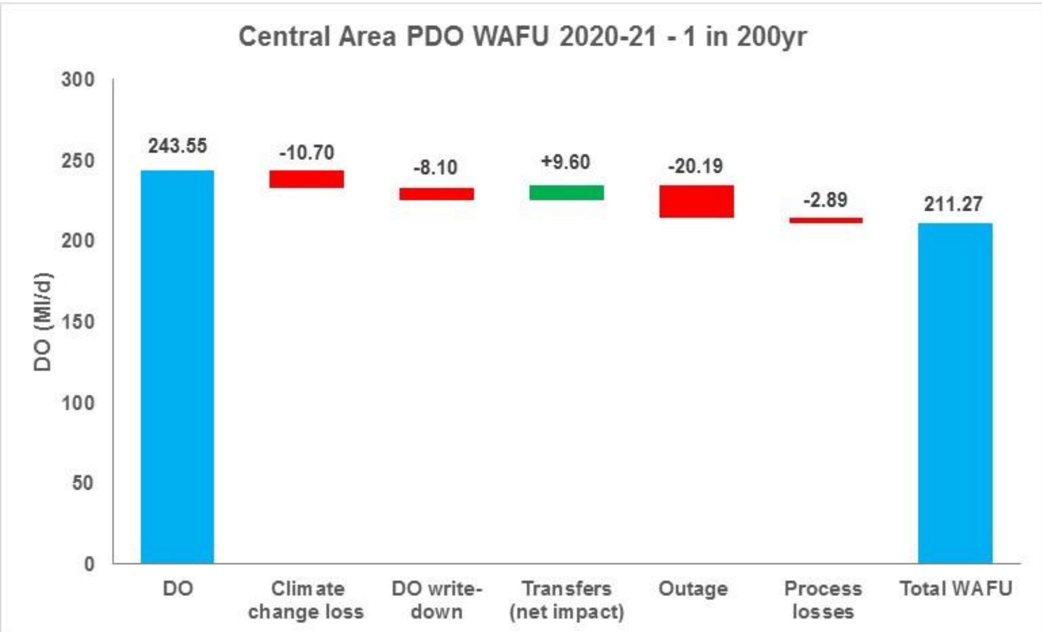

Figure 2C - Water Available for Use in the Central area at the start of the planning period for a 1-in-200 year drought at PDO.

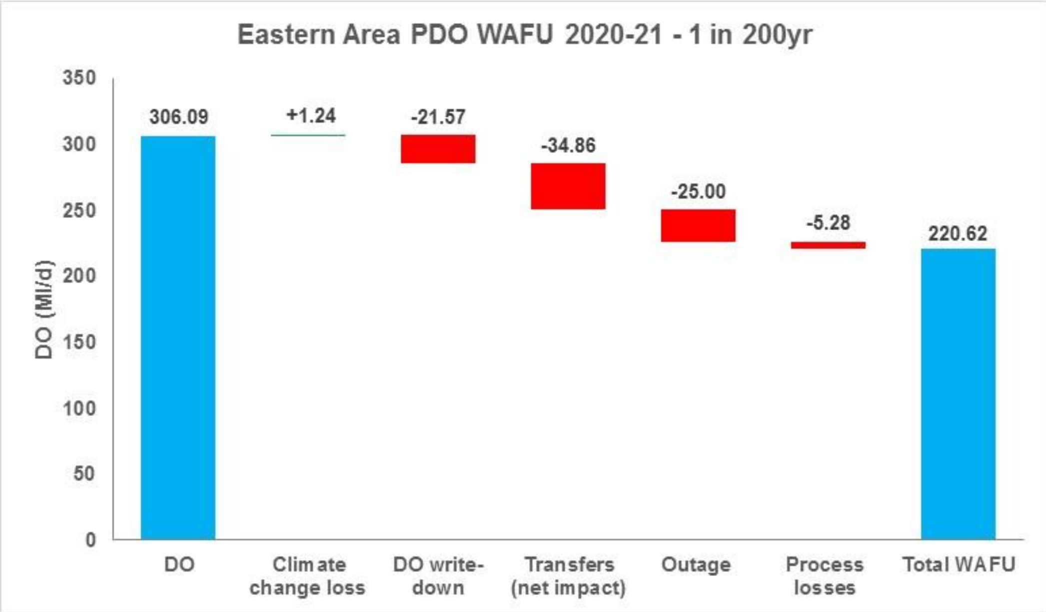

Figure 2D - Water Available for Use in the Eastern area at the start of the planning period for a 1-in-200 year drought at PDO.

Appendix 3: Our options appraisal process

The process of options appraisal is a gradual screening of a wide array of options to reach an optimum solution with a basket of robust options. It comprises the following key stages:

- Stage 1: Prepare supply-demand balance information.
- Stage 2: Develop a list of unconstrained options that takes account of government policy and aspirations.
- Stage 3: Undertake a problem characterisation and evaluate strategic needs and complexity.
- Stage 4: Decide on a modelling method.
- Stage 5: Identify and define data inputs to model(s).
- Stage 6: Undertake decision making (options appraisal) modelling.
- Stage 7: Carry out stress tests and sensitivity analysis.
- Stage 8: Produce a final planning forecast. This should include an Economics of Balancing Supply and Demand (EBSD) benchmark if using a different method to select options.

