Appendix D – Our Options

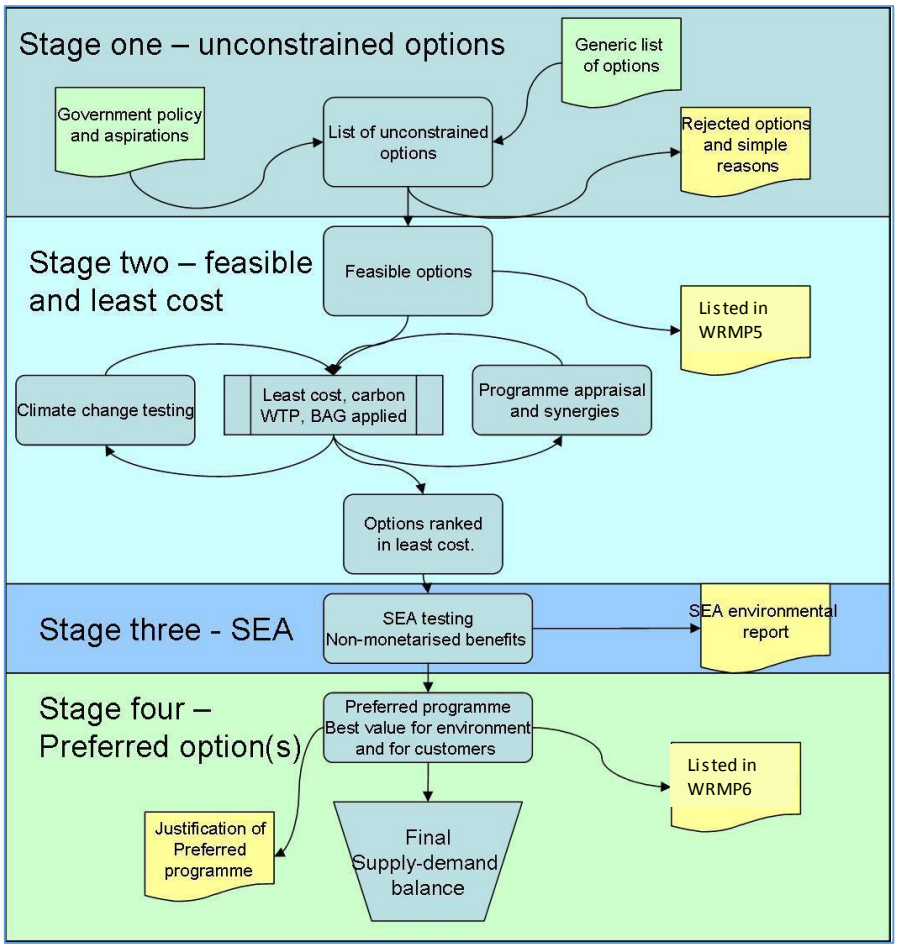
D1 Overview of our options appraisal process

An important stage in the water resources planning process is the identification and evaluation of the range of options we have available to us for managing the supply / demand balance over time. Our latest supply / demand balance challenge is larger than in any of our previous WRMPs. Our ability to respond to these challenges has been further constrained by statutory requirements to prevent future ecological deterioration, as required by the Water Framework Directive, thereby limiting our options for developing new sources of supply.

To meet these future challenges, we need to improve our supply capability by investing in expanding our water treatment and strategic distribution capacity, prioritising options that make use of existing water supply assets. We have followed a staged approach to establish and develop supply-side and demand-side investment options and subsequently carry out a decision making process as described in Appendix E.

Figure D1.1 illustrates the stages we go through to narrow down our list of possible investment options into the preferred programme presented in this WRMP. The process includes a Strategic Environmental Assessment (SEA) of the options and overall programme, willingness to pay (WTP) studies and economic appraisal using tools such as the Environment Agency's Benefits Appraisal Guidelines (BAG).

Figure D1.1: The stages of an option appraisal process



This appendix explains how we produced our unconstrained list of options and the screening process that we have followed. Chapter 6 of our Water Resources Management Plan summarises the preferred programme of options that we believe will provide a sustainable and best value solution to the long term water supply / demand balance challenges that we face. Descriptions of the social and environmental impacts of the full range of feasible options considered in our plan are provided in the accompanying Strategic Environmental Assessment (SEA) report.

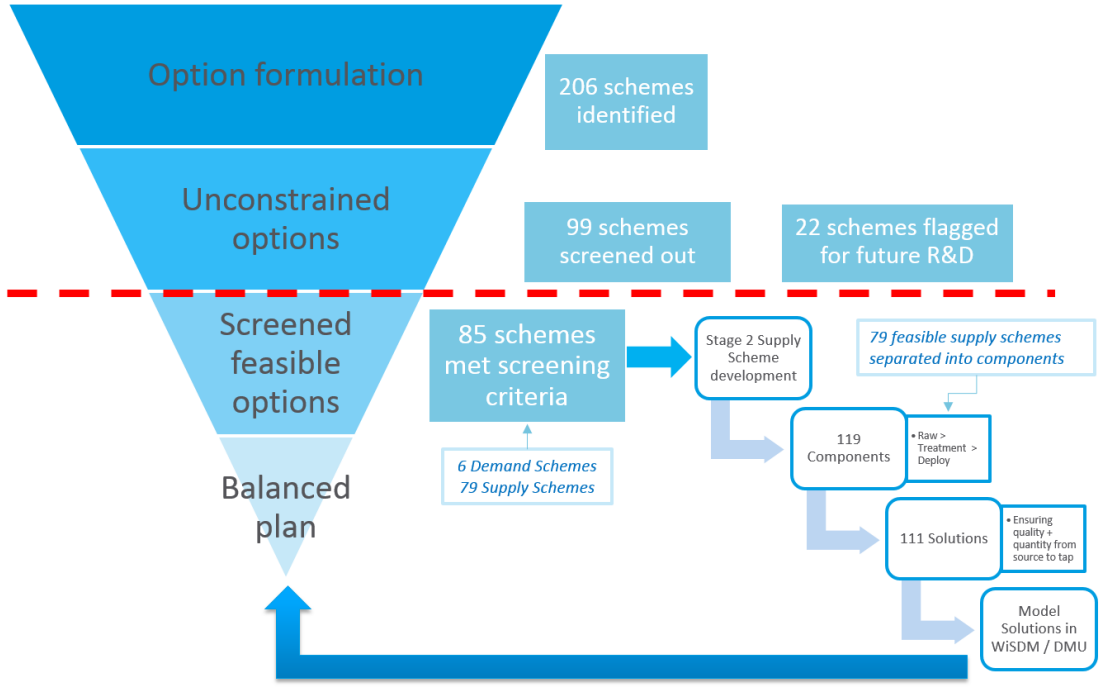
The first step of our options appraisal process was to carry out an initial assessment of a wide range of potential future supply-side and demand management options and a review of their viability. We used a screening process to exclude the least feasible options and to allow us to focus on those with the best potential for future development. The most feasible options were then taken forward for a more detailed engineering and environmental assessment.

The options appraisal process is at a strategic level and does not preclude the need for further analysis during the implementation of our plan. This strategic process is not a substitute for the detailed, option appraisal that would be needed to support site specific planning or abstraction consents.

The stages of this process have taken an initial list of 206 potential options to enhance water supply capability, and screened the potential options against a set criteria. This reduced the number of options to 85, of which 79 were supply-side related. During the next phase of option development, we sub-divided these feasible options into their raw water, treatment and deployment components. These 119 components were then engineered into 111 feasible supply options, representing the different ways that the components can be configured to deliver holistic source to tap supply solutions.

The stages of our screening process and how they have gradually reduced the number of options being considered in our final WRMP are illustrated in Figure D1.2 below.

Figure D1.2: The stages in our options appraisal process



Customer and stakeholder input was also critical to the option screening process. We sought the views of these parties through targeted workshops, bilateral discussions and the consultation stage of our draft WRMP in 2018. During the consultation phase for our draft WRMP in 2018, we received comments regarding different aspects of the supply-side options. Most comments were seeking more detailed explanation of the preferred options, in particular further supporting information on Water Framework Directive assessments, local environmental impacts and option delivery risks. Further clarifications were also requested regarding how our recommendations took account of changes to the Water Industry National Environment Programme version 3 (WINEP3), water trading, River Trent abstractions and the potential need to broaden the range of environmental considerations in our SEA.

Since publishing our draft WRMP, we have continued to investigate and develop all of the 'most feasible' options that were not screened out at the unconstrained options stage. We have also expanded our SEA to include a number of recommendations made through the consultation responses. These processes have resulted in an improved understanding of the costs, deployable output benefits, delivery risks and environmental impacts of the feasible options. In turn, our improved understanding has influenced our selection of the preferred programme of options and informed our PR19 Business Plan with the best available cost data. During this update process we have updated our assessment of long term supply / demand needs based on the outputs from WINEP3. We have also removed any options that have the potential to conflict with the water import and export proposals that were set out in the draft WRMPs of other water companies.

We have used this improved understanding of costs and benefits to update our appraisal of the supply / demand balance challenge and the investment required to satisfy different future scenarios. This allowed us to review the suitability of our preferred programme of options that we had outlined in our draft WRMP. Our review established that there is no need for any material change to the overall programme of new supply-side options set out in our draft WRMP. However, an adjustment was required to the scope and delivery timeline in order to meet WINEP3 objectives and to prevent conflicts with the WRMPs of neighbouring water companies. These adjustments have been incorporated into the preferred programme of options presented in this WRMP. We also introduced a mechanism to manage the risks, uncertainty and opportunity around delivering a number of these options.

During the consultation of our draft WRMP in 2018, several stakeholders asked for further explanation of the option appraisal process that we followed. The remainder of this chapter describes the types of options that were considered and explains the process we have followed to screen out the least feasible options. Appendix E also describes the techniques we have used to assess the challenges and determine the most appropriate investment approach.

D2 Unconstrained to constrained list of options

D2.1 Developing a list of unconstrained supply / demand options

During the early stages of developing our 2019 WRMP we identified a wide range of potential investment options that could be implemented to address projected supply / demand balance deficits over the 25 year planning period and beyond. These initial options were recorded in our list of 'unconstrained options'. Option formulation considered the potential to derive benefit from interventions categorised in one or more of the following areas:

- Leakage
    - Universal leakage reduction.
    - Targeted leakage reduction.
    - Do nothing new.
- Demand management
    - Improved water accounting through metering options (e.g. universal metering, meter installation upon change of occupier, incentivised metering, passive metering).
    - Water efficiency measures (e.g. incentivised, passive).
    - Financial measures (e.g. tariffs).
    - Do nothing new.
- Making more use of existing strategic assets and abstractions, for example options involving:
    - Improvements to existing assets with underused capacity/flexibility due to constraints posed by abstraction licences, treatment capacity, pipework constraints etc.
    - Improvements to existing assets where additional deployable output can be gained with relatively minor capital works.
    - Increasing capacity of sustainable existing abstractions (e.g. by modifying assets or abstractions, by changing the operational regime).
    - Transfer abstractions from environmentally unsustainable locations to locations where they are sustainable, e.g. by moving an abstraction point down-catchment to a location with greater flow.
    - Water quality improvements that have occurred, or are likely to occur, which affect river discharges from our waste water treatment works where these could be used to augment river flows and improve abstraction potential.
    - Developing transfers from areas of surplus to areas of deficit (e.g. with neighbouring water companies or within our water supply region).
    - Do nothing new.
- New supply options
    - Develop new water resources.
    - Water trading outside of the water industry.
    - Do nothing new.

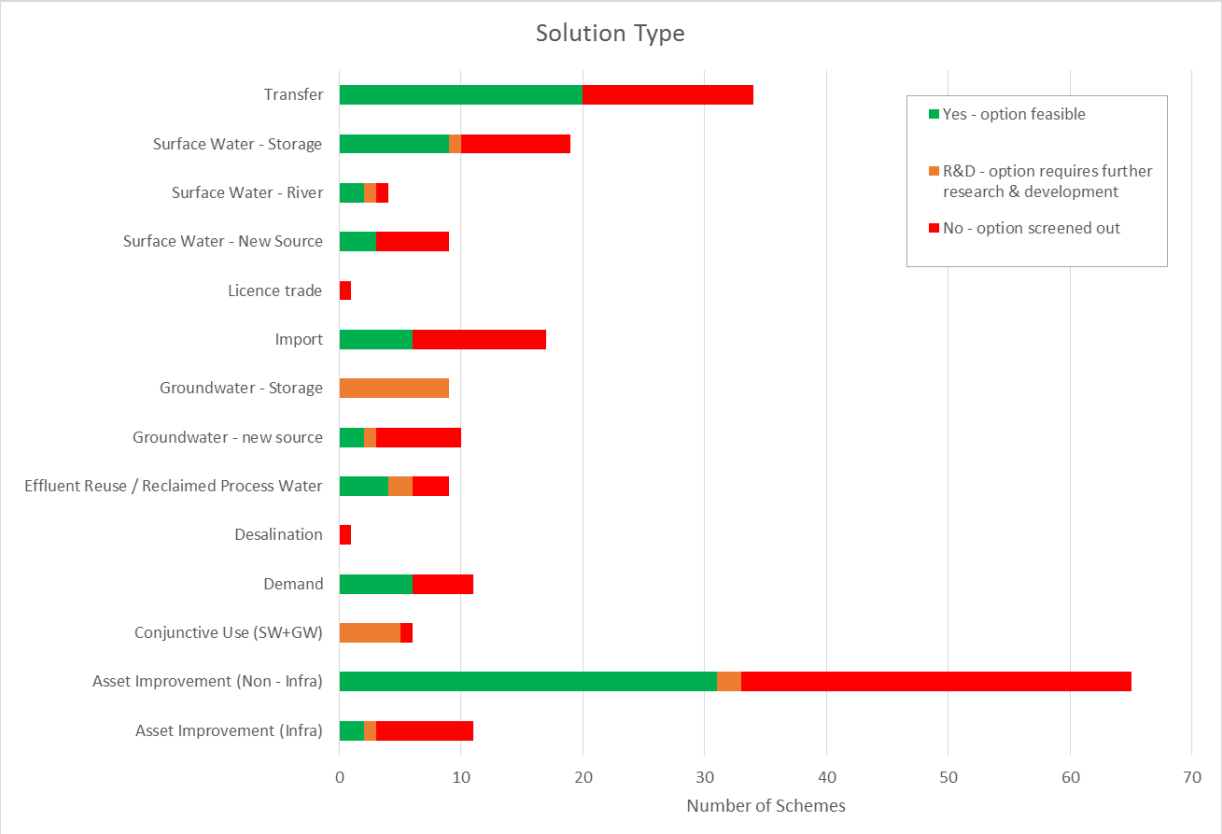
At the time that the initial unconstrained list was being developed, our detailed understanding of the future supply / demand balance needs of each of our Water Resource Zones (WRZs) had not been completed. Therefore, we developed a range of unconstrained options by considering those supply areas that we considered could be vulnerable to potential future changes in supply and demand for water. For example:

- WRZs where our extensive AMP6 Restoring Sustainable Abstraction low-flow investigations were indicating that we may need to reduce abstraction on environmental grounds.
- Areas supplied from sources which were identified in the Environment Agency's 2016 Sustainable Catchments data release as being likely to cause a future environmental deterioration and impact on Water Framework Directive status.

- Areas supplied from sources with current or projected water quality performance problems and where treatment or catchment investment is likely to be needed.
- Areas supplied from sources with current or projected supply performance or resilience concerns.
- Supply areas expected to see significant population and housing growth.
- Areas fed by sources thought likely vulnerable to drought and climate change, principally surface water sources where deployable output is linked to river flow or groundwater spring sources.

The range and type of unconstrained supply options that we identified through this process are illustrated in Figure D2.1.

Figure D2.1: Range of Identified supply-side unconstrained options



We collated a list of 206 initial options which had the potential to address the expected future supply / demand balance challenges. We had not assessed the feasibility, costs, benefits or environmental impact of these initial options at that stage; we had merely identified that they warranted consideration in the option screening and appraisal process. This formed our unconstrained list (or 'long list') of options.

Within the long list we formulated a list of potential water efficiency options that could be used to help customers reduce consumption, as summarised in table D2.1 and D2.2. One important difference in this WRMP planning period compared to our previous approaches has been the change in legislation around supplying non-household customers and the role of licensed retailers. Changes to the water market came in to effect on 1st April 2017, and mean that most businesses and non-household customers in England can now choose which company they want to supply their retail water services. The wholesale supplier of water no longer deals directly with these household customers, and instead it is the retailer who will offer services such as water efficiency to these customers. As a result, our previous water efficiency options to target non-household customers are no longer available to us, and instead we will engage with retailers to understand their water efficiency programmes.

Table D2.1: Range of identified demand-side unconstrained options

Type of scheme	Comment
New buildings Higher specification water efficient fitting as standard	Offer house builders advice on higher specification and more water efficient fittings in homes (A selection of taps, showers, WC, bath, water butts). Alternatively, we could offer a financial incentive/subsidy if there is an extra cost for installing fitting of a higher water efficiency specification.
Distribution of free water saving products	This is a continuation of our current policy to promote and provide water saving devices to all customers. This part of our current offer to meet our statutory water efficiency duty and regulatory water efficiency targets.
Domestic audit and retrofit including working with 3rd party partners	In addition to our own home audit and retrofit programme we will build partnerships with other organisations (e.g. social housing and energy efficiency providers) where partners install water efficient devices in customer homes on our behalf.
Education	Offering education to children and adults about the need for and benefits of using water wisely is a continuation of our current policy to promote water efficiency information to customers. This is part of our current offer to meet our statutory water efficiency duty and regulatory water efficiency targets
Rainwater harvesting / grey water reuse - retrofit domestic	Install rainwater harvesting / grey water reuse systems in existing domestic properties.
Rainwater harvesting / greywater reuse – new build domestic	Install rainwater harvesting / grey water reuse systems in new build domestic properties.

In addition to these water efficiency options, we have considered options to increase the uptake of domestic water metering.

Table D2.2: Range of identified demand-side unconstrained options (domestic metering)

Type of scheme	Comment
Compulsory household metering	Our supply area is not designated an area of serious water stress by the Environment Agency, and so we do not have legal powers to compulsorily meter household customers. However, we have tested whether such a policy could be cost beneficial.
Targeted accelerated metering programme with 'persuaded optants'	We would proactively install meters at property boundaries on a geographical basis and use the metered data to inform our network management and leakage targeting. We will engage with household customers and inform them whether they could have saved money had they been paying on a metered basis. Water consumption insight would also be used to target water efficiency activity.

D2.2 Options Screening Process

In line with the water resource planning guidance, we carried out outline feasibility assessment on the unconstrained list of potential options. This included assessment of programme constraints and the likely benefit to the supply / demand balance. We then applied a screening process to identify options that should be excluded from the next stage of the option appraisal process. Our previous WRMP in 2014 (WRMP14) used a series of high level questions that were used to screen out the least feasible options. These WRMP14 screening questions were based on technical guidance issued at the time by the Environment Agency, and they were developed with input from our stakeholders. For our latest options appraisal exercise, we used these WRMP14 questions as the starting point for our screening process, but we also derived a more detailed sub-set of questions that would help us to understand the likely issues, risks and concerns.

We shared these updated screening criteria with the Environment Agency and Natural Resources Wales at an early stage and we made some minor adjustments to the screening criteria on the basis of their feedback. At our September 2016 water resources stakeholder forum we shared our options screening approach, the screening criteria we proposed to use and the scope of our Strategic Environmental Assessment (SEA). We held breakout discussions on the proposed screening criteria and we sought views on our decision making framework. Following this engagement with regulators and stakeholders, we confirmed the screening criteria shown in Table D2.3, and we proceeded with the unconstrained options screening process.

We assessed each of the options on the unconstrained list against these screening criteria, and we recorded our decisions. We engaged the Environment Agency and Natural Resources Wales during the screening process to seek confirmation on our interpretation of possible environmental constraints, particularly with regard to the questions on abstraction licensing risk and potential Water Framework Directive impacts.

An overall negative response to any of the key questions meant there was a clear indicator of the option not being feasible and the option was screened out. Exceptions to this approach were when there was a compelling reason to take an option through to the feasible list.

Table D2.3: Unconstrained List of Options – Screening Criteria

Ref	Screening Criteria	Y / N
1	**Does the option address the problem?**	**Y / N**
	a) Is the scale of the option proportionate to the needs of the Water Resources Zone or area where there is a potential future shortfall?	Y / N
	b) Will the option have a high likelihood of being able to mitigate against future deployable output loss due to climate change impacts or licence changes to existing sources?	Y / N
2	**Does the option avoid breaching any statutory &/or regulatory constraints?**	**Y / N**
	a) Is the option likely to be acceptable in terms of planning and statutory environmental constraints local to the scheme (e.g. internationally or nationally designated sites), subject to any reasonable mitigation measures?	Y / N
	b) Does it cause serious damage or deterioration to the WFD water body? E,g. Category 1 and 2 Environment Agency's Achieving Sustainable Abstraction	Y / N
3	**Is the option promotable / does it meet customer and stakeholder expectations?**	**Y / N**
	a) Could this option have a negative impact on the customer experience at the tap? E.g. supply, pressure, water quality (taste, odour, discolouration), compulsory metering (customer complaints PR09)	Y / N
	b) Does the option compliment other parts of Severn Trent's business plan strategy and deliver wider benefits, e.g. supply resilience, quality and capital maintenance?	Y / N
	c) Is the option likely to be acceptable to local (non-statutory) stakeholder groups, subject to reasonable mitigation?	Y / N
	d) Does the option avoid customer discrimination or social equity issues?	Y / N
	e) Does the option clearly represent one of the more favourable development options for this specific source of water?	Y / N
4	**Do we have confidence that the option will succeed?**	**Y / N**
	a) Is the option scalable and operationally flexible to meet changing STWL supply/demand needs?	Y / N
	b) Is there a high level of confidence that the option will be technically feasible?	Y / N
	c) Is the option resilient under a range of external future scenarios? E.g. licence reform, water quality, climate change, political & legislative changes	Y / N
	d) Could the option deliver the benefits without the need for extensive trials, research and development?	Y / N
	e) Is likely that a Public Water Supply Abstraction licence be secured?	Y / N
5	**Is the proposed option subject to Welsh legislation?**	**Y / N**
	a) Does it satisfy Welsh Government's expectations for new water exports from Wales? E.g. the Future Generations & Wellbeing Act requirements?	Y / N
	b) Would the people of Wales be disadvantaged by this option?	Y / N
6	**Should the option be taken through to the Constrained List?**	**Y / N**

In January 2017 we issued the Environment Agency and Natural Resources Wales with our first iteration of a constrained list of options and our supporting assumptions. We then continued to work with the Environment Agency through 2017 to get their thoughts on the environmental or abstraction licensing considerations we need to give to the more feasible options. Environment Agency teams fed comments back during spring 2017, and their comments and data was used to inform our ongoing options screening and scoping process. As a result of Environment Agency input, six of these options were rejected / screened out, and a we refined the scope and design of a further 28 options to reflect concerns such as abstraction licence considerations, invasive non-native species risks, Water Framework Directive requirements and fish migration.