Unconstrained Options List

We adopted the following approach to ensure all relevant options were included in the unconstrained options list:

- Engaged with customers and stakeholders via pre-draft consultation (using a scheme preference online survey, willingness-to-pay research and scheme preference workshops) to elicit their views on the proposed options categories
- Published a notice in the Official Journal of the European Union (OJEU) to seek third party supplies
- Continued our active participation in Water Resources in the South East (WRSE), which is a group of regulators and other water companies whose aim is to identify regional solutions to water resources problems in South East England
- Conducted internal reviews of proposed options as part of the WRMP process.
- Consulted on the draft unconstrained list of options with the Environment Agency and Natural England

A total of 589 unconstrained options were considered

Constrained Options List

Through the screening process, we identified the constrained list of options and subjected it to a further screening process to ascertain whether they should be taken forward as feasible options that could reduce the supply-demand deficit in their respective WRZs. Screening of the constrained options list was based on the following:

- A Strategic Environment Assessment (SEA) and Habitats Regulation Assessment (HRA) were produced which summarise the environmental and social costs and benefits, and impacts upon European designated sites of each option. The SEA screening criterion illustrates:
  - the risk of adverse effects and where available, mitigation measures, and
  - the opportunity for beneficial effects resulting from the option.
- Links to other options such as mutual exclusivities and dependencies were identified
- Risks, including vulnerability of the option to future uncertainty relating to climate change impacts and regulatory changes, as well as the sustainability and acceptability of the option
- Phasing, i.e. whether the option can be constructed in a phased or modular way, which would increase its flexibility to be altered in response to future changes in the forecast supply demand balance
- Resilience, which is as an indication of the confidence that the option will deliver the required reduction in the supply demand balance deficit

A total of 396 options were included in the initial constrained options list.

Feasible Options List

The feasible list of options is a final screened list that has been tested on grounds of both monetised and non-monetised costs and benefits. A SEA and HRA was also produced which summarises the environmental and social costs and benefits, and impacts upon European designated sites.

The feasible list of options was taken forward into the investment model which was used to identify the best value solution in each WRZ. This, and subsequent decision-making processes were used to derive the portfolio of schemes that comprise the strategy for each area.

Appendix 4: Example of Scenario Testing to Identify Alternative Strategies (from draft WRMP)

We need to compensate for the loss of Deployable Output due to sustainability reductions in the Western area. As we cannot take any more water from the environment, the options for large-scale supply schemes are limited to desalination and water reuse. As part of our strategy for the area outlined in the draft WRMP, we proposed building a desalination plant at [redacted] to provide up to 100 Ml/d. There are several options to build the plant:

1. Incremental build; initially build the plant to 25 Ml/d capacity and then increase the capacity to 50 Ml/d in the second stage.
2. Incremental build; initially build the plant to 25 Ml/d capacity and then increase the capacity to 100 Ml/d in three further stages adding 25 Ml/d capacity at each stage.
3. Incremental build; initially build the plant to 50 Ml/d capacity and increase the capacity to 100 Ml/d in two further stages adding 25 Ml/d capacity at each stage.
4. Non-incremental construction to 50 Ml/d.
5. Non-incremental construction to 100 Ml/d.

Incremental construction costs more but it provides the flexibility to modify the scheme or select alternative options for different futures. The alternative options in this case are:

1. Indirect potable water reuse scheme at Budds Farm wastewater treatment works to provide 40 Ml/d.
2. Indirect potable water reuse scheme at Budds Farm wastewater treatment works to provide 60 Ml/d.
3. Indirect potable water reuse scheme at Portswood wastewater treatment works to provide 9 Ml/d.
4. Indirect potable water reuse scheme at Portswood wastewater treatment works to provide 13 Ml/d.
5. Indirect potable water reuse scheme at Woolston wastewater treatment works to provide 5 Ml/d.
6. Indirect potable water reuse scheme at Woolston wastewater treatment works to provide 8 Ml/d.
7. A combined indirect potable water reuse scheme at Woolston and Portswood wastewater treatment works to provide 20 Ml/d.

All incremental build options for the [redacted] desalination scheme were fed into the investment model along with the alternative strategies to select the option(s) that can meet demand at best value. A 100 Ml/d [redacted] desalination plant was selected as the most cost effective option.

As shown in Table 2, desalination is our customers' least preferred option. So while the model selected a 100 Ml/d desalination plant at [redacted], we did look into alternatives. One alternative was to limit the [redacted] desalination scheme to 50 Ml/d and instead develop a 40 Ml/d water reuse scheme by taking water from Portswood WWTW and releasing it in the river Itchen. However, there are concerns that release of water into the river may alter its natural flow regime with undesired consequences for aquatic life. It is also unclear if a monitoring regime can be put in place to mitigate the impacts of enhanced flow in the river. We have therefore opted to retain the 100 Ml/d desalination plant at [redacted] as originally selected by the investment model as the risks and benefits associated with the scheme are better understood.