Using this screening and engagement process, we created our option rejection log, which summarises the reasons for excluding any options from our list of feasible options. Table D2.4 demonstrates the screening criteria and the qualitative assessment of 'Yes / No' responses and includes commentary on the screened options and the key reason for rejection in the free text comment column.

Table D2.4: Option Rejection Log

WRMP Ref	Option name	1 Does the option address the problem?	2 Does the option avoid breaching any statutory &/or regulatory constraints?	3 Is the option promotable / does it meet customer and stakeholder expectations?	4 Do we have confidence that the option will succeed?	5 Is the proposed scheme subject to Welsh legislation?	6 Should the option be taken through to the Constrained List?	Key Reason for rejection
1	Acton Trussell Borehole	Y	N	N	N	n/a	N	No 'Water Available' for Public Water Supply Abstraction Licensing.
5	Derwent Valley Transfer Main	N	N	N	N	n/a	N	Option unfavourable. Alternative options better utilise the Carsington raw water source and Site R treatment and deployment are preferred. Option may potentially cause a detrimental impact to an environmentally protected site.
6	Derwent Valley Storage Increase	Y	N	N	N	n/a	N	Option may potentially cause a detrimental impact to an environmentally protected site.
10	Beckbury Group increase	Y	N	N	N	n/a	N	Option may potentially cause deterioration under WFD.
11	Belper Meadows BH Recommissioning	Y	N	N	N	n/a	N	Option may potentially cause deterioration under WFD.
13	Buckshaft BH Conjunctive Use	N	N	N	N	n/a	N	Option no longer valid. Distribution upgrades completed in AMP5.
15	Cotswold Springs Recommissioning	Y	N	N	N	n/a	N	Option may potentially cause deterioration under WFD.
19	Elan Reservoir Expansion (Small Dam to Wye)	Y	N	N	N	N	N	Option may potentially cause a detrimental impact to an environmentally protected site.

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20	Elan Reservoir Expansion (Medium new dam)	Y	N	N	N	N	N	Option may potentially cause a detrimental impact to an environmentally protected site.
21	Elan Reservoir Expansion (High dam)	Y	N	N	N	N	N	Option may potentially cause a detrimental impact to an environmentally protected site.
23	SITE S Hydraulic Enhancement & Increase flow	N	n/a	n/a	n/a	n/a	N	Option not valid as there is no Deployable Output benefit.
24	New Pipeline from Elan to Site U	N	n/a	n/a	n/a	n/a	N	Option no longer valid - superseded by Birmingham Resilience Project.
26	Site N to Site G	N	n/a	n/a	n/a	n/a	N	Option not valid as there is no Deployable Output benefit. This is being considered for PR19 Resilience.
28	Hencott Borehole	N	n/a	n/a	n/a	n/a	N	Option may potentially cause a detrimental impact to an environmentally protected site.
35	Kenilworth BH Scheme	Y	N	N	N	n/a	N	Option may potentially cause deterioration under WFD.
36	Warley Tower (South Staffs) Link	N	n/a	n/a	n/a	n/a	N	Option not valid as water not available for Deployable Output under Business As Usual. Drought scheme only.
37	Purton WTW (Bristol Water) Link	N	n/a	n/a	n/a	n/a	N	No 'Water Available'.

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40	Monksdale BH Recommissioning	Y	N	N	N	n/a	N	Option unfavourable. Low confidence in Deployable Output benefit after treatment processes.
41	Nanpantan WTW Redevelopment	N	n/a	n/a	n/a	n/a	N	Option no longer available. The land has been sold off.
42	New WTW at Carsington	N	n/a	n/a	n/a	n/a	N	Option not valid - superseded by option 125.
43	New river WTW at Hayden (Gloucs)	Y	Y	N	N	n/a	N	Other more favourable options to utilise River Severn water are available. Unsuitable location and water quality risks due to proximity of wastewater treatment works.
46	New river WTW on River Idle	Y	N	N	N	n/a	N	No Water Available for Public Water Supply Abstraction Licensing.
49	Nottingham Groundwater	Y	N	N	N	n/a	N	No Water Available for Public Water Supply Abstraction Licensing.
51	Pinnock Springs Recommissioning	N	n/a	n/a	n/a	n/a	N	Option no longer valid. Abstraction Licence revoked as part of AMP6 Restoring Sustainable Abstraction Programme.
56	River Tame Resource Development	N	n/a	n/a	n/a	n/a	N	Option unfavourable for final effluent reuse. Minworth STW is prioritised for further development due to greater Deployable Output benefit.

WRMP Ref	Option name	1 Does the option address the problem?	2 Does the option avoid breaching any statutory &/or regulatory constraints?	3 Is the option promotable / does it meet customer and stakeholder expectations?	4 Do we have confidence that the option will succeed?	5 Is the proposed scheme subject to Welsh legislation?	6 Should the option be taken through to the Constrained List?	Key Reason for rejection
57	Buxton Resource Development	N	n/a	n/a	n/a	n/a	N	Option no longer available WTW closed down.
59	Lower Severn to Site C	Y	Y	N	N	n/a	N	Other more favourable options are available for achieving same outcome.
60	New Birmingham Trent Support BH	N	n/a	n/a	n/a	n/a	N	Option not valid - superseded by scheme 144.
62	Convert Short Heath BH to Potable Supply	N	n/a	n/a	n/a	n/a	N	Option no longer valid. Duplication - this is a sub option to scheme 12.
63	Stableford BH Recommissioning	Y	N	n/a	n/a	n/a	N	Option may potentially cause deterioration under WFD.
65	Stanton by the bridge/Milton Combined Trent Augmentation	N	n/a	n/a	n/a	n/a	N	Option not valid - superseded by scheme 64.
67	Severn Rail Tunnel to Gloucester	N	n/a	n/a	n/a	n/a	N	Option no longer available.
69	River Dane to Site L	Y	N	n/a	n/a	n/a	N	No Water Available for Public Water Supply Abstraction Licensing.
72	Rudyard Reservoir to Site L	Y	N	n/a	n/a	n/a	N	Option may potentially cause deterioration under WFD.
73	Naturalise Site L Compensation	N	n/a	n/a	n/a	n/a	N	Option not valid as there is no Deployable Output benefit.
74	Site G River Severn Winter Licence	N	n/a	n/a	n/a	n/a	N	Option no longer valid - superseded by Birmingham Resilience Project.

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75	Rivelin Raw Export Reduction	N	n/a	n/a	n/a	n/a	N	Option not valid. Duplication of scheme 169.
76	Expand Uckington BH Output	N	n/a	n/a	n/a	n/a	N	Option no longer valid. Scheme being delivered in AMP6.
85	Middle Severn Support Reservoir	N	n/a	n/a	n/a	n/a	N	Option not valid. Duplication of scheme 143.
86	SITE S to Site G Transfer Link	N	n/a	n/a	n/a	n/a	N	Option no longer valid - superseded by AMP6 scheme.
87	Bourne Augmentation (Coleshill)	Y	Y	N	N	n/a	N	Option unfavourable for final effluent reuse. Minworth STW is prioritised for further development due to greater Deployable Output benefit.
91	Wing to Hallgates new link main	N	n/a	n/a	n/a	n/a	N	No Water Available for Public Water Supply Abstraction Licensing.
92	Site A to Birmingham Trunk Main	N	n/a	n/a	n/a	n/a	N	Option no longer valid - superseded by Birmingham Resilience Project.
93	Strategic Grid Enhancement (Site A to Leicester)	Y	N	n/a	n/a	n/a	N	No Water Available for Public Water Supply Abstraction Licensing.
97	Blackbrook Reservoir Transfer	Y	Y	N	N	n/a	N	Option no longer valid. More favourable development for source of water.
98	D.O. Recovery at Existing GW sites	N	n/a	n/a	n/a	n/a	N	Option is not valid. Recovery of Deployable Output is a maintenance driver for PR19 investment.

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100	Clungunford Resource	Y	N	N	N	n/a	N	Option may potentially cause deterioration under WFD.
106	Whitchurch Zone Resource	Y	N	N	N	n/a	N	Option may potentially cause deterioration under WFD.
107	Rutland Link	N	n/a	n/a	n/a	n/a	N	No Water Available.
113	New Borehole nr. Chalford	N	N	N	N	n/a	N	No Water Available for Public Water Supply Abstraction Licensing.
115	Barr Beacon Bulk Import	N	n/a	n/a	n/a	n/a	N	Option no longer valid - superseded by Birmingham Resilience Project.
116	South Staffs Borehole Raw Import into EVA	N	n/a	n/a	n/a	n/a	N	Option not valid. Low confidence in continuous supply.
118	Elan-Wye Additional Augmentation	Y	N	n/a	n/a	n/a	N	Option may potentially cause a detrimental impact to an environmentally protected site.
119	Process water recovery	N	n/a	n/a	n/a	n/a	N	Option not valid. Duplication of scheme 99.
124	Dove Augmentation (Clay Mills)	N	n/a	n/a	n/a	n/a	N	Option unfavourable for final effluent reuse. Minworth STW is prioritised for further development due to greater Deployable Output benefit.
126	Wellesbourne Conjunctive Use	Y	N	N	N	n/a	N	Option may potentially cause deterioration under WFD.

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127	Ombersley to Site U transfer	N	n/a	n/a	n/a	n/a	N	Option no longer valid - superseded by Birmingham Resilience Project.
129	Bromsgrove GW Licence Transfer	N	n/a	n/a	n/a	n/a	N	Option no longer valid. Scheme being delivered in AMP6.
130	Lower Worfe BH Augmentation	Y	N	n/a	n/a	n/a	N	Option may potentially cause deterioration under WFD.
133	Weston Jones Pump Replacement	N	n/a	n/a	n/a	n/a	N	Option no longer valid. Scheme being delivered in AMP6.
136	Purchase Eyebrook reservoir and associated abstraction licence.	N	n/a	n/a	n/a	n/a	N	Option unfavourable. Alternative option (scheme 190) for better use of source water.
137	Purchase borehole and licence from RWE for borehole site near Rugeley	Y	N	N	N	n/a	N	Option may potentially cause a detrimental impact to an environmentally protected site.
139	Transfer water from Campion Terrace and/ or Lillington boreholes to Site C for treatment	N	n/a	n/a	n/a	n/a	N	Option not valid as there is no Deployable Output benefit.
140	NO LONGER AVAILABLE - licence revoked. Purchase	N	n/a	n/a	n/a	n/a	N	Option no longer available.

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	abstraction licence from EON/ Uniper for High Marnham site near Newark							
141	Provide sufficient supply to Site K during low flows so that we do not need the controversial Wyelands drought order	Y	N	N	N	n/a	N	No Water Available.
143	W.Midlands Raw Water Storage	Y	Y	N	N	n/a	N	Option not available in timescales required.
145	Desalination in Severn Estuary	Y	N	n/a	n/a	n/a	N	Option may potentially cause a detrimental impact to an environmentally protected site.
146	Vyrnwy back pumping scheme	Y	Y	n/a	N	n/a	N	Option no longer valid - superseded by newly developed solution VYR02.
147	Importing icebergs/ tankers of water from Northern European countries	N	n/a	n/a	n/a	n/a	N	Option not valid as water not available for Deployable Output under Business As Usual. Perceived as an extreme Drought option.
148	R. Severn Free flow scheme - increasing storage in Severn during low flows by	Y	N	n/a	N	n/a	N	Option unfavourable. Low confidence in asset ownership buy in, may potentially cause a detrimental impact to an environmentally protected site and

WRMP Ref	Option name	1 Does the option address the problem?	2 Does the option avoid breaching any statutory &/or regulatory constraints?	3 Is the option promotable / does it meet customer and stakeholder expectations?	4 Do we have confidence that the option will succeed?	5 Is the proposed scheme subject to Welsh legislation?	6 Should the option be taken through to the Constrained List?	Key Reason for rejection
	replacing fixed weirs with sluice (gates) and actively managing levels							deterioration under WFD. Alternative options available for better use of source water.
149	To purchase abstraction licence from GDF Suez for Rugeley power station near R. Trent - scheduled to close summer 2016	N	n/a	n/a	n/a	n/a	N	Option no longer available.
153	Develop next phase of (EA) Shropshire groundwater scheme (SGS)	Y	N	N	N	n/a	N	Option may potentially cause deterioration under WFD.
154	Consider use of currently disused reservoir at Witcombe	N	n/a	n/a	n/a	n/a	N	Option no longer available.
156	Purchase abstraction licence from EON/ Uniper for Drakelow on River Trent site near Burton on Trent	N	n/a	n/a	n/a	n/a	N	Option no longer available.
157	Re use effluent/ waste water from other waste water	N	n/a	n/a	n/a	n/a	N	Option unfavourable for final effluent reuse. Minworth STW is prioritised for

WRMP Ref	Option name	1 Does the option address the problem?	2 Does the option avoid breaching any statutory &/or regulatory constraints?	3 Is the option promotable / does it meet customer and stakeholder expectations?	4 Do we have confidence that the option will succeed?	5 Is the proposed scheme subject to Welsh legislation?	6 Should the option be taken through to the Constrained List?	Key Reason for rejection
	treatment works e.g. from Huthwaite, Trescott, Rugby							further development due to greater Deployable Output benefit.
160	Bestwood BHs	Y	N	N	N	n/a	N	No Water Available for Public Water Supply Abstraction Licensing.
161	Much Wenlock BHs	N	n/a	n/a	n/a	n/a	N	Option not valid. Duplication of scheme 193.
164	Rowington BH	Y	N	N	N	n/a	N	No Water Available for Public Water Supply Abstraction Licensing.
165	Shrewley BH	Y	N	N	N	n/a	N	No Water Available for Public Water Supply Abstraction Licensing.
167	Thelsford BH	N	n/a	n/a	n/a	n/a	N	Option not valid. Duplication of scheme 126.
168	Birmingham Road BH	Y	N	n/a	n/a	n/a	N	Option may potentially cause deterioration under WFD.
170	Obtain water network rail are currently pumping out from their tunnels as part of their dewatering options	N	n/a	n/a	n/a	n/a	N	Option unfavourable. Location is unsuitable for deployment into the Strategic Grid.
171	Bromsgrove/ Site G Conjunctive use-	N	Y	N	N	n/a	N	Option not valid as there is no Deployable Output benefit.

WRMP Ref	Option name	1 Does the option address the problem?	2 Does the option avoid breaching any statutory &/or regulatory constraints?	3 Is the option promotable / does it meet customer and stakeholder expectations?	4 Do we have confidence that the option will succeed?	5 Is the proposed scheme subject to Welsh legislation?	6 Should the option be taken through to the Constrained List?	Key Reason for rejection
	Henley to Redditch link main							
172	Tettenhall BH	Y	N	n/a	n/a	n/a	N	Option may potentially cause deterioration under WFD.
177	WE005 - Infrastructure charges	N	N	n/a	N	n/a	N	Option unfavourable. Proposed OfWAT policy would remove opportunity to deliver these schemes.
180	*WE008 - Compulsory metering programme	Y	N	N	Y	Y	N	Option is not valid. We are not in a water stressed area as defined by the EA so cannot compulsory meter our household customers. We are proposing a proactive metering strategy (enhanced metering).
181	WE009 - Non Household	Y	N	N	Y	Y	N	Option is not valid. This is a retail activity and need to better understand their plans for this activity as the market develops.
182	WE010 - BOPPS	Y	Y	N	Y	N	N	Option is not valid. Keep our BOPPS policy under review, especially if metering is increased.
185	Expand Lake Vyrnwy	Y	N	n/a	n/a	Y	N	Option may potentially cause a detrimental impact to an environmentally protected site.

WRMP Ref	Option name	1 Does the option address the problem?	2 Does the option avoid breaching any statutory &/or regulatory constraints?	3 Is the option promotable / does it meet customer and stakeholder expectations?	4 Do we have confidence that the option will succeed?	5 Is the proposed scheme subject to Welsh legislation?	6 Should the option be taken through to the Constrained List?	Key Reason for rejection
188	Recover WRMP 14 Strategic Grid DO losses	N	n/a	n/a	n/a	n/a	N	Option no longer valid. This regional option for the Strategic Grid is superseded by multiple specific supply options.
189	Consider use of currently disused BHs at Stanley Moor	Y	N	n/a	n/a	n/a	N	Option may potentially cause deterioration under WFD.
196	Birmingham Boreholes (Hockley sites)	N	n/a	n/a	n/a	n/a	N	Option not valid. Duplication of scheme 12.
197	Overton Scar Repeated Peak Demand licence over abstraction	N	n/a	n/a	n/a	n/a	N	Option not valid. Duplication of scheme 106.
199	Increase Rodmore output	Y	Y	n/a	N	n/a	N	Option unfavourable. Low confidence in Deployable Output benefit after treatment processes.
201	Thoresby Licence trade	N	N	n/a	n/a	n/a	N	Option not available as being utilised for the Restoring Sustainable Abstraction Programme.
206	WE011 - Water Reuse	Y	Y	N	N	N	N	Option is not valid. There are no viable options available and have discussed with the EA who agree. We sponsored an EngD at Exeter University investigating RWH and undertook a greywater reuse trial in social housing

WRMP Ref	Option name	1 Does the option address the problem?	2 Does the option avoid breaching any statutory &/or regulatory constraints?	3 Is the option promotable / does it meet customer and stakeholder expectations?	4 Do we have confidence that the option will succeed?	5 Is the proposed scheme subject to Welsh legislation?	6 Should the option be taken through to the Constrained List?	Key Reason for rejection
								properties. We will continue to review any new/innovative schemes and would adopt these at the earliest opportunity.

D2.3 Initial development of feasible options

Options remaining in the process following this screening exercise were suitable for detailed assessment and cost-benefit analysis, considering:

- Long-term totex.
- Willingness to pay for the option.
- Benefits of the option (following the benefits assessment guidelines).
- Climate change mitigation impacts including the cost of carbon.

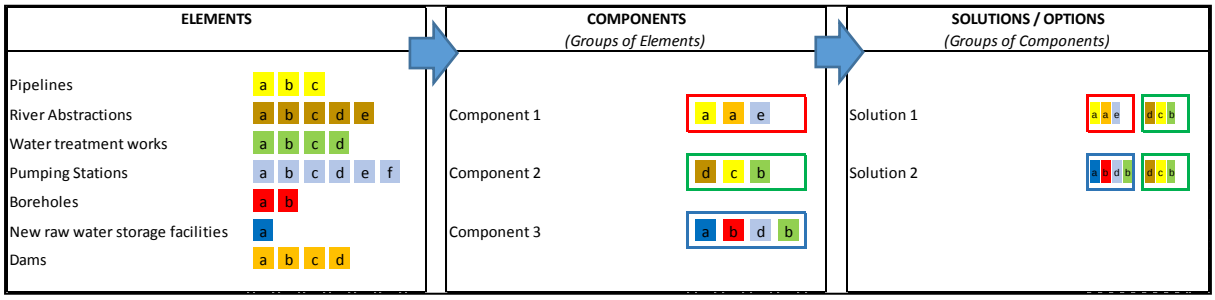
We adopted a standardised process for establishing the work or activities each option would entail to ensure that options remained comparable and any common interventions that existed across multiple options were considered in a consistent manner. This formed our strategic level feasibility assessment of the options.

Our approach to this feasibility assessment was to disaggregate the intervention activities required for each option into constituent parts, based on asset type. These parts were known as 'elements' and consisted of asset modifications, renewals or new provision of assets within the following element types:

- Pipelines
- River abstractions
- Water treatment works
- Pumping stations
- Boreholes
- New raw water storage facilities
- Dams

These option elements were closely aligned to the cost assessment process, mapped to our unit cost curves and enabling clear identification of items requiring bespoke cost estimates. Once our feasibility exercises had been completed at element level, we carried out two stages of re-aggregation to form the option (or solution) using the approach represented in Figure D2.2. This staged approach allowed us to ensure that our feasibility outputs remained appropriate as the elements were grouped together.

Figure D2.2: Standardised Planning Approach – Elements, Components and Solutions/Options



(This figure is diagrammatic only and does not intend to reflect actual elements, components or options)

Our process helped to reduce cost uncertainty by allowing a level of confidence to be assigned to each cost at an element level. Our approach has led us to develop a suite of options that are modular in nature, meaning that we do not need to commit to very long term construction projects and we can adapt our preferred programme as necessary over time.

Where appropriate we also sub-divided elements to provide the granularity necessary to derive detailed high-quality estimates of the operating costs. For example, water treatment process costs may be formed from:

- Non-variable operating cost
  For example: abstraction licence, bulk import availability fees, trading retainers, etc.
- Variable costs dependent on flow
  For example: power usage, sludge recycling, disinfection, ozonation, organics removal, metals removal, plumbosolvency treatment, UV treatment, etc.
- Variable, dependant on asset size but not flow
  For example: staffing, water quality analysis, hired and contracted services, routine inspection and maintenance, GAC regeneration.

Our standardised approach also included assessment of the deployable output from each options using our Aquator water resources model. The approach to modelling was to ensure that existing licences were not exceeded and that existing Hands-Off Flows (HOFs) were unaffected.

The resulting outcome from our standardised planning approach was a series of options which we are confident are assessed appropriately in terms of viability, cost and benefits. These option parameters were then incorporated back into our option appraisal process.

Table D2.5 shows the list of feasible options that we took forward for more detailed cost / benefit and SEA appraisal and that were then used in our investment modelling to inform our WRMP. In summary, through this unconstrained options screening stage we produced a list of 111 possible supply-side options.

Table D2.5: Feasible options (111 options)

Option Ref	WRMP Table – Option Type	Option Name	Option WRZ Location	Estimated WRZ benefit (Ml/d)	Delivery Period (yrs)	Final WRMP19 Preferred Option
GRD16	GW enhancement	Clungunford / Oakley Farm BH enhancements	Bishops Castle	2	5	-
GRD17	Bulk supply	Strategic Grid to Bishops Castle WRZ transfer solution	Bishops Castle	1.3	5	-
MIT01	Bulk supply	Site O WTW to Site K WTW raw water transfer main	Forest & Stroud	15	5	-
GRD15	Bulk supply	Whaddon (Strategic Grid WRZ) to Forest & Stroud WRZ transfer solution	Forest & Stroud	5	5	-
RAW07	Bulk supply	Potable water import to Kinsall WRZ at Whittington	Kinsall	1	5	-
BHS17	Bulk supply	Shelton WRZ to Mardy WRZ transfer solution adapting existing assets (Solution 1)	Mardy	3	5	-
BHS18	Bulk supply	Shelton WRZ to Mardy WRZ transfer solution using new assets	Mardy	3	5	-
GRD07	Bulk supply	Shelton WRZ to Mardy WRZ transfer solution adapting existing assets (Solution 2)	Mardy	1	5	-
GRD08	Bulk supply	Nottingham WRZ to Newark WRZ transfer solution	Newark	5	5	-
WTW01	Effluent reuse	New WTW on the River Trent near Little Haywood supported by raw water augmentation of the River Trent	North Staffs	13	10	-
BHS04	GW enhancement	Swynnerton BHs asset and water treatment enhancements	North Staffs	7	5	-
BHS09	GW enhancement	Elmhurst BH asset and water treatment enhancements	North Staffs	2	5	-
BHS10	GW enhancement	Elmhurst BH asset enhancements and transfer to Site L WTW	North Staffs	2	5	-
BHS13	GW enhancement	Croxton BH output increase and transfer to Hob Hill DSR	North Staffs	2.5	5	-
BHS14	GW enhancement	Croxton BH output increase and transfer to Hanchurch DSR	North Staffs	2.5	5	-
RAW01	SW new	Raw water import from Canals and Rivers Trust to Milford WTW	North Staffs	15	10	-
RAW17	Bulk supply	Carsington reservoir to Site L transfer solution	North Staffs	10	5	-
GRD11	Bulk supply	Site U WTW to North Staffs WRZ transfer solution	North Staffs	15	5	-
GRD13	Bulk supply	Potable water import to Peckforton and North Staffs WRZ	North Staffs	5	5	-
GRD18	GW enhancement	Peckforton Group BHs asset and water treatment enhancements	North Staffs	36	5	YES
UNK01	SW new	New WTW on the River Weaver near Nantwich	North Staffs	20	10	-
UNK03	SW enhancement	Support Site L WTW from the River Weaver	North Staffs	20	10	-
UNK07	SW enhancement	Improve Site L WTW outputs during low raw water periods	North Staffs	7	5	YES
DAM05	Reservoir enlargement	Site L Reservoir capacity increase (Size A)	North Staffs	5	5	-

Option Ref	WRMP Table – Option Type	Option Name	Option WRZ Location	Estimated WRZ benefit (Ml/d)	Delivery Period (yrs)	Final WRMP19 Preferred Option
DAM06	Reservoir enlargement	Site L Reservoir capacity increase (Size B)	North Staffs	14	10	-
WTW29	SW new	New WTW on the River Trent near Stafford, Staffordshire	North Staffs	22.5	10	-
GRD20	SW new	New WTW on River Dove near Uttoxeter supported by Carsington reservoir and deploying to Stoke (Size A)	North Staffs	18	15	-
GRD21	SW new	New WTW on River Dove near Uttoxeter supported by Carsington reservoir and deploying to Stoke (Size B)	North Staffs	27	15	-
GRD19	Bulk supply	DVA to Nottingham transfer pipeline capacity increase	Nottinghamshire	15	5	-
WTW28	SW new	New WTW on the River Trent near Stoke Bardolph, Nottinghamshire	Nottinghamshire	30	10	-
NOT01	Bulk supply	Ambergate to Mid Nottinghamshire transfer solution	Nottinghamshire	30	5	YES
NOT04	Bulk supply	Heathy Lea to North Nottinghamshire transfer solution	Nottinghamshire	25	5	YES
NOT05	Bulk supply	Site E to South Nottinghamshire transfer solution	Nottinghamshire	30	5	YES
GRD09	Bulk supply	Shelton WRZ to Ruyton WRZ transfer solution	Ruyton	1	5	-
GRD22	Bulk supply	Cross Wolverhampton strategic transfer solution	Shelton	10	5	-
SHE05	SW enhancement	Site M WTW expansion	Shelton	10	5	-
SHE06	Bulk supply	Site N to Shelton WRZ transfer solution (Low flow)	Shelton	10	5	-
WTW16	SW new	New WTW on the River Severn near Buildwas, Shropshire	Shelton	15	10	-
BHS16	GW enhancement	Much Wenlock BH treatment enhancements	Shelton	0.7	5	-
SHE01	SW enhancement	Site M WTW Expansion	Shelton	18	5	-
SHE02	Bulk supply	Potable water import to Shelton WRZ (localised)	Shelton	12	5	-
SHE03	Bulk supply	Potable water import to Shelton WRZ (WRZ wide)	Shelton	18	5	-
SHE04	Bulk supply	Site N to Nurton Transfer (High Flow)	Shelton	18	5	-
GRD01	Bulk supply	Site U WTW transfer to Wolverhampton and Telford WRZ	Shelton	21.5	5	-
GRD06	Bulk supply	Cross Wolverhampton strategic transfer solution	Shelton	15	5	-
BHS12	GW new	New GW source in the Hopton GWMU	Stafford	3.5	5	-
MIL01	GW enhancement	Milford BH output enhancements	Stafford	2	5	-
GRD05	Bulk supply	Leek to Stoke trunk main enhancements	Stafford	5	5	-
GRD10	Bulk supply	North Staffs WRZ to Stafford WRZ transfer solution	Stafford	7	5	-
GRD12	Bulk supply	Site Q WTW to North Staffs WRZ transfer solution	Stafford	7	5	-
BAM01	Bulk supply	Site R WTW to Ambergate pipeline capacity increase	Strategic Grid	7.5	5	-

Option Ref	WRMP Table – Option Type	Option Name	Option WRZ Location	Estimated WRZ benefit (Ml/d)	Delivery Period (yrs)	Final WRMP19 Preferred Option
BAM02	Bulk supply	Potable water import to Site R WTW with Site R to Ambergate pipeline capacity increase	Strategic Grid	60	5	-
BAM03	Bulk supply	Site R WTW to Grindleford pipeline capacity increase	Strategic Grid	7.5	5	YES
BAM04	Bulk supply	Site R WTW to Baslow pipeline capacity increase	Strategic Grid	20	5	-
BAM05	Bulk supply	Site R WTW to Ambergate transfer solution	Strategic Grid	50	10	-
CARSC01	Reservoir enlargement	Carsington to Site L, Site J and Site F WTWs	Strategic Grid	100	15	-
CARSC02	Reservoir enlargement	Carsington to Site L, Site F and Site E WTWs	Strategic Grid	100	15	-
CARSC03	Reservoir enlargement	Carsington to Site L, Site J, Site F and Site E WTWs	Strategic Grid	100	15	-
CLYWB01	Reservoir enlargement	Site U and Site P WTW upgrades supported by River Severn raw water storage capacity increase	Strategic Grid	90	15	-
VYR01	Bulk supply	River Severn raw water import to Site U and Site P WTWs	Strategic Grid	60	5	-
VYR02	Bulk supply	River Severn raw water import to Site U WTW	Strategic Grid	60	5	-
RIV01	Bulk supply	Potable water import to Chesterfield	Strategic Grid	20	5	-
LIN01	SW new	New source and treatment at Linacre reservoir	Strategic Grid	5	10	-
OGS01	SW enhancement	Site J WTW expansion	Strategic Grid	15	5	YES
LIT01	SW enhancement	Site F WTW expansion	Strategic Grid	10	5	YES
WIL02	SW enhancement	Site E WTW expansion and transfer main	Strategic Grid	21	5	-
WIL05	Effluent reuse	Site E WTW expansion and transfer main supported by raw water augmentation of the River Trent	Strategic Grid	35	5	YES
MEL23	SW enhancement	River Trent to Site Q WTW transfer with Site Q WTW enhancements	Strategic Grid	15	5	-
MEL29	SW enhancement	Carsington Reservoir support to Site Q WTW with Site Q WTW enhancements	Strategic Grid	26	5	YES
MEL37	Effluent reuse	Raw water augmentation of Staunton Harold Reservoir with Site Q WTW enhancements	Strategic Grid	5	5	-
MEL39	GW enhancement	BH raw water transfer to Site Q WTW with Site Q WTW enhancements	Strategic Grid	5	5	-
MEL41	SW enhancement	Site Q WTW enhancements with new supported abstractions from the River Derwent	Strategic Grid	15	5	-

Option Ref	WRMP Table – Option Type	Option Name	Option WRZ Location	Estimated WRZ benefit (Ml/d)	Delivery Period (yrs)	Final WRMP19 Preferred Option
MEL47	Effluent reuse	Site Q WTW enhancements supported by raw water augmentation of the River Trent	Strategic Grid	20	5	-
CRO04	SW enhancement	Blackbrook Reservoir to support Site B WTW	Strategic Grid	12	5	-
CRO05	SW enhancement	Thornton Reservoir to support Site B WTW	Strategic Grid	8	5	YES
CRO06	SW enhancement	River Soar to support Site B WTW	Strategic Grid	17	10	YES
CRO07	SW enhancement	Blackbrook Reservoir and Thornton Reservoir to support Site B WTW	Strategic Grid	17	5	-
WTW05	New reservoir	East Midlands raw water storage (Site CQ) including new WTW	Strategic Grid	45	10	YES
WTW06	New reservoir	East Midlands raw water storage (Site CHQ) including new WTW	Strategic Grid	45	10	-
WTW07	New reservoir	East Midlands existing raw water storage (Site ER) including new WTW and infrastructure	Strategic Grid	18	10	-
WTW08	SW new	New WTW on the River Severn near Ombersley, Worcestershire	Strategic Grid	15	10	-
BHS01	GW enhancement	Watery Lane BHs asset and water treatment enhancements	Strategic Grid	3	5	-
BHS02	GW enhancement	Waverly Road BHs asset and water treatment enhancements	Strategic Grid	2	5	-
BHS05	GW enhancement	Broomleys BHs asset and water treatment enhancements	Strategic Grid	1.1	5	-
BHS06	GW enhancement	Maximise deployment from Diddlebury WTW and Munslow BH	Strategic Grid	0.9	5	YES
BHS07	GW enhancement	Ladyflatte BHs asset and water treatment enhancements	Strategic Grid	2.7	5	YES
BHS11	GW enhancement	Haseley Spring source asset and WTW enhancement	Strategic Grid	2	5	-
BHS15	GW enhancement	Birmingham BHs conversion to potable supply	Strategic Grid	9	5	-
RAW02	SW new	Raw water import from Canals and Rivers Trust to Site C WTW	Strategic Grid	15	10	-
RAW08	Effluent reuse	Site C WTW output increase using additional and supported abstractions from the River Avon	Strategic Grid	10	10	-
RAW09	Effluent reuse	Site C and Site U WTW output increase using additional and supported abstractions from the River Avon	Strategic Grid	20	10	-
RAW11	Bulk supply	River Severn to Site C mutual support solution with supported River Avon abstractions - Size AA (Upper)	Strategic Grid	84.5	15	-
RAW12	Bulk supply	River Severn to Site C mutual support solution - Size BC (Upper)	Strategic Grid	78.5	15	-
RAW13	Bulk supply	River Severn to Site C mutual support solution with supported River Avon abstractions - Size CB (Mid)	Strategic Grid	79	15	-
RAW14	Bulk supply	River Severn to Site C mutual support solution with supported River Avon abstractions - Size DA (Lower)	Strategic Grid	64.5	10	-
RAW15	Bulk supply	River Severn to Site C mutual support solution - Size EB (Mid)	Strategic Grid	59	15	-

Option Ref	WRMP Table – Option Type	Option Name	Option WRZ Location	Estimated WRZ benefit (Ml/d)	Delivery Period (yrs)	Final WRMP19 Preferred Option
RAW16	Bulk supply	River Severn to Site C mutual support solution - Size FA (Lower)	Strategic Grid	44.5	10	-
DAM01	Reservoir enlargement	Stanford Reservoir capacity increase (Size A)	Strategic Grid	2.5	5	YES
DAM02	Reservoir enlargement	Lower Shustoke capacity increase (Size A)	Strategic Grid	2.5	5	YES
DAM03	Reservoir enlargement	Site A Reservoir capacity increase (Size A)	Strategic Grid	2.5	5	YES
DAM07	Reservoir enlargement	Site C Reservoir capacity increase (Size A) with transfer main from Site C WTW to Coventry	Strategic Grid	9	5	YES
DOR02	SW enhancement	Campion Hills WTW enhancements	Strategic Grid	2	5	YES
DOR05	SW enhancement	Site C WTW enhancements	Strategic Grid	8	5	YES
DOR07	SW enhancement	Site Q WTW enhancements	Strategic Grid	0	5	-
DAM11	New reservoir	West area new raw water storage with Site U WTW and deployment infrastructure upgrades	Strategic Grid	180	15	-
DAM12	SW new	New WTW on the River Severn near Ombersley with raw water imports into the River Severn	Strategic Grid	30	10	-
DOR08	SW enhancement	Site B WTW enhancements	Strategic Grid	3.6	5	YES
WTW30	SW enhancement	Site P WTW expansion	Strategic Grid	15	5	-
BHS03	GW enhancement	Preston Brockhurst BH asset and water treatment enhancements	Whitchurch & Wem	1.5	5	-
BHS08	GW new	New GW source in the Coven GWMU	Wolverhampton	3.5	10	-
UNK06	Bulk supply	Maximise outputs from Site N WTW	Wolverhampton	30	5	-

D3 Further development of the feasible options

Since we published our draft WRMP, we have continued to develop our understanding of the different feasible supply side options. These activities have improved confidence in the deliverability of considered options as well as an assessment of engineering viability. As a result, we have been able to better refine and improve confidence in the costs and deployable output benefits of each option.

Maintaining a consistent approach to the cost estimation across all options and option types is imperative to enable our decision making tools make appropriate and informed investment decisions. Our approach to generating our best central estimate of option costs has been carried out using one, or a combination, of the following cost datasets:

- **Standard options and asset model solutions:**
  Core to our cost estimation process is the Severn Trent Unit Cost Application (STUCA). This is our central cost repository which has, and continues to capture outturn project costs for all capital works that we carry out. We use this data to derive programme level average unit costs for the implementation of new assets and intervention activities. The unit costs, reduced to reflect the future cost efficiency challenges, are used to set target prices as part of our AMP6 procurement strategy. This provides consistency between AMP6 costs, our cost adjustment proposals and projected AMP7 delivery. Our process is well established having been used consistently for over a decade and previously reviewed and/or assured by third party specialists including Atkins, EC Harris, and Efficio. In addition, our unit costs and cost curves were used for our PR19 Business Plan and these were validated and benchmarked with proprietary cost information by Jacobs in early 2018.

- **Bespoke cost estimates:**
  In instances where our unit costs, cost curves or equipment lists are not available for certain assets that we have proposed within options, for example when proposing new innovative technologies, we have sought alternative methods of cost estimation. For these assets, direct costs have been estimated using frameworks, standard rates or 'bottom up' estimates obtained from our Asset Creation (delivery) teams and supply chain partners.

We have prepared our option cost estimates from the constituent parts of the option. As described in Section D2.3, options have been arranged from Components and in turn Elements. Elements represent individual asset units for the purpose of cost estimation and operational functionality. The total cost estimate for each option is the sum of the relevant Components and thus includes all associated Elements. Our approach has given a detailed build-up of costs with each estimate making best use of standard cost data and our own delivery costs.

Our estimated option costs include allowances for the contractor design fees meaning that we have design-and-build estimates for our options. We have also included our internal costs to procure, assure and manage the project, ensuring that customers are protected by appropriate supervision of the scoping, procurement and implementation process. An allowance for optimism bias has been included based our experience of the tender-to-outturn ratio of similar activities and guidance provided by the HM Treasury.

To estimate the operational costs of our options, we have collected actual cost data from our existing assets or other industry available records. These costs have been challenged based on the expected benefits from our ongoing or future improvement programmes. Future market trends for material expenditure are also considered to provide a robust, futureproof assessment of costs.

Appraisal of our cost estimation approach has not been limited to internal assessments and comparison. We have commissioned a further external benchmarking exercise by a third party to validate that our option costs remain competitive both inside and outside our sector.

The competitiveness and efficiency of our technical solutions is supported by the work carried by our consultants Atkins-ARUP and documented in a separate PR19 submission to Ofwat covering supply / demand and resilience workstreams. This approach has been through three levels of assurance to provide us with an appropriate level of confidence in our submission.

The focus of our options appraisal is a repeated assessment of costs, benefits and environmental impacts. We also considered the lifetime of each option, so that interim options could be used if necessary.

In formulating our preferred programme of options we have prioritised demand side measures over supply options. This is further supported by our approach to leakage targets within our WRMP.

We have used a variety of methods to understand the new and emerging future water supply / demand challenges and explore the available options to provide a sustainable and secure water supply to our customers into the future. This process included:

- Using our in-house expertise in hydrology, hydrogeology, ecology, engineering and economics to define and quantify risks and future supply / demand scenarios.
- Involving a number of specialist consultants and partners to help us develop the recommendations set out in our draft WRMP.
- Shared our emerging thinking with technical specialists at the Environment Agency,
- Engaged with expert stakeholders to understand their views.

A staged approach was carried out to progress options from conception through to development and subsequent appraisal. This has involved studying the individual asset areas (Elements) that each option involves. As the options are developed further there will be greater detail and design information for each option available.

We recognise the inherent value of our current assets and there has be considerable effort spent establishing ways of achieving even greater value from existing assets by carrying out appropriate modifications. In the assessment of all available options, we have invested in SEA, Habitats Directive Assessments and WFD compliance assessments to ensure environmental and sustainability aspects were understood.

Managing option uncertainty and risk

Since we published our draft WRMP we have continued to develop our understanding of the supply side options, prioritising the options that were either in our preferred programme or were close alternatives for the selected options. These activities have improved confidence in the deliverability of the options as well as providing an assessment of engineering viability. Each option has been assessed and assigned a risk rating across the following areas:

- Engineering
- Water Quality
- Environmental Assessment
- Land & Planning
- Constructability & Operation
- Legal
- Security

The risk rating for each parameter was combined and converted into a technical viability confidence rating for the options. Each option has been assessed for confidence in:

- Technical Viability
- Stated Deployable output benefit
- Time to benefit (Delivery programme)
- Cost

A standard methodology was applied to all options to assess confidence ratings and a confidence score and parameter tolerance level derived in accordance with the guidance 'Assurance Framework APR16 for OfWAT (Annex 5 confidence grades)'. These tolerance bands were then applied in our DMU model to derive the preferred programme of options as described in Appendix E of our WRMP.

Our WISDM investment modelling and the DMU sensitivity analysis, described in Appendix E, considered many different future scenarios and different outputs from the options based on the confidence scoring. This has allowed us to test how robust the selection decisions were to uncertainty around the delivery costs, the construction time and the deployable output benefit of each option. The sensitivity around these parameters were considered in the selection of the preferred programme of options for our WRMP alongside the future needs of our customers. In this manner, and balancing risk, we have prepared a preferred programme of options that we believe is achievable and will meet the needs of our customers.

D4 Water trading - Redacted

D5 Water efficiency and metering options

D5.1 Overview – Base Programme

In line with customer expectations, our statutory water efficiency duty and regulatory guidance we are committed to delivering a high quality innovative and effective water efficiency programme and we propose a base water efficiency programme as shown in Table D5.1

Table D5.1: Base Water Efficiency Programme

Period	Total Ml/d Water Saving	PCC impact (litres per person per day)
AMP 7	16.70	2.08
AMP 8	16.30	1.98
AMP 9	15.91	1.88

This programme compares to our AMP6 household programme of 18Ml/d. In AMP6 we also had an enhanced 7Ml/d non-household demand reduction programme targeted in to WRZ's (Strategic Grid and Nottinghamshire). As a result of the opening of the non-household retail market in England we stopped our non-household programme and increased household activity to make up the shortfall.

Changes to the water market came in to effect on 1 April 2017, and mean that most businesses and non-household customers in England can now choose which company they want to supply their retail water services. The wholesale supplier of water no longer deals directly with these non-household customers, and instead it is the retailer who will offer services such as water efficiency to these customers. Delivery of water efficiency with non-household customers is highlighted as a key opportunity and differentiator in the retail market, and as a result, our previous water efficiency options to target non-household customers are no longer available to us.

Despite requesting information to inform our WRMP, we have received no information on the proposed water efficiency activities of retailers operating in our supply area, though we will continue to monitor what is happening in that market and continue to engage with Retailers. As part of the options for our AMP7 plan and beyond we are reviewing opportunities to incentivise non-household water efficiency in a compliant way both in England and for our Welsh WRMP. (Note: only customers using >50Ml per year are contestable in the Wales). If non-household opportunities are developed these will be tested in AMP6.

In developing our proposals, we have made reference to:

- Environment Agency (EA) / Natural Resources Wales (NRW) Final Water Resource Planning Guidance.
- Defra Guiding Principles for water resource planning
- Water Strategy for Wales
- Waterwise Evidence Base Reports
- Market Transformation Programme
- Waterwise Water Efficiency Strategy for the UK
- Our own water efficiency programme and, consumption modelling forecasting analysis
- Water Strategy for Wales

We have also engaged with Environment Agency and Natural Resources Wales.

To inform our WRMP, we have assessed the viability of a range of potential water efficiency options:

- Providing free products to our household customers on request;
- Subsidising higher value water saving products for our household customers;
- Carrying out water efficiency audits and install water saving products in the homes of our household customers (Home Water Efficiency Check HWEC programme currently delivered by 3rd parties, testing insourcing options);
- Incentives for housebuilders to build new properties to 110 litres per person per or less;
- To work with social housing to carry out water efficiency audits and install water saving products in the homes of social housing tenants;
- To continue to provide education and advice to our household customers on how to use water more wisely;
- Rainwater harvesting / water reuse options.

Our base programme maintains the approach we have successfully followed in previous years:

- Free products on request for our customers,
- Subsidised higher value products on request for our customers,
- Advice to our customers on how they can use water more wisely,
- Carrying out water efficiency audits and install water saving products in the homes of our household customers.

D5.2 Our enhanced demand management programme

D5.2.1 Water efficiency options

Our WRMP includes additional household water efficiency activities that go beyond our baseline activities, and responds to the challenge given to us by customers and stakeholders. Under our proposed enhanced demand management programme, our projected PCC at 2045 is 113 litres per person per day (l/p/d) during a 'normal year', which sets a level of ambition that outperforms the target proposed in the 2018 National Infrastructure Commission report of 118 l/p/d.

We know that achieving this level of reduction is ambitious and will require significant partnership working with a wide range of stakeholders. Whilst we welcome the desire for further ambition, we also have to recognise the challenges of influencing consumer behaviour. We are currently actively engaging with the wider industry and DEFRA to explore what longer term national targets for PCC may be, in line with the proposals in the Government's 25 year Environment Plan in in 'A Green Future: Our 25 year plan to Improve the Environment' and the Governments call for evidence in setting National PCC targets.

The demand management benefits of metering and water efficiency have been modelled as part of our assessment of the supply / demand balance. Our expected demand reduction benefits are based on data from our own activities as well as taking the lessons learnt from other water companies who have already delivered extensive metering programmes.

When setting out even more stretching ambitions for PCC we need to recognise current customer choices. For example, during the hot, dry weather in summer 2018 customers chose to use extremely high volumes water, with the peak use equivalent to 100 l/p/d additional demand.

We recognise that achieving our WRMP normal year forecast target for 2045 of 113 l/p/d will require significant multi-stakeholder cooperation and enablers:

- Metering to help target activity and engage customers on usage.
- A national shift in attitudes and behaviours.
- Legislative / regulatory change (e.g. current Building Regulations permit houses to be built to 125 l/p/d (even optional standard is 110 l/p/d)).
- Mandatory Water efficiency labelling for products will be essential – we are working with Waterwise, the wider industry and DEFRA on this.

Driving towards even lower PCC targets cannot be achieved by the water industry in isolation. We need the participation of a wide range of stakeholders (such as Local Authorities, Housebuilders, Non-Governmental Organisations, Product Manufacturers) and customers. This need for wider stakeholder participation was also acknowledged by Government in their call for evidence on setting national PCC targets, who recognise that PCC reduction is not something the industry can achieve in isolation.

We continue to explore water re-use technologies and innovation. We are continuing to explore both rainwater and grey water reuse opportunities as part of our innovation programme including a community rainwater harvesting trial in 20 homes in Llys Rhysnant in Powys.

The activities that make up our enhanced demand management programme and will contribute to our ambitious PCC targets are as follows:

Home Water Efficiency Audits

We will carry out proactive water efficiency audits and install water efficient products in our customers' homes (HWEC) in targeted, geographical areas.

In addition to our baseline water efficiency programme our plan is to carry out a further 10,000 audits annually over a 15 year period. The size of the programme is finite and limited by the number of household customers and assumed uptake rates. We have trialled this approach during AMP6 and we currently see an uptake rate of approximately 20% which we expect to be maintained.

An additional 10,000 audits per year will deliver a further 1.34 Ml/d of savings per AMP.

Social Housing Water Efficiency Checks

We will deliver a HWEC programme working directly with social housing providers to help their tenants save water which will help more vulnerable customers by making their water and potentially their energy bills more affordable as they reduce their water consumption.

We have trialled working directly with social housing providers on a HWEC type programme which has proved successful so have included this channel within our delivery plan.

An additional 7,000 audits per year will deliver a further 0.94 Ml/d of savings per AMP.

This home audit approach is higher cost compared to simply providing products to customers on request, but it provides greater certainty that products are installed and that savings are being achieved as well as additional opportunities to engage customers to promote behaviour change for water efficiency and sewer blockage prevention. Our trial of this approach in 2015-17 has also shown that this approach is also popular with our customers. To keep costs down, we intend to roll this programme out area by area but we will also focus on areas with potential supply demand deficits first. In addition, trials to deliver home audits during

metering activity are being undertaken to explore opportunities to support more vulnerable customers all across the Severn Trent region by targeting those with high consumption or customers who are struggling to pay.

D5.2.2 Household metering

Our previous Water Resource Management Plans have set out an ongoing approach to household metering that has been led by customer demand for the free meter option. As a result, only around 42% of households in our region currently pay by meter. Our last WRMP projected that this would grow to around 70% by 2040 based on our current metering policy. Metering at this low level will not support delivery of our demand management ambition.

We have reviewed our metering strategy and the underlying assumptions, building on the learning from other water companies' recent experiences of metering and we have benchmarked the costs and benefits used to inform our approach. Three companies – Southern Water, Thames Water and Affinity Water – have undertaken large scale metering programmes since 2010 and have reported demand reductions of between 8% and 16.5%. Their experience supports the benefits of metering. We have also initiated an extended metering trial to gain even more confidence in our proposals.

We plan to increase the proportion of metered households to 65% in 2020-25, with full metering by 2035. This will require us to treble our current run-rate. Compulsory metering can still only be undertaken in areas classified by the EA as seriously water stressed. So, we aim to achieve our targets by installing meters proactively and offering customers the opportunity to switch based on information on what their measured bill would be. We recognise that this is an ambitious target which involves real risk, it is nonetheless, the best option for customers. We'll ensure that we do not invest customers' money unnecessarily and will reflect our actual expenditure through our ODI mechanism.

We expect the increase in meter coverage to deliver a demand saving of around 10Ml/d by 2025. This includes benefits from finding and fixing leaking supply pipes. Again, this involves risk since we have seen some evidence in summer 2018 of metered customers' usage being higher than non-metered customers. Anecdotally, this is driven by a mindset of "I'm paying for it, so I'll use it". We'll feed this into our analysis of how customer and community demands and expectations have changed and what impact this has on peak treated-water supply requirements.

To maximise the supply pipe leakage reduction opportunity, we are proposing to install meters externally at customers' properties' boundaries wherever possible. As meter technology develops, and over the course of the 15 year programme we would expect innovation in metering technology to help reduce the number of properties that can't be metered, through the use of smaller, non-intrusive clamp on meters and ultra-sonic flow meter technology. The roll out will be undertaken on a water resource zone basis, targeting the zones with the greatest supply and demand challenges first.

We have an ambition to achieve full metering coverage by the end of AMP9. However, recognising the need for innovation for us to reach 100% meter penetration we have assessed the materiality of the risks to our supply / demand balance should we not achieve our full meter coverage ambition. When assessing the benefits of a persuaded optant strategy we have taken a precautionary approach to the demand management impact of an average 10% demand reduction. Based on the benefits reported by other companies, we believe that achieving full meter coverage could deliver up to an 80Ml/d demand benefit. This is less than the 16.5% demand reduction reported by Southern Water, reflecting the fact that customers would not be forced to adopt measured charges. Our current thinking is that to secure the full 80Ml/d reduction would require us to

adopt an external metering policy and combine this with a policy of helping customers tackle supply pipe leakage on their properties.

We know that our historic approach to metering growth will not achieve our ambition to reach 100% coverage, proactively help customers reduce demand for water or support our leakage reduction targets. We have explored the costs and benefit of a range of different metering growth strategies that could accelerate the required pace of meter coverage. Options included:

- Continue current free meter optant programme (Optant),
- Change of occupier metering,
- Proactive metering (selective) and,
- Compulsory metering.

Free meter optants (Optant)

Maintaining historic metering growth strategies through a free meter optant approach would not support our ambition to reach 100% coverage, proactively help customers reduce demand for water or support our leakage reduction targets. Installing meters via a reactive, disparate programme is also less efficient. Meter optants are also likely to already be lower users or know they will pay less as a result of measured charges compared to rateable value despite the fact they may not actually be water efficient and therefore present limited demand savings. Free meter options will continue to be offered to customers to promote customer choice. During AMP7 we forecast optant rates of around 138K, with declining optant installations in AMP8 and AMP9 as the proactive (selective) metering programme will have already installed meters.

Change of occupier metering

When assessing options we took account of our Change of Occupier initiative from AMP5, which experienced high abort rates (refusal of fitting, refused access and missed appointments) and subsequently high costs. Base unit costs of £215 per meter installation rising to £276 per installation when factoring in abortive costs. A change of occupier approach also fails to recognise what our customers have stated around choice. If applied fairly to all customers, change of occupier metering does not allow us to prioritise or maximise delivery in the areas of greatest deficit, and would not support in depth understanding of changing water demand in our network through high installation density that a proactive area by area provides.

Proactive metering (Selective)

We have developed a proactive metering strategy that will accelerate the rate of meter coverage through AMP7 and AMP8 with options to get to universal metering by the end of AMP9. This is three AMP programme towards universal meter coverage. In developing options for the proactive meter roll out we have prioritised the programme on the basis of our supply / demand balance challenge. This means we will be targeting deficit areas early in the programme to maximise the benefits and offset sustainability reductions, mitigate for growth and delay potential supply side schemes. When developing the plan we have identified the priority areas for AMP7 as the North Staffordshire, Nottingham and Newark WRZs. The planned approach is for area by area installation programme to maximise efficiency of delivery. In addition to this targeted roll out, we are developing trials to deliver additional meter coverage through our planned infrastructure maintenance and renewal activity. We think this may reduce the whole life costs of the programme and potentially reduce customer impact. Given the views our customers have expressed (fairness, responsibility, leakage, behaviour change) and our learning from other companies as well as our own, we are intending to implement a ‘persuaded optant’ strategy in AMP7 - installing meters proactively and offering customers the opportunity (but not forcing) to switch based on information on what their measured bill would be. Our plan would mean by the end of AMP9 we will have full meter coverage, but not all customers will be billed by measured charges. We will closely monitor customer uptake rates as well as the demand reduction impacts this policy delivers.

Ahead of our AMP8 plan we will engage with customers, stakeholders and regulators to review options and potential benefits of pursuing a compulsory metering policy.

Compulsory metering

We do not currently have the power to implement a compulsory metering programme as we are not classified by the Environment Agency as a seriously water stressed area. When assessing this option the costs and delivery are the same as our proposed proactive (selective) metering programme, with the difference being customers would be forced to adopt measured charges rather than our proposed approach for 'persuaded optants'.

Table D5.2: Metering option costs and benefits

Option	Comments	Available option	Number of meters in plan	Cost per installation	Demand benefit
Optant	Customer demand led programme	YES	AMP7 138K AMP8 82K AMP9 16K	£205	10%
Change of occupier	Installation on change of occupier	YES	zero	£276	10%
Selective (proactive metering)	Area by area approach, non-chargeable install	YES	AMP7 359k AMP8 686k AMP9 428k	£205	10%
Compulsory	Area by area compulsory meter installation and charging	No (not classified as water stressed)	zero	£205*	10%

*costs as per proactive (Selective) metering model

Metering option selection

When assessing these future options to accelerate coverage we took account of our Change of Occupier initiative from AMP5, which experienced high abort rates (refusal of fitting, refused access and missed appointments) and subsequently high costs. If applied fairly to all customers, change of occupier metering does not allow us to prioritise or maximise delivery in the areas of greatest deficit.

We do not currently have the legal power to implement a compulsory metering programme as we are not classified by the Environment Agency as a seriously water stressed area. However, in our cost / benefit assessment the costs and delivery of compulsory metering are the same as our proposed proactive metering programme. The difference is under a compulsory metering approach, customers would be forced to adopt measured charges rather than our proposed approach for 'persuaded optants'.

Our ambition to increase meter coverage has been directly informed by our customers' views. They told us that metering, in their experience, encourages behaviour change, through more personal responsibility and creates the opportunity to save money. They have told us they strongly support interventions that encourage responsible use of water, are sustainable in the long term, offer value for money and are good for the environment. When presented with the options to help manage the supply / demand balance challenge, metering was the most favoured intervention. Customers also told us that metering is fairer and in line with

other utilities they receive and pay for. Our customers were also very clear about the need for choice, which is why we are proposing a persuaded optant strategy, rather than pursuing compulsory metering.

We have also listened to our stakeholders, and have taken account of the broader Government ambition for reducing demand for water and per capita consumption as set out in the 25 Year Environment Plan in 'A Green Future: Our 25 year plan to Improve the Environment'. We believe full meter coverage will support our wider demand management programme and help customers understand and manage their water use. Full meter coverage will be key to increasing our knowledge and understanding of changing water use across our network which is essential if we are to meet our stretching leakage targets.

We acknowledge that by using existing technologies and methods, no company has achieved this level of meter coverage (Southern Water have achieved 93% meter coverage, Anglian Water have achieved 88% meter coverage with 92% ambition by 2020 and 95% ambition by 2040). However, given the timeframe for delivery we also recognise the potential for innovation in more advanced metering technology, including non-intrusive metering and flow measurement that will provide additional options and opportunities to enable us to install meters in currently challenging locations. Advanced metering and flow measurement technology is already developing to the point that low cost non-intrusive flow measurement devices are a realistic opportunity over the timescale for our programme to help us reach the 100% ambition.

In terms of aspiration, our proactive metering plan is no different from other multi-AMP plans where we don't yet have the full delivery tactics because it is simply too early to establish these. Our new proactive metering trial will help us fine tune our AMP7 implementation tactics and prepare for the significant increase in metering activity – particular areas of focus are; demand impact; communications; meter and meter reading technology; leakage impact; meter location, and; existing pipe material 'hot spots'.

Our innovation team is also investigation options associated with advanced metering technologies. Assessing a range of meter technologies is a key component of our proactive metering trial. This insight will be used to refine our delivery plans and ensure we are selecting the right level of meter technology to maximise the demand management benefits.

Based on current technology and processes, and the metering programmes already delivered (93% Southern Water) or planned by other water companies (95% Anglian Water) we believe that ambitions beyond 95% are realistic with innovation. A shortfall of 5% would only equate to a 4 Ml/d deficit in our forecast demand savings, which, when spread across our entire region would represent an increase of 0.4% on household demand, or the equivalent of 1.06 litres per household. Close monitoring of the programme will allow us to continually assess the likely impact and develop to mitigate any shortfall. One example may be bespoke in home audits, advice and devices including leak alarms for properties we are unable to meter.

In our PR19 Business Plan we have included an AMP7 Outcome Delivery Incentive (ODI) around our metering proposals. This ODI is designed to protect customers from the uncertainty of achieving the increased meter installation rate described in our WRMP. The design of the ODI means that customers' AMP7 bills will reflect investment for around two-thirds of the 2020-25 meter volumes included in the WRMP. The remaining one-third will be reflected in bills at the end of the 2020-25 period (i.e. effectively customers will be paying for these meters in arrears rather than upfront). We will report annually on progress with delivering our meter installation target.

The metering ambition described in the WRMP is not affected by the ODI mechanism. The leakage and demand management strategy described in our WRMP is based around delivering our proactive metering programme. Our performance commitments around leakage and per capita consumption also reflect the

outcomes of the full metering programme. However, the ODI mechanism means that our PR19 plan will not include the up-front investment associated with the full metering programme. As we report on annual progress, we will build the learning into our adaptive planning.

Both through our metering installation trial in AMP6 and through the yearly monitoring of the programme in AMP7 we will closely monitor installation rates and progress with the roll out. We will report on progress annually and the installation rate will link directly to our ODI measure around metering. The risks around the metering delivery programme also link to our PR19 water resources investment uncertainty mechanism, and we will review progress with our overall water supply / demand programme throughout AMP7. We will maintain an ongoing review of both the long term climate change driven supply / demand needs and the risks around our delivery programme, and if necessary we will revise our long term investment plan to accommodate the latest information. In Appendix E we describe our approach to managing long term uncertainty and assessing potential alternative programmes of long term investment.

We believe this metering approach complements our 'no-regret' package of leakage, metering and demand management measures. We would follow an area by area approach, targeting the water resource zones with the greatest supply/demand deficit (Nottingham, North Staffs and Strategic Grid). This will complement our longer term plans for new water source development, as we want to (and will need to demonstrate to planners and regulators that we have) fully explored options to manage water demand before we seek to develop new sources of water.

The Chester WRZ, which was previously in the Dee Valley Water, is now part of Severn Trent. Based on the views of stakeholders we have aligned the metering plans for former the former Dee Valley area with those of Severn Trent. As there is no projected supply / demand deficit forecast in that zone, proactive metering will take place toward the end of programme in AMP9.

As a result of this metering policy change, we expect the rate of meter coverage to accelerate in AMP7 and we aim to have achieved full coverage by the end of AMP9. We have considered the cost / benefit implications of a range of metering delivery profiles, and we have tested different options for increasing the pace of delivery and for prioritising which zones to focus on. The expected meter coverage that our recommendation will deliver is set out in the Table D5.3 below.

Table D5.3: Household meter installations and coverage per AMP

Period		AMP7	AMP8	AMP9	AMP10
Current metering policy	Number of meter installations	148,309	134,424	121,935	110,684
	%age of households metered by end of AMP	55%	60%	65%	69%
Recommended new metering policy	Number of meter installations	496,899	768,177	443,743	0
	%age of households metered by end of AMP	65%	88%	100%	100%

We believe that there are wider demand management benefits that will result from increasing metering coverage, especially if we target the delivery on a geographical basis. In particular, we view the need for increased meter coverage to be a crucial enabler to delivering our very ambitious leakage reduction strategy. Currently around 57% of our household customers are not metered, and that means we have to estimate their consumption when we monitor leakage performance on our network. That makes it very difficult to distinguish changing consumption patterns from any leakage breakout on our network.

By increasing the number of metered properties on our network, we will have greater visibility of changing water demand patterns and better control of our network performance. This will make leaks easier to detect, and will mean we are able to deploy leakage repair more effectively and efficiently. This improvement in leakage detection and repair performance will be crucial to us achieving our challenging 15% leakage reduction target in AMP7 and our long term ambition to reduce leakage by 50% by 2045.

D5.2.3 Climate Change Impacts on Demand options

Our WRMP uses demand forecasts that reflect our assumptions around 'dry-year' demand for water, and so they reflect the impacts of hot, dry weather conditions on customers' water consumption. We also make a further allowance for the likely climate change impacts on household water consumption using the data and guidance given in UKWIR 13/CL/04/12 Impact of Climate Change on water demand. In the UKWIR study, median percentage climate change impacts on household demand at 2040, relative to 2012 are published for each river basin within the UK - the Severn and South Humber basins are used for Severn Trent. For our WRMP, the annual average forecasts use the average of the factors for these basins, therefore have a 0.905% increase in consumption over that period. As the base year for our modelling is now 2015/16 and the final forecast year is 2044/45 the percentage change is shifted along as there has been no further evidence since this report.

As per the UKWIR technical guideline, the additional demand caused by climate change has been added to the external use micro-component only, which means that the overall effect is relatively small. Table 6 of the WRMP data submission (Customer side management) shows the volumetric demand management benefit of our metering strategy and includes a climate change impact equivalent to 0.9% by 2045. The annual percentage impact profile is as per line '27- Percentage of consumption driven by climate change' in Table 3.BL.

Consistent with the conclusions of the UKWIR study, because the impacts of our water efficiency activities on our demand forecasts already reflect the impacts of hot, dry weather any additional effects of climate change are small and only apply to external use of water. Therefore, in our WRMP we assume that climate change have no impact on our internal household water efficiency measures

Table D5.4: Climate change impact on demand management

Period	2020-25	2025-30	2030-35	2035-40	2040-45
Climate change impact on demand management options	zero	zero	zero	zero	zero

Greenhouse Gas and Carbon effects of Demand Management Options

Our draft WRMP included an assessment of the greenhouse gas emissions associated with our supply side schemes, but it did not explicitly consider the greenhouse gas effects of the demand management measures.

For the final WRMP we have undertaken additional work to quantify the greenhouse gas emissions associated with our demand management schemes. We considered the embedded carbon associated with the demand management products, and the operational carbon associated with travelling to and from customers' properties plus the benefits of reducing the amount of treated water put into supply.

The carbon components considered are as follows:

- Embodied carbon of the scheme/option.
- Scheme/option ongoing carbon – assumed future component replacements/repairs, as a result of implementing the scheme
- Congestion Carbon – CO2 emissions as a result of anticipated travel and congestion associated with the scheme.

For each of these components the tonnage of CO2 is quantified and monetised[1] to enable the carbon impact to be assessed for each investment option. The demand side investment options are:

- Active Leakage Detection
- Metering Policy
- Water Efficiency Programme Options

Table D5.5 below presents the individual GHG components and measures quantified for each demand side investment option. The following caveats have been made in the current AIC/AISC calculations shown below in the table.

- The AIC/AISC and Tonnage/Cost values shown below are taken from Strategic Grid WRZ, except the Water Efficiency Programme which is at company level.
- The SDB leakage profile has been used for the Active Leakage Control AIC/AISC calculation.
- Both ALC and Metering Policy AIC/AISC's have been calculated over 80 years. However, the Water Efficiency Programme AIC/AISC has been calculated over 15 years.
- Carbon Assumptions still need to be finalised for Metering Policy and Water Efficiency Programme.

[1] The assumed cost of carbon used in the assessments was 48.76 £/tCO2e

Table D5.5: Modelled GHG Components for Demand Side Investment Options

Option	GHG Component	Tonnage	Cost (£)	AIC (p/m^3)	AISC (p/m^3)
Active Leakage Detection	Carbon (Detection Hours)	5,057	£246,623	76.60	105.73
	Carbon (Additional Repairs)	261,151	£12,733,741		
	Additional ALC Repairs Congestion	6,591,085	£321,381,328		
Metering Policy	Embodied Carbon – Install	12,226	£596,174	236.72	317.47
	Embodied Carbon Replacement (15 year AL)	12,580	£613,413		
	Carbon – Congestion	776,510	£37,862,664		
	Ongoing Carbon	1,456	£71,038		
Water Efficiency Programme - Baseline	Embodied Carbon – Devices	866	£42,263	133.67	178.68
	Carbon - Congestion	197,079	£9,609,598		
Water Efficiency Programme - Enhanced Delta	Embodied Carbon – Devices	273.4	£13,330	30.29	47.54
	Carbon - Congestion	76,454	£3,727,937		

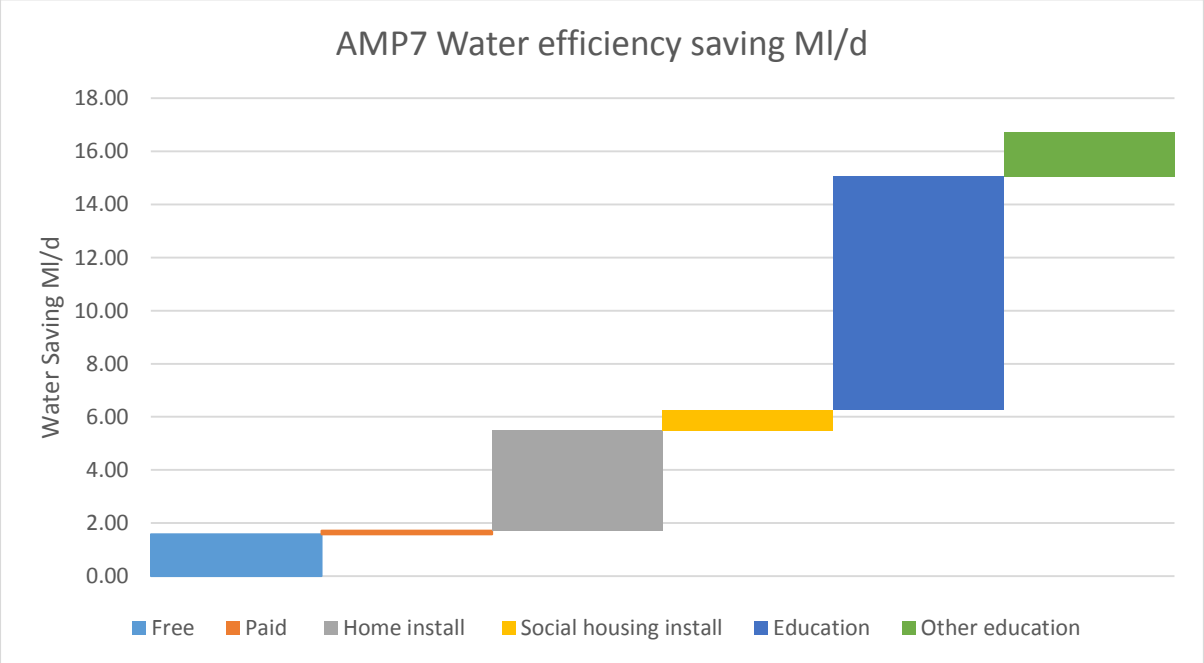
D5.3 Revisions to demand saving assumptions

Through more accurate measurement of the water savings from our activities we are now more confident in the levels of savings we can forecast for our AMP7 water efficiency programme. We have used our AMP6 water efficiency programme to re-assess the savings we previously assumed from our water efficiency activity. This has included using measured savings and information from our current home water efficiency audit and install programme (HWEC) and surveys by our free product supplier. This has resulted in a small reduction in the savings we forecast compared to our old assumed water savings. The impact of these changes is shown below in Table D5.6 and Figure D5.1:

Table D5.6: Water saving assumptions

Period	Total Ml/d Water Saving (previous water saving assumptions)	Total Ml/d Water Saving (revised water saving assumptions)
AMP 7	20.06	16.70
AMP 8	19.39	16.30
AMP 9	16.31	16.91

Figure D5.1: AMP7 water efficiency saving Ml/d



D5.4 Decay of savings

Our improved understanding of the amount of water saved through our different water efficiency activities has also helped us to understand how the potential for future savings will likely decay over time. This is because:

- Over time, customers will replace their existing water fittings with more modern and efficient fittings. For example, the Market Transformation Reports conclude that existing toilets and taps will be replaced with more efficient models. The lifespan (replacement rate) of products ranges from 15 – 25 years, e.g. toilets have been assessed as 15 years, taps 25 years, which will limit our opportunities for installing cistern displacement devices (CDDs) and retrofitting WCs to dual flush or flow regulators. In our baseline demand forecasts we assume reductions in consumption from technology and behaviour

change, therefore decaying savings from retrofit products ensures we do not double counting savings.
- The product life of retrofit products.
- Customers removing retrofit items.

We use different decay rates for different approaches (Table D5.7). We have based these decay rates with reference to:
- Waterwise evidence base reports
- Revisiting the long term benefits of our previous water efficiency install programme

Table D5.7: Percentage decay of previous year's savings

Approach	% decay of previous year's saving
Free products	5.50 %
Paid/Subsidised products	1.25 %
HWEC/ Metering Teams	5.50 %
Infrastructure charges	0.00 %
Education	5.00 %

D5.5 Water efficiency options not taken forward

The following options were included on our unconstrained list, but have not been taken forward in our draft WRMP.

Infrastructure Charges

During AMP6 we have investigated options to incentivise developers to build new houses to more water efficient standards to 110 litres person day or less through a discounted infrastructure charges scheme. As an option this is high cost for low benefit, and is dependent on the outcome of an OFWAT consultation on proposed changes to new connections charges. It is anticipated this option will no longer be viable in future.

Water Reuse

Although we are still committed to testing and trialling domestic water reuse options (grey water and rain water) there are currently no commercially viable household retrofit options and new build solutions could only be undertaken by developers. Alternative water sources and reuse could feature as options in future if new technologies are developed however at this stage there is no certainty around the required technology. Instead, we propose to investigate this option on an R&D basis in the short to medium term.

In AMP 5 and 6 we have undertaken rainwater harvesting and grey water reuse trials in an attempt to open up this opportunity. In partnership with a Social Housing provide we trialled a novel greywater reuse system in ten new build properties. For rainwater harvesting and reuse we sponsored and Engineering Doctorate at Exeter University to investigate conventional and novel low cost rainwater harvesting systems. Although there are no viable retrofit systems available currently, we will be using the outcome of the research to continue R&D studies to investigate these opportunities, focusing on the potential dual benefits of active attenuation and water reuse offered by these systems.

D6 Our recommended supply options

The latest supply / demand balance challenge identified in this WRMP is larger than in any of our previous WRMPs. Our ability to respond to these challenges has been further constrained by statutory requirements to prevent future ecological deterioration, as required by the Water Framework Directive, thereby limiting our options for developing new sources of supply.

To meet these future challenges, we need to improve our supply capability by investing in expanding our water treatment and strategic distribution capacity, giving priority to solutions that make use of existing water supply assets. The supply-side and demand-side investment options that we have considered are described in Section D2 and the decision making process to determine our preferred programme of options is included in Appendix E. Our WRMP proposes a number of water supply-side options to enhance our supply capability, and to replace sources of unsustainable abstraction. These options form part of our long term package of supply and demand measures to balance supply and demand.

A summary of the preferred programme of options is provided in this section. More information about the environmental and social impacts of these options is included in the Strategic Environmental Assessment that accompanies this WRMP.

Our preferred programme of options has been adjusted since we published our draft WRMP in December 2017. We have used our improved understanding of costs and benefits as described in Section D2 to update our appraisal of the supply / demand balance challenge and the investment required to satisfy different projected future scenarios. We have also considered and acted on the comments we received during the consultation process as part of this updated appraisal. This allowed us to review the suitability of our preferred programme of options that we had outlined in our draft WRMP. Our review established that there is no need for any material change to the overall programme of new supply-side options set out in our draft WRMP. However, some changes to the scope and delivery timeline of our preferred programme of options is required in order to meet WINEP3 objectives and to prevent conflicts with the WRMPs of neighbouring water companies. We have also introduced a mechanism to manage the risks and uncertainty around delivering a number of these options.

The adjustments made to the preferred programme of options since we published our draft WRMP comprise:

- Substitution of two options with two materially identical options of an alternative scale.
- Inclusion of a new option to supplement the outputs of two existing options already within the preferred programme of options.
- Removal of two options.
- Adjustments to the timing and programme for the delivery of the options.

Figure D6.1 illustrates the changes to the programme of options between our draft and final WRMP. The figure shows all of the proposed supply-side options that featured in our draft WRMP and compares them with the options which now feature in our final WRMP. The figure shows the option name, deployable output benefit and the delivery timing of each option in the preferred programme. The blue bars represent the preferred programme of options in our draft WRMP whilst the orange bars represent the revised preferred programme of options in our final WRMP.

Figure D6.1: Comparison of our preferred programme of options between our draft and final WRMPs

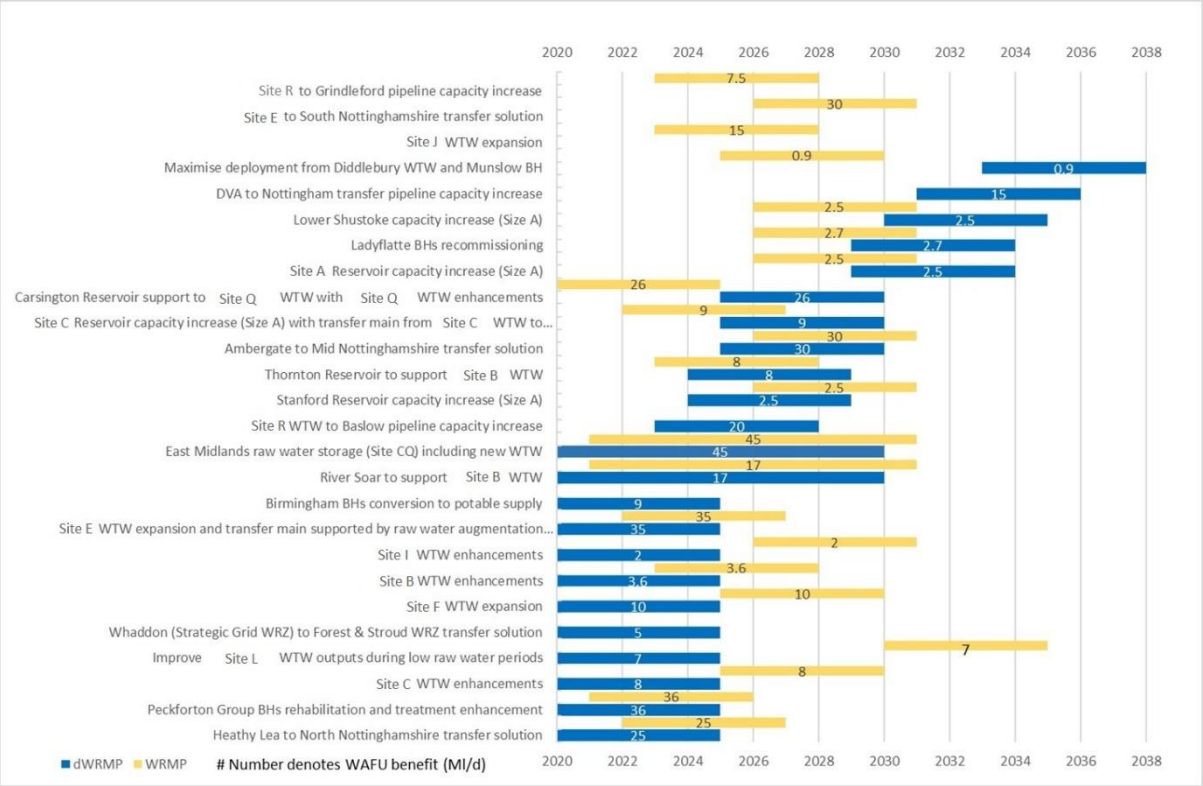


Figure D6.1 demonstrates that while the majority of the options remain unchanged, we have made revisions to the timing and sequencing of these options. The figure also illustrates that there are now three options in our final WRMP that were not within the preferred programme of options in our draft WRMP. The three options being introduced to our preferred programme do not present a material change from our draft WRMP as they are variations to the scale and scope of previously preferred options that featured in our draft WRMP. Similarly, two options have been removed from the preferred programme. These revisions to the preferred programme of options between our draft WRMP and our final WRMP are:

Revision 1: Option - Site E to South Nottingham transfer solution to replace DVA to Nottingham transfer

Our draft WRMP included consideration of four feasible options to increase our capability to transfer treated water from our Strategic Grid WRZ to our Nottinghamshire WRZ. These were:

- GRD19: DVA to Nottingham transfer pipeline capacity increase
- NOT01: Ambergate to Mid Nottinghamshire transfer solution
- NOT04: Heathy Lea to North Nottinghamshire transfer solution
- NOT05: Site E to South Nottinghamshire transfer solution

All four options were variations of a similar theme with the aim of increasing the strategic link capacity between the surface water treatment capacity on the Strategic Grid and the groundwater supplied areas of the Nottinghamshire WRZ. This is to support the reductions in WFD led groundwater deployable output in the Nottinghamshire WRZ. In our draft WRMP we recommended proceeding with a preferred programme containing options NOT01, NOT04 and GRD19 over AMP7, AMP8 and AMP9.

For our final WRMP, the revisions to WINEP3 and its implications for our groundwater sources in Nottinghamshire, alongside the updated option costs and benefits appraisal has led to a revision to the

recommended strategic transfer options. We are recommending replacing option GRD19 with option NOT05. This is not a material change from our draft WRMP and is simply a revision to the recommended route and size of upgraded capacity for transferring treated water.

Revision 2: Option - Site R WTW to Grindleford pipeline capacity increase to replace Site R WTW to Baslow pipeline capacity increase

As described in section 3.5 of our Statement of Response, since our draft WRMP was published we have worked with our neighbouring water supply companies to better align our future water trading plans. Three of our options involved variations to the way we operate the Derwent Valley reservoirs:

- BAM03: Site R WTW to Grindleford pipeline capacity increase
- BAM04: Site R WTW to Baslow pipeline capacity increase
- BAM05: Site R WTW to Ambergate transfer solution

In our draft WRMP we included option BAM04 for implementation by 2028. This option would provide an increase of up to 20Ml/d output from our Derwent Valley reservoirs into our Strategic Grid WRZ, and would likely require a reduction in the current export arrangements to our neighbour, Yorkshire Water.

Since we published our draft WRMP we have worked with Yorkshire Water to better understand the impacts this would have on their WRMP and to better align our assumptions around future changes to way the Derwent Valley reservoirs are utilised. As a result, we have amended the preferred programme of options in our final WRMP to reflect the needs of both Companies. In the preferred programme of options in our final WRMP we have now included the smaller scale option BAM03 to replace BAM04. Option BAM03 is expected to achieve an additional deployable output benefit of 7.5Ml/d from the Derwent Valley reservoirs into our Strategic Grid WRZ. Our water resources modelling shows that we can sustain this increased output without impacting on our current arrangements with Yorkshire Water. This is a change in scope to the option recommended in our draft WRMP.

Revision 3: Option - Site J WTW expansion (included since our draft WRMP)

In our previous description for Revision 2, above, we outlined that due to the impacts on Yorkshire Water, we have needed to reduce the scope and deployable output benefit achieved from the Derwent Valley reservoirs related options. To ensure that we can balance our supply/demand needs, we have substituted an alternative option into the preferred programme to make up for the resulting capacity shortfall. The driver for requiring additional treatment capacity is the need to provide sufficient supply into the Strategic Grid WRZ to support the Nottinghamshire WRZ via the new strategic transfer links proposed within the preferred programme of options.

For this additional supply and transfer mechanism to be most effective, the treatment capability needs to be located upstream of the new transfer links, thereby utilising our capability to abstract from the River Derwent. In the light of constraints at the Derwent Valley reservoirs our preferred way of generating this additional capability is to expand our existing water treatment works at Site J. This option is in keeping with our other preferred options to increase treatment capacity at Site F and Site E treatment works.

Revision 4: Option - Birmingham boreholes conversion to potable supply (removed since our draft WRMP)

The preferred programme of options in our draft WRMP included an option to convert a number of existing flow augmentation boreholes into public water supply assets. Our intention was to improve deployable output capability in the Birmingham area and our Strategic Grid WRZ. Since publishing our draft WRMP we have updated our supply / demand assessment to reflect WINEP3, updated the costs and benefits of our supply options and revised our long term leakage ambition. Upon re-optimising our long term investment plan as a result of these changes, the Birmingham borehole conversion option is no longer in our preferred programme of options and our final WRMP has been adjusted accordingly.

However, this option remains feasible and whilst we do not have any plans for it to be progressed, it forms part of our contingency planning as a well formed and viable alternative in the event that our other preferred options benefiting the Strategic Grid WRZ are found to be unsuitable during subsequent design development stages.

Revision 5: Option - Whaddon to Forest and Stroud transfer (removed since our draft WRMPl)

Our draft WRMP included this option to increase the transfer of treated water from our Strategic Grid WRZ to our Forest & Stroud WRZ to offset an expected reduction in deployable output at our Buckshaft groundwater site. Since we published our draft WRMP the Environment Agency have issued WINEP3 information which confirmed the scale of the required environment programme in that area.

WINEP3 confirmed the conclusions we arrived at in 2018 during our ongoing environmental investigations into the impact of our Buckshaft source on the neighbouring Cinderford Brook. Those conclusions were:

- We should focus on in-river and habitat improvement measures to help improve the status of the Cinderford Brook rather than make long term reductions in abstraction form Buckshaft.
- We should reduce the Buckshaft abstraction licence to limit future abstraction growth and prevent future deterioration of WFD status.

Therefore we no longer require options to offset a reduction in output at our Buckshaft site meaning that the Whaddon to Forest and Stroud transfer is not included in our preferred programme of options in our final WRMP.

D6.1 Our final WRMP preferred programme of supply-side options

Our preferred programme of supply-side options includes 22 options to be delivered over 3 AMP periods. This appendix (Appendix D) describes the process that we carried out to arrive at this preferred programme of options to address our future supply needs whilst safeguarding and minimising impact to our customers and the environment. The following section provides a description of each option included in our preferred programme. Further details for each option is provided in Appendix D10 as well as in our supporting SEA Environment Report and Water Framework Directive Compliance Assessment documents.

Our preferred programme of supply-side options is:

Heathy Lea to North Nottinghamshire transfer solution (Ref NOT04)

This option provides a new strategic transfer capacity from the Strategic Grid Water Resource Zone (WRZ) into the Nottinghamshire WRZ, via a new pipeline with a total distance of 34.6km. A new pumping station is also proposed as part of this option.

Supply Benefit: 25Ml/d

Site C water treatment works enhancements (Ref DOR05)

The current maximum output of Site C treatment works is limited to 27 Ml/d, this option will enable the site to produce 36 Ml/d deployable output. This option will install additional treatment capacity which will increase output and improve resilience by providing some redundancy in our treatment process to allow maintenance and protect against failure.
Supply Benefit: 9Ml/d

Site I water treatment works enhancements (Ref DOR02)

A minor improvement to the treatment process at Site I WTW will allow us to increase treatment capacity. The additional output will be used in the Strategic Grid WRZ.
Supply Benefit: 2Ml/d

Site E water treatment works expansion and transfer main supported by raw water augmentation of the River Trent (Ref WIL05)

Using our existing abstraction on the River Trent at Witches Oak intake we will install a 50 Ml/d expansion to Site E WTW. A new pipeline will be included to transfer the additional potable water for use in the Strategic Grid WRZ.

In our draft WRMP, this option included using Barnhurst wastewater treatment works final effluent to augment flows in the River Trent to support the abstraction at Witches Oak. There were a number of concerns brought to our attention through our WRMP consultation stage. Specific concern was raised regard the impact on the River Penk, Staffordshire and Shropshire canal and Aqualate Mere SSSI. As a result, we have now modified this option so that it no longer requires the diversion of Barnhurst wastewater treatment works final effluent into the River Trent.

We are currently carrying out a number of assessments to establish an alternative means of supporting the River Trent abstraction and raw water supply to the expanded WTW. These discussions include the potential for one or more of the following raw water sources being used:

- Procurement of existing third party abstraction licences.
- Supporting the River Trent abstraction from an alternative source.
- Making greater use of the Derwent Valley system and Carsington reservoir for this option.
- Provision of raw water resource from third party suppliers such as the Canal and River Trust.

Our analysis of the alternatives and discussions with potential suppliers will be concluded by March 2019. We will not require an increase to the overall abstractions from the River Trent, unless they are supported by an equivalent input from another source.
Supply Benefit: 35Ml/d

Site F water treatment works expansion (Ref LIT01)

Using spare raw water from Carsington reservoir, we will use our existing abstraction at Site F to support a 30 Ml/d expansion of Site F WTW. Existing pipelines will be used to transfer the additional potable water for use in the Strategic Grid WRZ.
Supply Benefit: 10Ml/d

Site J water treatment works expansion (Ref OGS01)

Using spare raw water from Carsington reservoir and utilising the storage at Site J reservoir to maximise utilisation of the River Derwent, we will use our existing raw water abstraction with enhancements to raw water transfer capability to support a 40 Ml/d expansion at Site J WTW. The option will include a new pipeline to distribute the water into our Strategic Grid WRZ.
Supply Benefit: 15Ml/d

Site B water treatment works enhancements (Ref DOR08)

By improving the treatment processes, we will increase the sustainable output of Site B WTW using the existing raw and potable water transfer capability.
Supply Benefit: 3.6Ml/d

Improve Site L water treatment works outputs during low raw water periods (Ref UNK07)

The maximum design capacity of Site L WTW is 48 Ml/d but its normal output is closer to 44 Ml/d. Site L WTW operates in conjunction with the wider groundwater sources in the North Staffordshire WRZ, and the zonal deployable output is maximised by optimising the balance between the reservoir and the groundwater sources. During winter and spring, we maximise use of the reservoir while storage is at or above target levels, and during summer months we reduce output from the reservoir and increase use of the groundwater sources.

The minimum output from Site L WTW is around 16Ml/d due to the configuration of the water treatment process. This minimum output is a key constraint on the zonal deployable output. When reservoir storage is very low we cannot reduce Site L WTW output below 16Ml/d, meaning that to preserve storage we have to shut down the treatment works and transfer all demand onto the groundwater sources.

This option will reconfigure Site L WTW to allow output to go below the current 16Ml/d minimum. This will give greater operational flexibility during dry weather and will improve the conjunctive use with the North Staffordshire groundwater system.
Supply Benefit: 7Ml/d

Peckforton Group boreholes asset and water treatment enhancements (Ref GRD18)

The Peckforton borehole group will require enhanced water treatment in AMP7 due to deteriorating raw water quality in the groundwater unit. Installation of treatment offers an opportunity to increase the output from the group and relieve the supply/demand stress within the North Staffordshire WRZ. The option will include enhanced water treatment installation, new chlorination treatment, new pumping plant and the potential upgrade of Tixall booster pump to get water into the North Staffordshire zone.

This option brings wider benefits, as it allows us to preserve the integrity of the wider North Staffordshire water resource zone and prevent the large loss of zonal deployable outputs that would be caused by restoring sustainable abstraction licence changes.
Supply Benefit: 6.5Ml/d increase in source outputs, but has benefit of preventing the wider loss of 29.5Ml/d of zonal deployable output.

River Soar to support Site B water treatment works (Ref CRO06)

This option will make use of the River Soar to support Site B WTW during critical periods. Site B WTW receives its water from Site B and Swithland reservoirs. One of the most viable options to increase raw water availability is to provide a new feed into the system from the River Soar. This scheme would preserve reservoir storage by using the river source when flows are above the hands off flow (HOF), and then using reservoir storage to supply the treatment works when river levels are below HOF.

Based on the 2013 Environment Agency's Soar CAMS review, the river has 17Ml/d water available for abstraction. This option would also include: the creation of a primary settlement lagoon to aerate water and trap river sediment prior to transfer to Site B WTW, new raw water pipelines & pumping stations, and upgrades to treatment processes to enable treatment of river water.
Supply Benefit: 17Ml/d

East Midlands raw water storage including new water treatment works (Ref WTW05)

We have been engaging with a number of third parties who own existing, operational quarries that are nearing the end of their useful life and that could be used for future raw water storage. We have not included specific details of the preferred option here due to commercial sensitivity of our ongoing discussions, but we describe the option here as the conversion of large, disused third party quarries for the strategic storage of water abstracted from rivers during periods of high river flow.

Several quarries have been investigated and the SEA has identified the need to carefully develop such solutions to avoid adverse effects on geological SSSIs that are present within some disused quarries, as reflected in the precautionary major adverse rating for the SEA geological objective. Further investigations will be required to develop this innovative solution in a sustainable manner so as to minimise adverse environmental effects whilst maximising the potential beneficial effects associated with using large disused quarries for substantial and sustainable water supply benefit, as well as allied recreational and biodiversity enhancement opportunities. This accords with County Council core policies for the sustainable reclamation of former mineral workings.

The option will include the conversion of the Asset to a raw water storage reservoir which will be filled with water pumped from the River Soar at times of high flow. A new water treatment works located at the Asset will treat raw water from either the River Soar or raw water storage reservoir. A new pipeline will transfer potable water to the nearby Avon Soar Link Main which forms part of the Strategic Grid.
Supply Benefit: 45Ml/d

Site Q water treatment works enhancements supported by Carsington reservoir (Ref MEL29)

This scheme will increase the dry weather output from Site Q water treatment works by increasing abstraction from the River Dove, supported by additional releases from Carsington reservoir. Infrastructure will be installed to enable augmentation releases of up to 30Ml/d from Carsington Reservoir to the River Dove catchment. A new contact tank will be installed at Site Q water treatment works to operate in series with the existing contact tank to increase the overall treatment output to 235Ml/d.
Supply Benefit: 26 Ml/d

Site C Reservoir capacity increase with transfer main from Site C water treatment works to Coventry (Ref DAM07)

A small increase in storage capacity at Site C Reservoir will allow us to increase output at Site C WTW. A new pipeline will transfer potable water to our existing network for use in the Strategic Grid.
Supply Benefit: 9Ml/d

Site R WTW to Grindleford pipeline capacity increase (Ref BAM03)

By improving the hydraulic performance of the DVA we will be able to use spare treatment capacity at Site R WTW. Additional raw water will derive from a combination of existing spare capacity in the Derwent Valley reservoirs and a reduction in the export to Yorkshire Water which is currently up to 68 Ml/d.

In our draft WRMP, we presented a large scale scheme that would increase the capacity of a longer length of pipeline thereby increasing the supply benefit. The option included in our draft WRMP (Site R WTW to Baslow pipeline capacity increase) required us to vary our raw water export arrangements from the Derwent Valley reservoirs to Yorkshire Water. During our draft WRMP consultation this was considered to be unacceptable to Yorkshire Water. By reducing the size of the option we are able to provide a supply benefit without varying the raw water export arrangement.

Supply Benefit: 7.5Ml/d average

Stanford Reservoir capacity increase (Ref DAM01)

At Stanford Reservoir an expansion of 11% would provide an additional 147 Ml of storage. The embankment has been designed to overtop for events between the 150 year and 1,000 year floods. In this option the spillway is to be raised by a small amount without making any alterations to the embankment.
Supply Benefit: 2.5Ml/d

Thornton Reservoir to support Site B water treatment works (Ref CRO05)

This scheme will make use of the Thornton reservoir by constructing a raw water main and installing a booster pump to Site B water treatment works.
Supply Benefit: 8Ml/d

Ambergate to Mid Nottinghamshire transfer solution (Ref NOT01)

This solution involves the construction of a new strategic link main from the Strategic Grid WRZ into the Mansfield area of the Nottinghamshire zone. The concept is for a new 21km pipeline and pumping station to be installed, which will transfer water from our Strategic Grid WRZ into the Nottinghamshire WRZ to replace unsustainable groundwater abstraction.
Supply Benefit: 30Ml/d

Site A Reservoir capacity increase (Size A) (Ref DAM03)

This scheme will increase Site A reservoir capacity by 5% to provide an additional 7.8 Ml of storage, involving raising the top water level by 0.17m.
Supply Benefit: 2.5Ml/d

Ladyflatte Borehole asset and water treatment enhancements (Ref BHS07)

Ladyflatte borehole stopped abstracting in 2013. It is licenced to produce just over 3Ml/d and the treatment was designed to treat that quantity. Upgrading the process units to achieve the licence would be considered as part of the option.

Supply Benefit: 2.7Ml/d

Lower Shustoke capacity increase (Ref DAM02)

At Lower Shustoke reservoir an expansion of 10% would provide an additional 192 Ml of storage and would involve raising the top water level by 0.52m. Lower Shustoke reservoir operates in conjunction with Upper Shustoke which, together, form an off-line storage facility. At this stage it has been assumed that a non-return arrangement could be fitted to the pipework connecting the two reservoirs. This arrangement would enable the lower reservoir to be held at a higher water level than in the upper reservoir.

Supply Benefit: 2.5Ml/d

Site E to South Nottinghamshire transfer solution (Ref NOT05)

This solution will increase the capacity of network connections to the Nottinghamshire WRZ from two potable water sources in our Strategic Grid WRZ – the Derwent Valley Aqueduct and Site E WTW. This will enable additional transfer of potable water from the Strategic Grid WRZ into Nottinghamshire WRZ.

Supply Benefit: 30Ml/d

Maximise deployment from Diddlebury water treatment works and Munslow borehole (Ref BHS06)

The concept behind this option is to upgrade existing assets at Diddlebury WTW to provide an additional flow into the local distribution service reservoir in order to meet peak demands within our Ludlow control group. It assumed that the Diddlebury and Munslow BHs will continue to operate as usual. No investment is planned to increase the yield of these groundwater sources.

Supply Benefit: 0.9Ml/d

D6.2 Delivering our Preferred Programme of Options

The large size and scale of our preferred programme of options represents the increasing challenge we are facing during this planning period to meet the supply / demand balance into the future. We have given careful consideration to our ability to deliver the proposed engineering programme of new sources of supply. We acknowledge that our preferred programme of options is challenging in terms of the number of options needing to be progressed in AMP7. Since publishing our draft WRMP, we have made a number of changes to the preferred programme of options in terms of both the supply-side option selection and the phasing of the programme. Our revised programme promotes a more balanced delivery across AMP7 and AMP8 preventing it being too 'front-end loaded'. In combination with our robust delivery management process, this will reduce the risks around the overall delivery programme.

Our robust, established delivery management process and standards facilitate the development and delivery of a large programme of capital investment projects. This delivery process is overseen by our Programme Management Office (PMO) whose centralised position ensures that standard procedures are implemented and that all information including project deliverables, risks and issues are considered throughout the entire investment period.

The delivery strategy for our overall AMP7 capital programme has already begun, and our Capital Delivery teams are translating the wider PR19 Business Plan into an AMP7 delivery programme to understand our high level prioritisation criteria. Our delivery programme will mature as we progress towards the commencement

of the AMP7 period and gain better understanding of individual project constraints and interdependencies through collaboration with key stakeholders. Liaison with our water resources, operational, network control and delivery teams will ensure that network interventions are co-ordinated to minimise impact and risk to our day to day operations and customer supplies.

We will build on the learning from AMP6, which has been a relatively busy period in terms of interventions to existing assets where the intervention had potential to impact service to customers. We recognised this early in AMP6 and improved our intervention risk assessment process administered by our Network Control team. They now have a minimum 12 month look ahead plan to allow efficient and risk based approach to phase activity impacting on our ability to maintain service to our customers.

In developing the preferred programme of options we have been able to determine an outline delivery programme, however we have not yet undertaken a detailed phasing study for the potential construction interaction between options and we acknowledge that maintaining security of supply is of paramount importance. At this stage, our outline delivery programme gives us sufficient information for us to be confident that our existing resilience capability will allow us to undertake the required interventions without impacting service to customers.

Referring to the preferred programme of options described in Section D6 and Figure D6.1, we will be commencing delivery of 11 supply side options in AMP7, 10 in AMP8 and a further one in AMP9. Of the options to be delivered in AMP7, five require interventions on existing surface water treatment work located across our Strategic Grid WRZ. These are:

- Option OGS01: Site J WTW
- Option DOR08: Site B WTW
- Option DOR02: Site I WTW
- Option WIL05: Site E WTW
- Option MEL29: Site Q WTW

All of the above treatment works are already ‘second source resilient’. This means we can make up any production shortfall using alternative treatment plants whilst short duration connection / diversion activities are undertaken. Although Site E WTW and Site J WTW require significant construction activity, this work will be separate and offline from the existing treatment processes as we plan to develop separate process streams to improve overall resilience capability of the expanded works.

The remainder of the options in our preferred programme being commenced in AMP7 (without direct WTW interaction) involve making connections to the existing network. We are confident that we have identified a viable approach to making these connections without impacting on customer supplies. For example:

- Option NOT04: Heathy Lea is a pipeline transfer option which will require short duration shutdowns to allow connections to the existing network and cause no impact to production capacity. The Derwent Valley Aqueduct is a twin pipeline at the point of connection so there will no reduction in distribution capability.
- Option BAM03: Site R to Grindleford capacity improvements will involve short duration shutdowns to allow the pipeline capacity improvement to be carried out. However, this is on part of the grid that is already duplicated and there will be no reduction in distribution capability.
- Option CRO05 and CRO06: Making additional provision of raw water available to Site B WTW from the River Soar and Thornton Reservoir will require localised connection to the raw water inlet to Site B WTW. These can be managed appropriately by utilising our operational flexibility at that site to prevent impact to customer supply.

- Option GRD18: Peckforton Boreholes in the North Staffs WRZ are individually second source resilient using other boreholes or increased output from Site L WTW. This will allow short duration shutdowns whilst new water treatment works are constructed and commissioned. Conversely, Site L WTW production can be reduced by increasing borehole production during connection / diversion activity, though the work required is relatively minor in nature.

Option WTW05: The implementation of the East Midlands raw water storage (Site CQ) option including a new water treatment works will be carried out largely offline from our current water production and distribution capability. Similarly, the Site C reservoir expansion and distribution enhancements will require only minimal work to the water production site, which is second source resilient.

Overall, we are confident that our preferred programme of supply side options is achievable, will provide the stated benefits and meet the challenge of providing a cost effective and sustainable water supply into the future. If, during subsequent option development, an option is identified to be no longer deliverable then we will identify an equivalent alternative from our feasible options list. Our consistent approach to deriving and preparing the feasible and preferred options means that we are confident that we have alternatives available in all of our WRZs. We are also confident that these alternatives have been developed sufficiently to prevent significant impact to the deliverability of the plan outcomes.

We also recognise that there is uncertainty around the costs, timescales and deployable output benefits that the new schemes will deliver to us. That is why we have tested multiple alternative supply / demand investment scenarios to examine the sensitivity of our investment decisions to the uncertainty around these parameters. In Appendix E we explain our approach to managing long term uncertainty and we describe the advances we have made in our investment modelling tools. Through our DMU modelling we have been able to explore whether our recommended supply / demand investment decisions are robust given the uncertainty around costs and benefits. In Appendix E we describe how we have arrived at our recommended programme and we show why we are confident that the recommended schemes represent robust decisions, even with the uncertainty around costs and deployable output benefits.

We have also put in place a PR19 mechanism to protect customers from the bill impacts of this uncertainty, to ensure that we do not ask customers to pay for investment that proves to be unnecessary or unsuccessful. For example, if climate change does not lead to a reduction in deployable output at the pace and scale predicted in our plan, then customers would face higher bills. This is because the supply schemes have a degree of irreversibility. Furthermore, if we can identify cheaper ways of reducing leakage this would change the balance of solutions, potentially leading to more demand side measures at PR24 and beyond. There are also uncertainties associated with delivering our supply / demand programme, for example the delivery timescales of our new supply schemes and also the willingness of customers to voluntarily adopt metering in such a large step-up.

In our PR19 plan we have proposed an approach to mitigate this risk by using a real option mechanism that would give us the right but not obligation to act, given a defined trigger. Use of a real option mechanism supports an adaptive pathway approach that allows for investment to be delivered only where the risk of mal-adaptation is low and after consideration of whether there is sufficient time to implement options if they are shown to be required in the future. This allows for the re-appraisal of decisions iteratively as uncertainty is reduced (i.e. converted to definitive impact or reduced model error) over time. Following an adaptive pathway approach will mean that interventions are more likely to be based on certainty and could change the type of intervention (e.g. favour more demand side measures).

We consider that the material uncertainties used in our analysis are likely to reduce with time. This gives us confidence that the use of a real option mechanism will be in the best interests for customers. Uncertainty can be expected to reduce most obviously as a result of:

- Review of the climate change impact implied by the UKCP18 projections; and
- Improvements to scheme certainty as we progress through feasibility.

To protect customers we have defined the following components in our Real Option mechanism:

- the outcome;
- the trigger;
- the cost; and
- how the costs would be recovered if the option was triggered.
- The trigger for the uncertainty mechanism will be an annual reappraisal of the climate change (and other material) uncertainties that have the potential to drive major investment.

UKCP18 will provide the first refresh of climate data projections in 10 years. We will analyse the effect of these projections on our WRMP using the same climate change and scaling approach (which is in-line with best practice).

The WRMP annual review will take account of the following:

- increased level of certainty afforded by the latest information (focusing, but not explicitly, on climate change impact and uncertainty as identified by UKCP18);
- time needed to efficiently deliver required additional supply side capacity;
- advantages of following an adaptive pathway where material uncertainty still remains;
- impact of our demand management assumptions and performance within the AMP. We have ambitious leakage and metering programs that we are committing to delivering for our customers irrespective of the future supply demand challenges we may face. Any outperformance in demand management may negate the need for additional supply schemes, or delay their implementation; and
- wider benefits on delivering supply side capacity early.

This analysis will take at least 12 months to complete, but should provide a more certain baseline of climate change impact and reduced residual uncertainty. Following completion of this analysis, we will present the results and associated investment impacts to the EA for independent challenge and scrutiny.

D6.3 SEA and environmental considerations

Our WRMP is accompanied by a separate Strategic Environmental Assessment (SEA) Environmental Report, a Habitats Regulations Assessment (HRA) and a Water Framework Directive (WFD) assessment to ensure an integrated approach to environmental assessment of our WRMP.

We have integrated environmental factors into the development and selection of options and our decision making approach. The first stage of screening, described in Appendix D2, included environmental criteria to ensure options with a high potential for negative environmental impact were removed between the unconstrained list and constrained list stages. Options on the constrained list were further developed and prepared to a level of detailed commensurate with the strategic nature of the planning process. Environmental constraints were again considered and suitable provision made to the option arrangement in order to avoid or mitigate potential environmental impact. This included, for example, alternative routing of new pipelines or adjustments to the location of new assets.

Integrating environmental considerations into the option development and selection process has meant that our appraisal process takes into account a range of factors including technical feasibility, delivery risks and environmental considerations in an equal manner. The SEA process facilitated review of critical environmental constraints in an agreed and consistent manner, ensuring that we considered the full range of potential environmental impacts of the options.

We included environmental mitigation when refining the selected least cost options to formulate our preferred programme of options. This ensured that the option costs were robust and representative. We prepared social and environmental costs for all options to monetise any remaining impacts and enable an appropriate comparisons between options to be made and assist the decision making process. The environmental and social values were included in our Water Infrastructure and Supply Demand (WiSDM) investment optimisation modelling (described Appendix E) alongside the capital and operational costs of the options.

We recognise the need to carry out an 'in-combination' assessment of our preferred programme of options with the WRMP of our neighbouring water companies. We will complete this in-combination assessment once information about the final preferred programme of all neighbouring companies is available.

We have updated Section 7 of our SEA Environmental Report to demonstrate how the SEA has influenced the selection of the preferred programme of options. This includes the discussion of options in the feasible list that were not taken forward into the preferred programme. For example, the SEA identified certain reservoir options, transfer options and a river augmentation option in our constrained list which had a wide range of major adverse effects. These options were not selected due to their poor performance against the SEA objectives, which informed their removal from our WRMP.

Further explanation of the different aspects of our environmental appraisal is provided below.

Habitats Regulation Assessment (HRA)

No likely significant effects have been identified for options in the preferred programme of our final WRMP. In light of the recent People vs Wind European Court of Justice (ECOJ) ruling, we will review all our HRA screening conclusions to identify those that relied on mitigation to conclude no Likely Significant Effects (LSE) both individually and 'in combination'. Any options in our preferred programme where this is applicable will be subject to a HRA Stage 2 (Appropriate Assessment). Should there be a need for an HRA Stage 2 (Appropriate Assessment), then the Natural England criteria are more applicable. This then will entail:

- Identifying which preferred options that have a LSE were recommended for 'down the line' assessment.
- Reviewing our reasoning to see if it meets the Natural England criteria.
- If Natural England criteria is not met, then we will need to consider undertaking a more conclusive assessment; but
- If uncertainty remains then the Option may need to be subject to Stage 4 imperative reasons of overriding public interest (IROPI).

We will also review the potentially-relevant in-combination Development Plans.

Landscape

The SEA Objective concerning landscape and visual amenity focusses on potential adverse effects on landscape designations. It is acknowledged that Ancient Woodland is important due to its contribution towards landscape quality. Therefore, the presence of Ancient Woodland influences the sensitivity of the designated landscapes (Refer to Table 4.4 in our SEA Environmental Report). Nevertheless, potential adverse effects on Ancient Woodland are already considered within the Biodiversity objective topic and addressing these effects within the landscape and visual amenity objective topic may be considered as double counting.

Local Nature Reserves

Local designated sites such as Local Nature Reserves (LNRs) are not included within the scope of SEA methodology as set out in Section 5.2.1 of our Scoping Report. We have identified a total of five LNRs which influence the severity of the adverse residual effects towards the SEA objective of biodiversity, flora and fauna to four options in our preferred programme (NOT01, GRD19, WIL05, LIT01). These LNRs are:

- Teversal/Peasley Network LNR
- Bulwell Hall Park Meadows LNR
- Sutton Bonnington Spinney & Meadows LNR
- Bulwell Hall Park Meadows LNR)

These LNRs sites will also be considered in the project level environmental assessment during the implementation phase of options, including thorough consultation with the relevant authorities.

Sites of Special Scientific Interest (SSSIs)

Our assessment of the implementation phase of several options in our preferred WRMP (NOT01, NOT04, LIT01, WIL05, DAM03, CRO05) has identified potential adverse effects on a total of 11 SSSIs, as described in Section 7.2 of our SEA Environment Report. Consequently, project level environmental assessment will inform the detailed design and selection of mitigation measures, for example optimisation of the pipeline routes to ameliorate adverse effects.

The mitigation measures that we applied to options in our WRMP are high level commensurate with the early and strategic development stage of the option. As the option development phase progresses through to detail design stage then discussions will be held with Natural England and other stakeholders to agree appropriate mitigation measures following the detailed environmental assessment.

Biodiversity

We acknowledge our ability to influence, protect and enhance the biodiversity of our regions as a result of the scale and scope of our operation. Promoting biodiversity, particularly in the aquatic ecosystem, is one of the cornerstones of our business objectives. In terms of the SEA, we have reviewed the assessment to identify opportunities for achieving biodiversity gain. These opportunities will likely revolve around the creation of new habitat associated with the reservoir options but we will also seek other opportunities to support biodiversity gain where appropriate. Option WTW05, for example, provides opportunities for bankside habitat creation.

We recognise the importance of preserving the fauna and flora which depend on our reservoirs. Some of the assessments we have undertaken in connection to these storage options have already identified potential adverse impacts on ecology as well as loss of habitat. However, we have expanded our WFD assessments (Appendices A and B of our WFD assessment report) and SEA assessment (Environmental report and SEA matrices) of the construction and operation phases of option implementation to include further consideration of habitat loss, changes in water quality within the reservoirs and impacts on ecology. Where potentially

adverse impacts are identified, we will endeavour to undertake further investigations and develop mitigation measures in consultation with Natural England, local Wildlife Trusts and other relevant stakeholders.

Section 7 of the SEA Environmental Report presents strategic opportunities for Net Gain of biodiversity in our final WRMP.

'In combination' effects

We understand the need to consider the potential environmental effects of our options as a collective and not just individually. For our draft WRMP, an initial in-combination assessment was undertaken using the information available at the time. This considered potential interactions between options WIL05, LIT01 and MEL29, as these solutions targeted abstractions and hence posed a potential risk of deterioration to the waterbodies in question.

We recognise the need to carry out an updated 'in-combination' assessment of our final WRMP preferred programme of options with the WRMPs of our neighbouring water companies. We will complete this in-combination assessment once information about the final preferred programme of all neighbouring companies is available.

Monitoring plan

Section 8 of the SEA Environmental Report provides high-level monitoring targets and indicators as appropriate to the strategic level of the assessment (refer to Section 8.3 of the SEA Environment Report). These will be used to help develop specific targets when we undertake detailed environmental assessment as the options are developed in the future. The targets will also inform future monitoring plans, which will be used during the implementation phase of the plan.
The strategic targets cover several potential impacts to the natural environment, built environment and human receptors and include data sources where appropriate, as highlighted in Section 8 of the SEA. These will include water resources, water quality, biodiversity, climatic factors, transport, nuisance (community), amenity effects, landscape and visual amenity and cultural heritage.

The proposed monitoring indicators for the impacted receptors (described in Section 8.3 of the SEA Environmental Report) include data sources where possible, for instance, complaints logged with us and Local Authority Environmental Health Officers or equivalent and specific species and habitats surveys. The responsibility for the monitoring plan and the process we follow when taking remedial action will also be presented in this section.

Prior to the implementation of options, detailed monitoring plans will be put in place with specific targets and with responsibility clearly assigned. This will mean that the effects of options can be measured and actions tracked.

D7 Greenhouse gas emissions

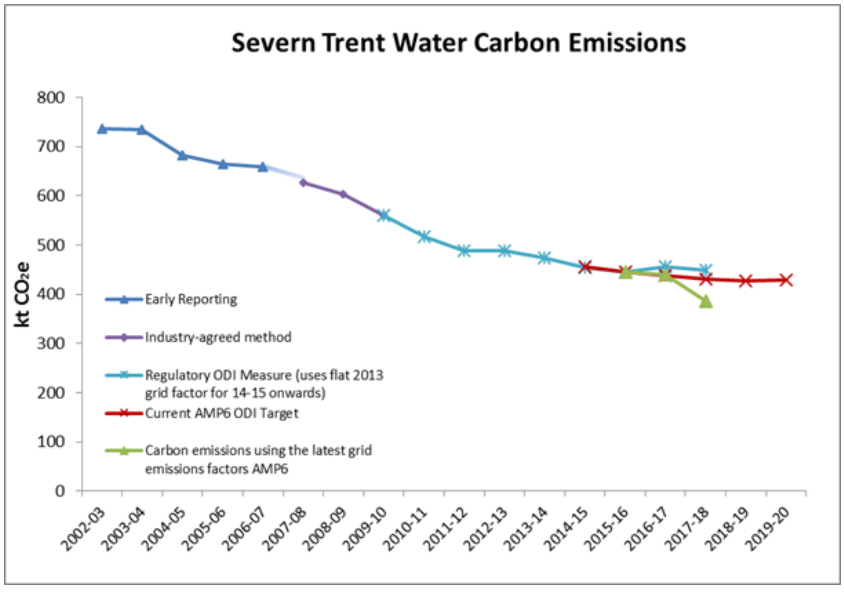
Greenhouse gas (or 'carbon') emissions contribute to climate change and need to be reduced. In 2017-2018, Severn Trent's total operational emissions are 386 $ktCO_2e$ per year, which is around 0.1% of the UK's total emissions. On top of this, there are significant emissions in our supply chain from outsourced maintenance and construction activity.

We recognise that we need to reduce our direct carbon emissions and influence our indirect emissions. Our long term aim is to continually reduce carbon emissions and generate renewable energy, in a way which provides value for our customers. Considering carbon emissions in our planning processes is a key way to do this.

The price we and others, pay for energy and environmental taxes mean that there is an increasingly close link between cost and our carbon impact. These costs are increasing as the UK moves to a low-carbon economy. So aside from our commitment to play our part in reducing emissions, impact on our customers' bills is a key reason to focus on carbon emissions. Our research shows that customers and stakeholders agree with our overall strategy of prioritising action to reduce carbon where there is a long-term financial benefit to customers.

We consistently track and project our operational emissions in line with Government guidance. Since 2008 we have been using the UKWIR Carbon Accounting Workbook for calculating operational greenhouse gas emissions[2]. We publish this information annually in our annual report and accounts and report our performance to Ofwat and to the Carbon Disclosure Project. We also set ourselves internal and external carbon targets and incorporate these into our business plans for every five year price review period. Despite increasing demand for water, and increasingly stringent quality requirements, we continue to reduce our emissions year on year, when accounting for the most recent grid emissions factor as demonstrated in Figure D7.1.

Figure D7.1: Severn Trent Operational Carbon Emissions 2002 - 2017



Between 2009-2017 we have held the Carbon Trust Standard in recognition of our consistent carbon reduction and our carbon management programme.

Every five years we will set out what emissions reductions we think we can achieve. This will take into consideration the upwards pressures we face and the investment plans we have agreed with our customers

[2] *Carbon accounting in the UK Water Industry: methodology for estimating operational emissions, report no 08/CL/01/5*

and stakeholders. We want to maintain the improvements we have made, and find ways to reduce carbon further whilst still improving service. We know that this should be done only at a cost our customers are willing to pay. The future supply / demand challenges described in our WRMP mean that our ambition to continue reducing carbon emissions will become increasingly difficult. Many of our solutions for replacing unsustainable sources of abstraction and preventing future environmental deterioration are carbon intensive.

Our changing boundary

As described in Section A.1, we realigned our company boundary in 2018 to accommodate the addition of Dee Valley Water customers and associated operations. At the same time we formed the new company 'Hafren Dyfrdwy' for our customers and operations in Wales. This activity resulted in the parts of the former Dee Valley Water area that were in England being transferred into Severn Trent. Similarly, parts of the previous Severn Trent area that were in Wales were transferred into Hafren Dyfrdwy. All aspects of our service, customers and operational assets within the transferred areas were moved to the respective company.

In our draft WRMP, we demonstrated the effect that our WRMP proposals will have on our carbon emissions using a baseline of the 2016-17 carbon emissions data as a comparison. In order to retain a suitable comparison, we have adjusted this baseline to be representative of the revised company boundary. Our approach has been to apply the relative proportion of carbon emissions for each area reported in Q1 2018 to the 2016-17 baseline for each company as reported in the 2017/18 Annual Performance Reports:

Severn Trent

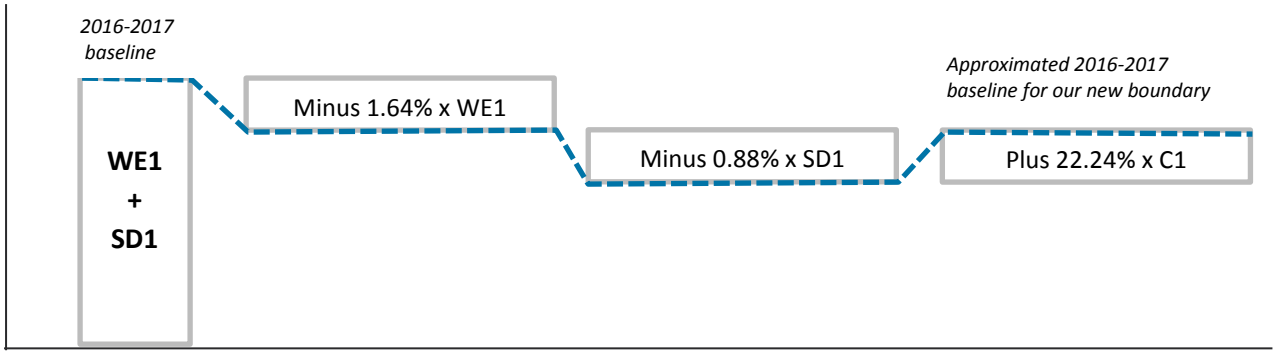
- WE1 Size of our carbon footprint – Water (2016-17 actual) 250 ktCO2e
- SD1 Size of our carbon footprint – Waste (2016-17 actual) 207 ktCO2e
- Size of our carbon footprint – Water (England) proportion (Q1 2018) 98.36 %
- Size of our carbon footprint – Water (Wales) proportion (Q1 2018) 1.64 %
- Size of our carbon footprint – Waste (England) proportion (Q1 2018) 99.12 %
- Size of our carbon footprint – Waste (Wales) proportion (Q1 2018) 0.88 %

Dee Valley Water / Hafren Dyfrdwy

- C1 Gross operational greenhouse gas emissions (2016-17 actual) 8.385 ktCO2e
- Gross operational greenhouse gas emissions – (England) proportion (Q1 2018) 22.24 %
- Gross operational greenhouse gas emissions – (Wales) proportion (Q1 2018) 77.76 %

Our revised 2016-17 baseline carbon emissions can therefore be best represented as shown in Figure D7.2.

Figure D7.2: Waterfall diagram showing the approach to revising the carbon emissions baseline



Following this approach, the revised 2016-17 baseline is therefore 453 ktCO2e comprising:

- Carbon footprint – Water 2016-17 approximated for new boundary 247.78 ktCO2e
- Carbon footprint – Waste 2016-17 approximated for new boundary 205.18 ktCO2e

Our approach to carbon in the water resource management plan

Our approach to considering carbon impacts in this water resource management plan is similar to the approach we used during our previous water resource management planning processes. We assess the carbon impacts of different activities and include these impacts in the selection of the preferred programme of options.

To do this we estimated the carbon impacts of the individual supply-side options and combined these with a notional price for carbon in our WiSDM investment planning model. We have used a notional price of carbon of £48.76 per tonne of CO_2e, based on the previous 'shadow cost of carbon' published by the UK Government. The benefits of this approach are:

- We are able to quantify the most significant direct and indirect carbon impacts of our water resource management plan over the 25 year planning period.
- Carbon is considered as a part of decision making and can influence the cost benefit ratio of different options. This helps us to identify and prioritise the lower-carbon solutions which meet our requirements.

Our approach is based on the 2012 UKWIR guidelines[3] which included:

- Guidelines to estimating embodied and operational carbon associated with water company projects.
- Guidelines for carrying out whole-life costing including carbon values.
- Guidelines for what carbon prices and emissions factors to apply in whole life costing.

We believe that our approach strikes the right balance between our intention to minimise our carbon footprint and our other commitments to customers.

For each individual capital scheme, changes to direct operational emissions from fuel, processes and energy use (known as scope 1 and 2) emissions were estimated and used to calculate operational carbon impacts. The predominant driver of operational carbon emissions in all of our supply-side options is electricity consumption.

The primary indirect carbon impact of our individual capital schemes (known as scope 3 emissions) is embodied carbon, i.e. the carbon associated with the construction of assets. An embodied carbon impact has been estimated for each option in the plan.

D7.1 The carbon impacts of our WRMP

We have estimated both the embodied and operational carbon emissions impact of the supply and demand measures outlined in our final WRMP using the following approach.

[3] UKWIR (2012) '*A framework for accounting for embodied carbon in water industry assets*' (CL01/B207)

Operational Emissions

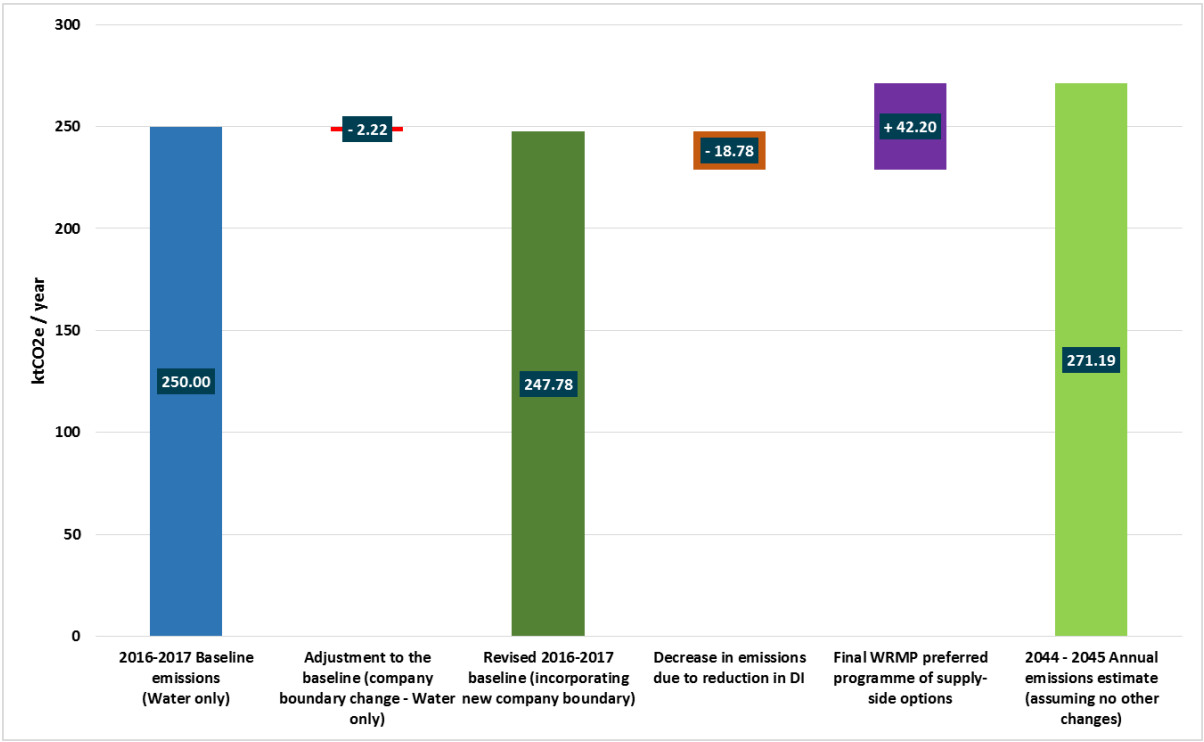
We have used our operational GHG emissions model to generate a projection of the likely carbon impacts that result from our 25 year WRMP strategy.

The methodology used to produce the overall profile for water services consisted of the following steps:

- The baseline operational emissions for water supply activities was calculated using the most recent final version of the UKWIR Carbon Accounting Workbook (version 11, April 2017). The baseline was adjusted to provide an approximation to the effect of revising the company boundary.
- Increases to the baseline have been calculated where new capital schemes require additional electricity after commissioning as described above. The projected additional net energy consumption per year as a result of the capital schemes included in the plan is 100 GWh – equivalent to around 42.2 ktCO2e per year using the current conversion factors for electricity from the national grid. This impact would be phased based on the timing of implementation of the capital schemes.
- Changes to the baseline emissions have been estimated based on the projected changes to the overall distribution input, which represents planned levels of leakage and demand (for example due to growth or water efficiency measures). These factors influence the energy requirement to pump and treat water and hence affect carbon emissions. There is a decrease in distribution input during the planning period equating to a projected reduction of approximately 18.8 ktCO2e/yr of operational carbon emissions by 2044/45.
- Changes to the energy efficiency of our operations and our renewable energy generation from water services assets have not been included. These measures are discussed further below.
- Changes to the emissions intensity of grid electricity has not been included.

The impact on operational carbon emission for the water production and supply part of our business is shown in Figure D7.3.

Figure D7.3: Annual operational carbon impact of the WRMP



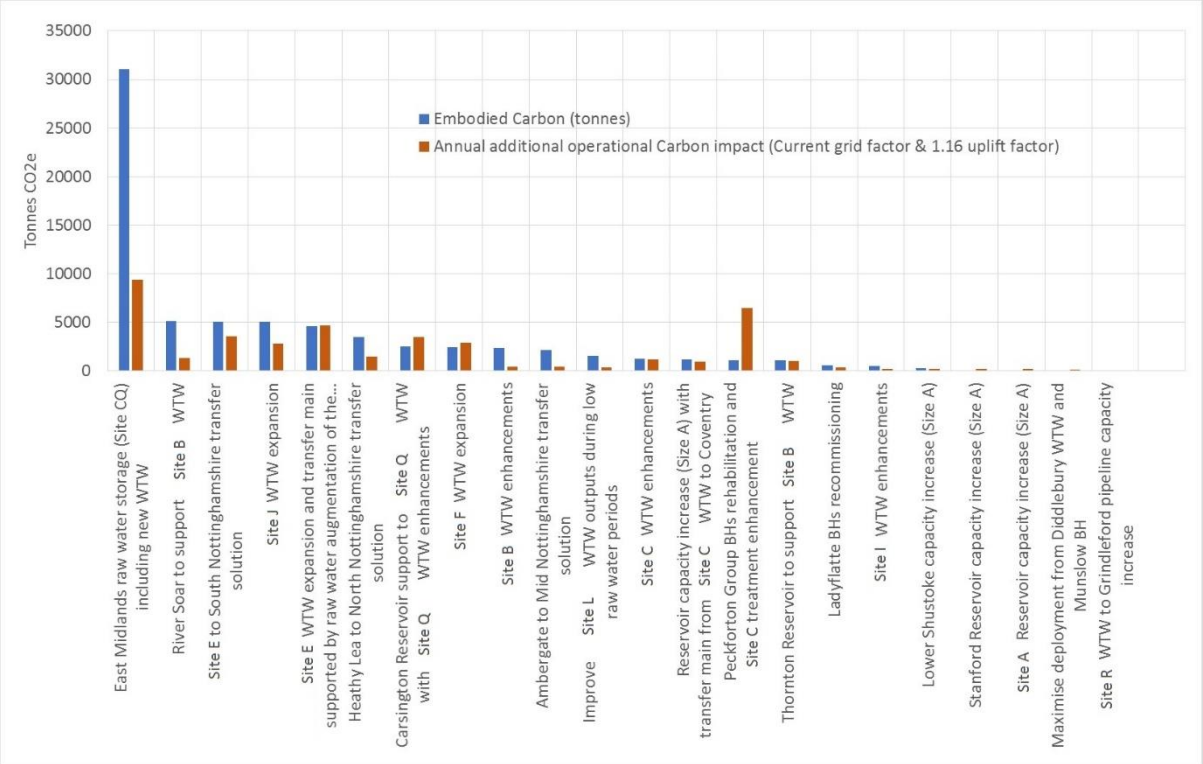
The net result of the long term strategy set out in our final WRMP is an increase in our carbon emissions – provided we exclude the effect of changes to the emissions intensity of the national electricity grid. This is the result of the increase in energy consumption due to water resource capital schemes and an increase in distribution input during the planning period.

Taking into account the effect of a continuing national move to lower-carbon energy as projected by Government, our total emissions and emissions intensity may decrease significantly over time, as the majority of our emissions result from our consumption of grid electricity.

Embodied Emissions

We have summed the embodied emissions projections from the supply-side options in our preferred programme to understand the total embodied carbon impact of this WRMP. Note that factors used in the calculation are current and no consideration of future changes to emissions intensity of different products and activities is considered in these numbers. Figure D7.4 provides a summary of the embodied and operational carbon impacts of our preferred programme of supply-side options.

Figure D7.4: Embodied and annual operational carbon impacts of options included in our final WRMP



The total embodied emissions impact of the schemes in the plan is estimated to be 71.6ktCO_2e, based on the emissions factors in the EA embodied emissions calculator. This is equal to approximately 16% of our current company annual operational emissions.

Our approach to estimating the impact of our WRMP on greenhouse gas emissions is commensurate with the strategic nature of the WRMP. As our preferred options are developed further, and in greater detail, our understanding of the effect each option has on greenhouse gas emissions will improve. Similarly, we will be able to provide an improved estimate of the impact that our WRMP has on our greenhouse gas emissions as we progress the adaptive planning approach to our programme and gain greater understanding of long term grid carbon factor trends.

D7.2 Measures to reduce our carbon impact

The options set out in our WRMP that ensure we can meet the future demand for water form only part of our overall investment plans. Our wider investment plans, and the estimated carbon impacts of these schemes, are set out in more detail in our PR19 business plan.

One of the key outcomes for the PR19 business plan will be that we continue to protect our wider environment. Our activities to achieve this outcome include reducing our contribution to climate change by cutting carbon emissions. As part of our overall PR19 plan we will be continuing measures to reduce our overall carbon emissions. The beneficial effects of these wider initiatives have not been included in the carbon projections included in our WRMP. The main actions we included in our wider PR19 plan are summarised below. Other measures include improving our transport efficiency and research into better ways to manage our process emissions.

Energy Efficiency

Approximately 70% of our company emissions come from grid electricity consumption. We continue to improve our energy efficiency through a combination of energy efficiency projects and operational energy management. Our projects include pump replacement and refurbishment, pump monitoring and control optimisation and site heating and lighting improvements. Our strategy also includes an ongoing focus on asset optimisation and process improvement, for example through improving our telemetry systems and optimising the way we control our network. We plan to continue a programme of efficiency measures to continue to reduce emissions.

Renewable Energy

We are leaders in the UK Water sector for renewable energy generation. The more renewable energy we generate, the lower our carbon footprint. Currently, the equivalent of 34% of the energy we use in Severn Trent is generated from Severn Trent plc renewable energy sources. In the regulated business, the majority of this energy generation comes from sludge in the wastewater side of the business, but we also generate energy from hydropower in the water side of the business. We will continue to look at remaining renewable opportunities in the regulated business and pursue those where it is economic to do so. We also continue to grow renewable generation in the non-regulated business, which helps reduce UK carbon emissions.

Optimisation in delivery and innovation

There are a number of ways by which we can reduce carbon impacts as we deliver our plan. These include innovating in design, consistently challenging our supply chain to come up with low-carbon solutions and selecting newer, more efficient technologies. For example, we would expect to take advantage of improved technology available on the market as we come to deliver the capital schemes described in the water resources management plan over the next 25 years.

D8 Environmental and social costs

The methodology adopted for the valuation of environmental and social effects uses the Environment Agency's Benefits Assessment Guidance (BAG) documentation. This includes the original BAG (EA, 2003), plus the updated User Guide (Eftec, 2012a) and Worked Example (Eftec, 2012b) published in 2012, which link the original BAG with more recent guidance on the use of value transfer in project appraisal. This adapted methodology is consistent with the approach adopted for our previous WRMP in 2014.

In accordance with the BAG, environmental and social effects of each feasible list component were qualitatively assessed in the first instance. Once effects had been qualitatively assessed, significant effects were then quantified and, finally, monetary values were calculated according to the approach described by the BAG User Guide where possible. Quantitative parameters considered include the affected population and the scale of effect (e.g. length of pipeline). Relevant data and monetary valuation calculations for each component were recorded in individual assessment proforma. Sensitivity testing of environmental and social costs was also carried out by varying important parameters for each impact category.

The BAG impact categories valued for the feasible list of components for both construction and operational phases are summarised below. In many cases, the identified effects could not be monetised due to the limitations of suitable, relevant studies to enable use of the benefits transfer approach to monetisation recommended by BAG. The SEA, HRA and WFD assessments were therefore used to provide semi-quantitative assessments of these effects.

Construction Environmental and Social Costs

Construction environmental and social costs were assessed over the relevant period during construction based on the design of each component or (in the absence of specific information) generic impacts in relation to construction duration, HGV and traffic movements, and impacts on recreational activities. We were able to calculate monetary values for the following construction effects:

- Disruption to recreational activities during construction works. The transfer value used for the valuation of recreation during the construction phase is based on the willingness to pay to undertake different informal recreation activities (Willis & Garrod, 1990). This value is based on the disruption to walkers from construction activities as a cost per person per year.
- Human health impacts from transport. The value transfer used is derived following the Defra Damage Cost Approach (Interdepartmental Group on Costs and Benefits / Defra, 2015b).
- Marginal cost of traffic delays associated with congestion during construction works. The transfer value selected for the valuation of congestion is based on the marginal cost of congestion associated with HGV and LGV movements (Sansom et al., 2001).

Operation Environmental and Social Costs

Operational environmental and social costs are based on annual average impacts. We were able to calculate monetary values for the following operational effects:

- Disruption to recreational activities during operation, using the same transfer value used to assess construction impacts (Willis & Garrod, 1990).
- Human health impacts from transport during operation or from general operational emissions to the air, both derived using the Defra Damage Cost Approach (Interdepartmental Group on Costs and Benefits / Defra, 2015b).
- Marginal cost of traffic delays associated with congestion during operation (Sansom et al., 2001).

It should be noted that, in addition, carbon emissions associated with each component for both construction and operation were assessed using water industry guidance and carbon valuation was carried out using national UK government carbon valuation guidance.

Environmental and Social costs of components in the feasible list

Environmental and social costs of the components on the feasible list of options range between £0 - £465,000 (average £34,000) during construction and between £0/year - £48,000/year (average £6,000/year) for operational effects. These are all negative dis-benefits and result from temporary or permanent impacts on recreation, air quality and traffic congestion.

Inclusion of Environmental and Social Costs into the FinalWRMP19

The environmental and social values were included in our Water Infrastructure and Supply Demand (WiSDM) investment optimisation modelling alongside capital and operational costs of the options. A fuller description of the WiSDM investment optimisation approach is given in Appendix E.

Since we published our draft WRMP, we have continued to investigate and develop all of the options considered in our draft WRMP. We have also expanded our Strategic Environmental Assessment to include a number of recommendations made through the consultation responses. This has resulted in an improved understanding of the costs, deployable output benefits, delivery risks and environmental impacts of all of the options. In turn, this improved understanding has influenced our decision making of the preferred options and informed the accompanying PR19 Business Plan with the best available cost data. During this update process we have updated our assessment of long term supply / demand need based on the outputs from WINEP3. We have also removed any options that have the potential to conflict with the water import and export proposals that are set out in the draft WRMPs of other water companies.

A total of 22 supply solutions were selected for the final WRMP19 programme. Temporary construction impacts of these solutions range between £0 and £187,000 (average £21,000). The average cost of the selected solutions (£21,000) which is lower than the average cost of the feasible components (£34,000) demonstrating that WiSDM utilised the environmental and social costs in the optimisation process. Operational dis-benefits of the final WRMP19 programme were valued at between £170/year and £15,000/year (average £3,000).

A combined total of £450,000 of temporary dis-benefits were identified during the construction phase of all supply solutions in the final WRMP19 programme across the planning period.

D9 Resilience options

Our WRMP specifically considers our resilience to drought events, and sets out our long term proposals to manage this risk. Our WRMP has been developed in parallel to our wider PR19 investment plans. This has ensured an aligned approach to preventing loss of water supply to customers. Our improved operational resilience is achieved by carrying out interventions that enable us to provide a continuous supply of water under a wide range of shocks and stresses. Our PR19 plans set out the investment we need to make across the whole of our water supply and distribution system to so that our customers benefit from:

- Water that is always there when they need it, and;
- Water that is good to drink.

Our plan to achieve these outcomes include a programme of proposed investments that will improve our ability to maintain supplies to customers during times of; loss of water resource (for example, occurring due to borehole contamination); loss of treatment capacity (for example, due to asset or power failure), or; distribution issues (for example burst pipelines). Our overall strategy for managing system resilience is to:

- Operate at the right level of risk.
- Optimise the use of our existing assets/system capability.
- Minimise failure points and implement a more pro-active maintenance approach which allows investment to be prioritised effectively.
- Maximise efficiency and resilience - build a future network which is resilient and effective for customers and the environment and efficient to operate.

Finding the optimal response

To help find the optimal resilience response to risks to our critical infrastructure, processes, systems and networks, we apply the Cabinet Office's 2011 'Keeping the Country Running' '4Rs' four box model (resistance, reliability, redundancy and response and recovery) as demonstrated in Figure D9.1.

Figure D9.1 Components of the four box model

Source: Keeping the Country Running: Natural Hazards and Infrastructure Report

These terms are defined as:

- Resistance — Protecting or engineering assets and systems to withstand resilience events.
- Reliability — Ensuring assets and systems have a wide and stable operating range to operate under a resilience scenario.
- Redundancy — Duplicating capacity so service can be maintained under a resilience scenario.
- Response & recovery — Ability to effectively recover asset or system capability after a resilience event.

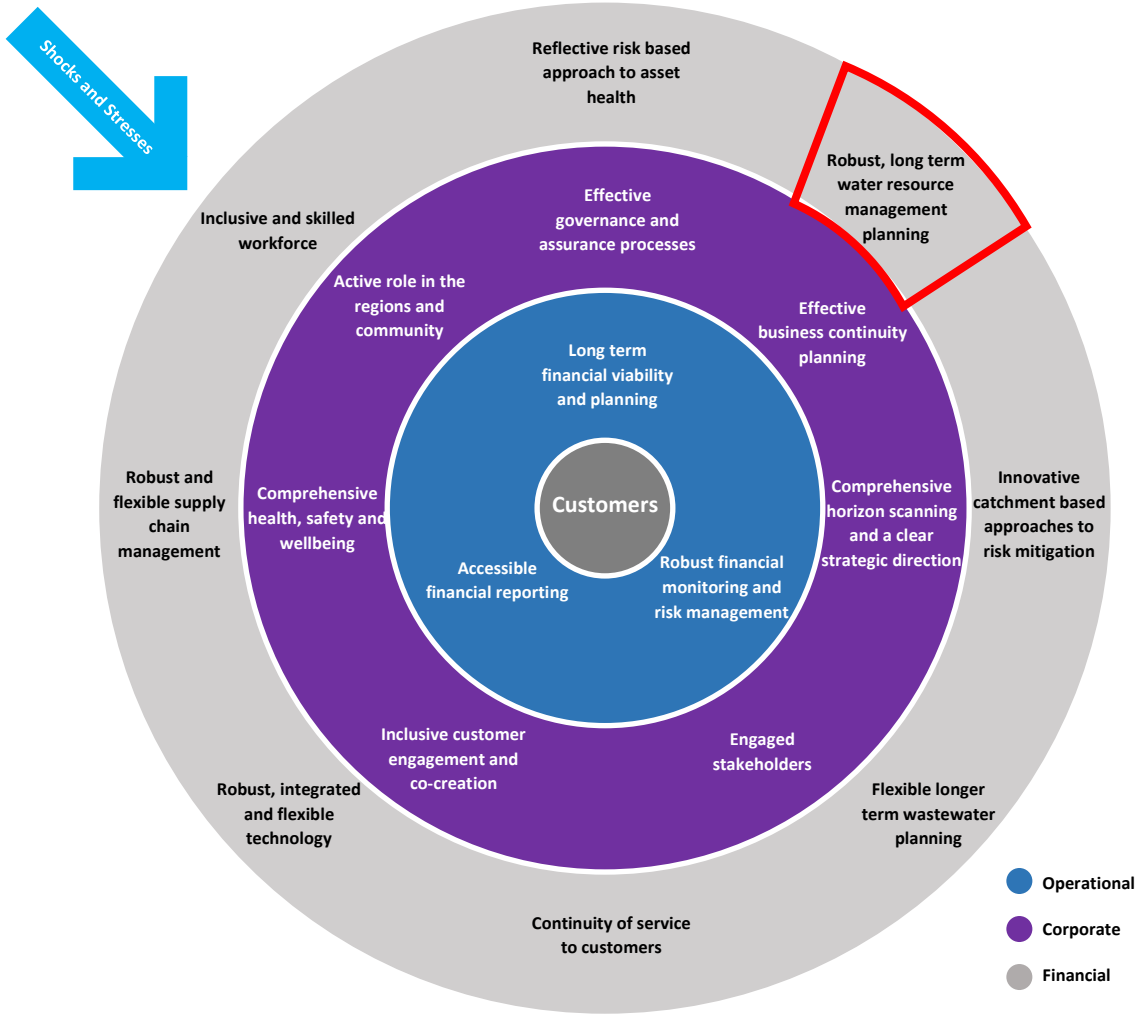
We considered each of the 4Rs against a given risk in turn to ensure that we don't assess resilience options too narrowly. Before opting for an asset heavy solution we would first consider other options or a blend of options to produce the most cost effective and proportionate strategy. For example, for a short duration interruption and discolouration event, operational and process improvements may be more effective than building additional redundancy.

Our 'resilience in the round' framework

We have developed the Cabinet Office's approach that we historically used into a 'resilience in the round framework' as we move to a 'systems thinking' approach. While our current approach addresses resilience, developing a more systematic approach has been essential to ensure our approach is more rounded and drives greater focus on finding the optimal solution for corporate and financial disruption as well as operational drivers.

We've worked with leading consultants experienced in resilience best practice and employed a holistic framework of a well-functioning and resilient system. The framework brings together the processes and activities already in place, with the approach set out by Ofwat, into a single framework known as our 'resilience wheel', Figure D9.2. Approaching resilience through our resilience wheel ensures we think about the short-term risks and longer term trends that could impact our ability to deliver service – both business as usual and during times of external stress – and what we do to avoid, cope and recover from this disruption.

Figure D9.2 The 'resilience in the round' framework we have adopted – our resilience wheel



For our wider PR19 business planning, we decide on the best resilience solution 'in the round'. Avoiding or managing risks in one component may effectively make us resilient in another, for example, our industry leading innovative catchment management initiatives tackle pollution problems at source, thus minimising costly treatment solutions later. Systems thinking also crosses between our operations, financial systems and wider organisation - with risks identified in one area informing our approach in another. For example, our long term financial viability testing, stress tests operational risks (e.g. failure of key assets, failure to deliver what customers want, cyber security) and risks to our organisation (e.g. failure to comply with legislation, health and safety) to inform our approach to long term financial planning. Adopting this framework ensures we don't look at resilience in isolation – the components work together as a system.

Our risk-based approach to building operational resilience puts customers at the centre of our decision making while balancing the needs of the environment and our communities.

We have taken a holistic systems approach to understanding the interrelations between the multiple decisions we make to plan and deliver operational resilience. Systems thinking enables us to make better, more informed and sustainable choices because we're able to better understand the wider consequences of decisions in one part of the system and their impact on others.

For our wider PR19 investment planning, we have applied these strategic principles to the following areas. These are outlined in more detail in Sections D9.1 to D9.5:

- Resilience of our critical assets
- Borehole and ground water resilience
- Power resilience
- Local resilience
- Risk to our assets from flooding

Where we identified that new supply capacity is needed to maintain the supply / demand balance, we have prioritised the selection of options that make the best use of our sustainable sources of supply. We have focussed on options that:

- Increase the flexibility and resilience of our supply system, such as the new strategic supply links.
- Increase or optimise deployable output from existing, sustainable sources where possible, such as increasing the capacity of our existing water treatment works.
- Make use of potential trades in and out of our region to optimise national use of resources.

The preferred programme of options and appraisal of different investment choices has been developed in parallel with our wider water distribution and supply resilience strategy. We have ensured that we understand the holistic total expenditure (Totex) implications of our investment choices and we can derive a fully integrated, optimised supply/demand, infrastructure and leakage investment plan.

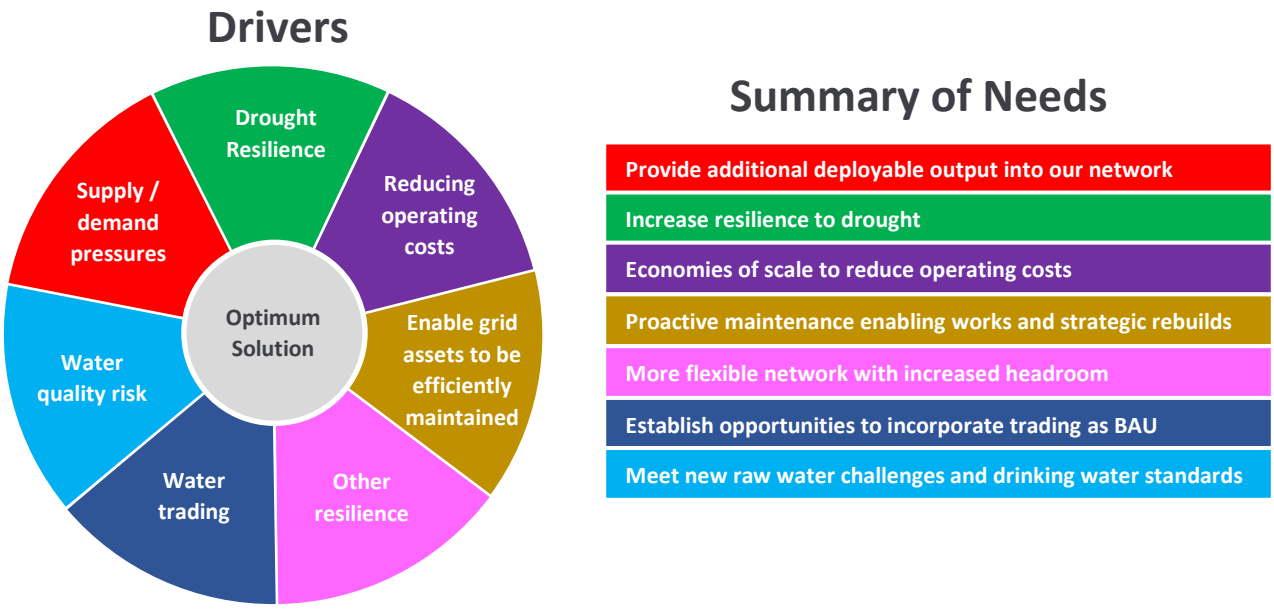
Our supply-side and demand-side investment decisions are underpinned by our broader capital maintenance and water quality investment programme. At the same time, the options and activities included in our WRMP not only contribute to addressing future supply / demand challenges, but also deliver broader benefits to our customers by creating more resilient supplies.

The full range of drivers that have been considered as we have sought to optimise water resources and supply / demand options over the long term are summarised in Table D9.1 and illustrated in Figure D9.3:

Table D9.1: Drivers considered when selecting an optimum programme of options

Driver	Summary of need and opportunity
Reduce operating costs	Reduce water treatment and pumping costs by achieving economies of scale and maximising the outputs of our treatment works with lower variable operating costs.
Enable Grid assets to be efficiently maintained	Improve maintenance efficiency through strategic rebuild rather than 'patching' individual processes with multiple intervention activities. Allow more efficient maintenance interventions by extending the period for which whole process streams can be taken offline. Reduce the risks to water quality and customer interruption when assets are taken out of service. Enable major water treatment works to be taken fully offline. Enable critical aqueducts and pipelines in our grid to be taken offline for inspection and extended maintenance.
Drought resilience	Increasing resilience to drought and reducing cost of failure.
Supply / demand pressures	Provide increased capacity to address future deficits driven by climate change, water framework directive and population growth. Release 'locked up' deployable output by removing constraints.
Water quality risk	Effectively meet new raw water challenges and drinking water standards.
Water trading	Identify opportunities for trading water with neighbouring water companies, both into and out of our region.
Other resilience	Remove risks by developing a flexible network that can continue to maintain supplies during an unplanned outage at a water treatment works or an unplanned interruption to a strategic link. Provide more headroom to meet future peak demand.

Figure D9.3: Factors influencing the optimum plan of options.



D9.1 Resilience of our critical assets

Following the events at Site O in July 2007 we have been progressively seeking to reduce the risk associated with the temporary loss of supply from our critical assets including aqueducts and our surface water treatment works. Capital investment projects carried out in AMP5, and those ongoing in AMP6, will improve our resilience in the event of a temporary loss of a number of our major water treatment works.

We have extended and improved on our methodologies and learning from previous studies to cover all our critical assets so that we can understand and quantify risk in a systemic and consistent way. We have identified that we continue to hold a risk of loss of supply to large numbers of customers in the event of catastrophic failure at one of a number of our surface water treatment works or a section of our Strategic Grid aqueduct or pipeline. Our investigations to date have identified the assets that pose greatest risk to security of supply if they were to fail. Our surface water treatment works, their performance and resilience are also key in ensuring that we provide sufficient day to day operational headroom across our network.

The interconnectivity and resilience already built into our network is designed to enable us to move water in a flexible and sustainable way in response to an unplanned event. However, this resilience has been provided over a number of AMP investment periods and in some cases only meets the requirements of *"Water there when you need it"* and not the requirement of *"Water that is good to drink"*. Our investigation has identified interventions that could be made to the existing assets to improve how we can operate in a resilience scenario that will allow us to meet both requirements. The improved performance of the resilience assets will allow for enhanced and more flexible operation of our water supply network so that we can maintain levels of service standards even when the system needs to be operated in a resilience scenario.

Our PR19 plan for improving the resilience of our critical assets is summarised below;

- **Strategic sections of assets.**
  Risks associated with the tunnel and conduit sections of the Strategic Grid, which form a strategic link in Derbyshire will be addressed. Almost 100,000 customers will benefit from the reduced risk of long duration interruptions.
- **Large surface water treatment works.**
  To improve the resilience of four of the larger surface treatment works to reduce the risk to almost 400,000 customers experiencing supply interruptions as a direct result of an outage.
- **Network assets.**
  To improve the capability of the distribution infrastructure to move water around and maintain supply in the event of one of our larger treatment works failing. Over 2.5 million customers would benefit from an improved level of service from preventing such failures and half would also benefit from reduced risk of discoloured water supplies.

D9.2 Borehole and Ground Water Resilience

For groundwater resilience we have focused on identifying investment options to ensure that none of our customers that are reliant on a single or significant groundwater source will go without supply for more than 24 hours as a result of a significant failure event.

Greater understanding of our groundwater assets and their vulnerability has been gained through AMP5 and AMP6; determined through a combination of our Borehole Capital Maintenance programmes, enhanced groundwater monitoring and surveys and better recording and understanding of actual and near miss pollution events. The data obtained from these activities has indicated some vulnerability across our groundwater asset base.

Analysis has shown that whilst groundwater source failure events are of a low probability, they do and have occurred, and in particular supply areas are potentially high consequence events. The impact on customers can be high (loss of supply) as well as the impact to our company operations when we are required to respond to events. Our investigation has focused on supply areas where the consequence of these risks occurring is amplified due to the vulnerability of the groundwater source, for example where there is little or no medium or long term asset resilience in place to maintain customer supplies.

A loss of supply to customers for durations of weeks or months would cause significant resource and manpower burden but also with the potential for profound reputational, financial, regulatory and social problems. We are therefore committed to carrying out investment to protect our customers.

The type of solutions that we are investigating to improve the resilience of our groundwater asset base range from catchment management, treatment, and new distribution connections. These are being investigated in conjunction with maintenance investment plans as well as our supply / demand balance and strategic options for addressing drought.

D9.3 Power Supply Resilience

Power dips or power outages have the potential to cause unplanned supply outages to our strategic grid water treatment works and other water sites. In order to improve the power supply resilience there are two elements of work:

- Immediate solutions to eliminate power dips across assets and critical processes.
- Long-term solutions to ensure power is always on, for example by ensuring capacity with standby generators, on-site temporary power supply connection points or with Uninterruptable Power Supplies (UPSs) where these are sufficient.

A number of initiatives were delivered in AMP5 for improving resilience, such as; schemes for purchasing generators and using them as stand-by for emergency situations; purchase and installation of fixed generators, and; installation of connection point for alternative power sources / generators.

In AMP6 a programme of work is currently being delivered at five sites that are classed as ‘too critical to fail’. The main scope of this programme is to identify and implement quick fixes and immediate solutions to eliminate power dips across assets and critical processes that could cause unplanned works outages, and interim control measures if needed.

In AMP7 we are considering power supply resilience at our water treatment processes in addition to overall site resilience.

D9.4 Local Resilience

Our approach to resilience includes preparing ourselves for the occurrence of undesirable events and disruption to our ability to serve our customers. During an incident, our business continuity plans come into effect to ensure that we seamlessly deliver services that are as close to business as usual for our customers.

We take a customer focused risk-based approach to business continuity aligned to the National Risk Register. Our organisational framework ‘Being Prepared’ and our ‘Business Continuity Standard’ follow ISO 22301 best practice (though we are not formally accredited) and the Business Continuity Institute Good Practice Guideline 2018. The framework includes emergency response plans that comprehensively cover all our critical assets – water supply, wastewater and alternative supply.

We work closely with the 18 local resilience forums that cover our region to ensure support for our vulnerable customers. We also work with other agencies during incidents to, for example, provide tankers or pumps to help support fire and rescue services. During an incident we will update Defra teams, government ministers and other senior stakeholders to ensure they remain fully briefed; And following an incident, we'll hold a de-brief session to obtain feedback and learn lessons.

Incident plans are regularly updated and tested and include an annual strategic level exercises. We also actively participate in exercises with external stakeholders, including local resilience forums, emergency services, local authorities and the Environment Agency to test our procedures, identify areas for improvement and to increase competency. We run a number of events every year, engaging external stakeholders and also attend other externally run events whenever we can.

Where incidents occur and are of strategic level importance – as in the long duration incidents of 2018, we are prepared to quickly mobilised a 'gold level' incident team lead by our Executive Team with support from business and strategic leaders. Continuity of service is ensured through increased production, tankering and flexing resources to deliver the best response. Our close working with local resilience forums and our logistics partners to provide alternative supplies, and focus on our vulnerable customers to ensure they receive the level of support they expect, including hand delivering alternative supplies where necessary. And throughout, we've kept customers informed, answering queries directly through text messaging and social media 24 hours a day 7 days a week.

D9.5 Flooding resilience

In early 2016, following a series of significant flood events around the country (Carlisle being a precipitative event) the UK Government initiated the National Flood Resilience Review (NFRR) to assess the UK's ability to maintain essential services during extreme flooding and extreme weather events. As part of the NFRR work we have re-assessed our vulnerability at all of our sites and assets against the Environment Agency (EA) Extreme Flood Outline Maps that are based on up to 1 in 1000 year events. We can now foresee the impact that loss of service from flooding can have and the risk across our entire asset base. We have considered potential solutions and developed a cost estimate for a programme of work for AMP7 and beyond for flood protection against a 1 in 1000 year event, prioritised based on site/asset level criticality.

We collaborated with our stakeholders (including city and district councils, flood & coastal committee, Environment Agency, National Flood Forum, Cabinet Office, Defra) to commence partnership approaches to this resilience challenge. We have focussed on the impact to our assets and our ability to serve our customers arising from river flooding (fluvial), surface water run-off (pluvial) and groundwater levels rising. There are a number of examples where we have installed flood protection schemes and we have learned from previous events such as at Site O WTW in 2007, where we improved the resilience of our services in many areas, including:

- Flood barriers have been established at some key, at risk, assets.
- Single points of failure within our assets have been identified and addressed.
- Second sources are available to our larger populations.
- Power supply resilience has been improved.

In response to Regulator and other organisations' challenges, and now that the sites have been identified, we believe it is prudent to make them resilient so that we are capable of maintaining service in the occurrence of an extreme event. We have carried out a site-specific appraisal of the unique flood protection requirements for each site and we have identified specific flood protection solutions.

Using the strategic resilience planning principles described in Figure D9.2, we have prepared a range of solutions that should be implemented to improve the resilience of the sites to flooding events. This approach enabled us to minimise investment requirements whilst maximising resilience benefit outcomes. Typically these solutions comprise:

- 'Do nothing' (where impact is considered acceptable for a short period of time)
- Increasing interconnectivity so that service provision is no longer dependent on a single asset,
- Relocation of critical equipment/asset
- Mobile back-up equipment
- Permanent defences at key asset level
- Permanent defences at site level

We have sought the views of our customers through various quantitative and qualitative channels so that we have a holistic picture of their needs. We undertook deliberative research to test appetite to protect assets so that service could be maintained in these circumstances. The feedback we received suggests that for the marginal cost of our proposals customers are willing to pay for the benefits.

D10 Description of our recommended supply options - Redacted