Water Resources Management Plan 2019

Annex 8: WRMP strategy

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Version 1

from Southern Water

Contents

Southern Water

1. Executive summary

In this Annex, we set out the approach we have followed to develop and select the strategy for the Water Resources Management Plan (WRMP) for each of the company's three supply areas. The Technical Overview presents a summary of the process we have followed to develop the WRMP. Here we focus on the investment modelling part of that process.

The objective of a WRMP is to ensure that there are always enough supplies available to meet anticipated demands in all water resource zones (WRZs) under every planning scenario or defined design condition, even under the conditions of greatest water supply stress.

We have developed an economic least cost model (the 'investment model') to help select the combination of options – the portfolio of options – which maintains the supply-demand balance at least cost. The investment model is a **decision making tool** that helps the company identify the optimum set of options based on cost, but it does not necessarily identify the final strategy we adopt in the plan, as there may be other factors that need to be considered and addressed, such as customer preferences for different option types, outcomes from environmental assessments of the options, and regional planning initiatives.

We then also use the investment model to test the robustness of our final strategy against a range of assumptions, to help identify key alternative options that we may need to investigate in parallel with the preferred plan.

Separate investment models were developed for each of the three sub-regional supply areas (Western, Central and Eastern), which are geographically separate (with each supply area consisting of between three and seven WRZs). Although the building blocks for the strategy are the individual WRZs, there are inter-connections (either current or potential) between them, and thus actions in one WRZ can have an impact on other inter-connected WRZs within that sub-regional area. The model must take account of the supply-demand balances for each planning scenario, including transfers and bulk supplies, in all the WRZs in each supply area at the same time in order to develop a consistent solution for the supply area.

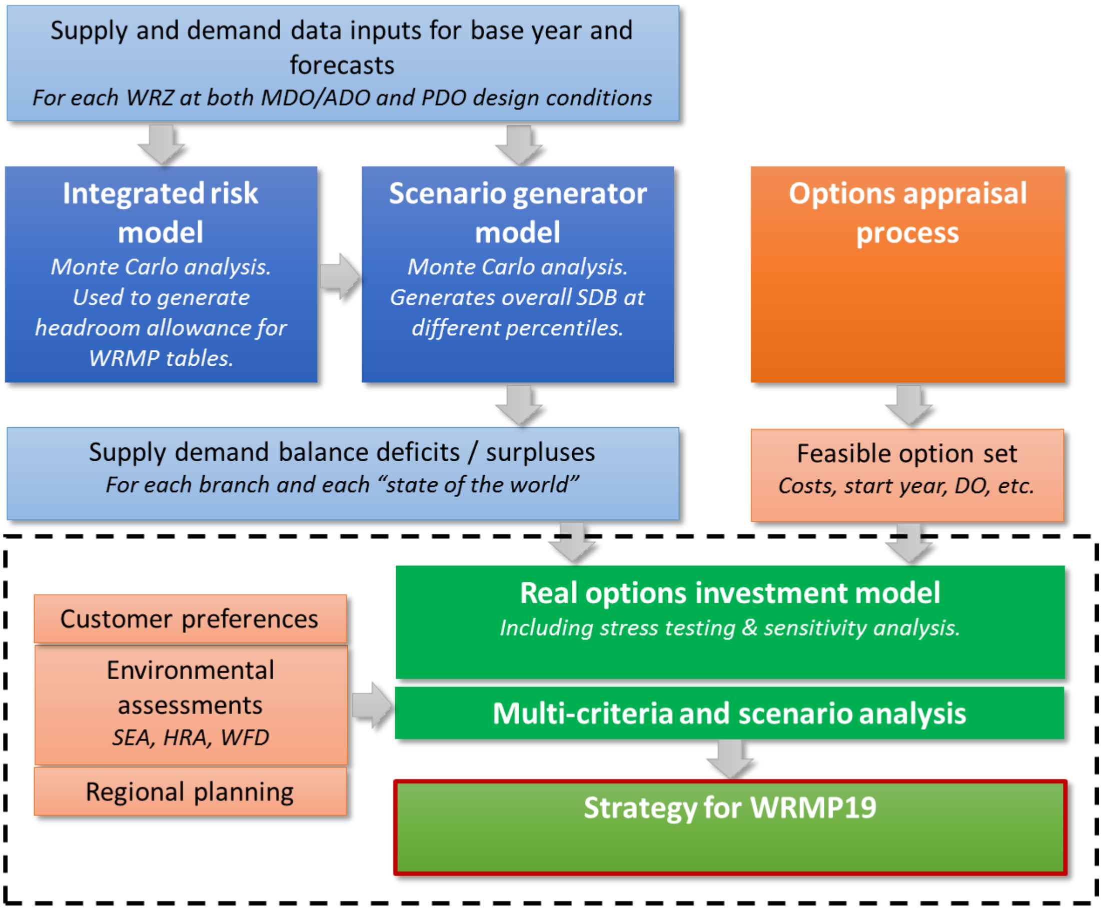
The key inputs needed to allow investment modelling are:

- The surplus or deficit in supply compared to demand (known as the supply-demand balance) across the planning period under each of the design conditions and for each WRZ
- A list of feasible options (supply-side, demand-side, and water trading) with associated information on costs and the volume of water these provide in each of the design conditions

There are various different investment modelling approaches that a company could use to support its decision making for its WRMP. The problem characterisation section of Annex 1 sets out the company's analysis for identifying its preferred decision making tool: **for WRMP 2019 the company has employed a Real Options methodology for all three supply areas**.

Figure 1 below presents an overview of the inputs and decision making tools.

Figure 1 High level overview of decision making process and inputs



The Real Options approach used to inform the decision making for this plan solves the supply-demand deficits simultaneously for seven different **'states of the world'** across five different '**futures**' or **'branches'**.

- 'States of the world': represent a snapshot of different climatic conditions and intra-annual pressures on water resources and demands, from normal year through to severe and extreme droughts, looking at periods when water supplies are at their minimum, and at periods of peak water demand during summer months
- Different possible 'futures' modelled by different 'branches': represent a plausible set of supply-demand balances for a range of possible future scenarios, for which different solutions may be needed

The use of different futures in the Real Options approach effectively recognises that **the future is not certain**, so tries to identify how solutions may change through time in the face of different possible future water resource pressures, and also identifies a common set of 'no regrets' options in the short term which should be developed regardless of which future may materialise.

These uncertain futures are a key reason why we have adopted the Real Options approach – so that key schemes and alternatives which address these uncertainties can be investigated and progressed in parallel to the preferred plan. Should the magnitude of the future uncertainties be less severe, then some of the schemes would not need to proceed past feasible investigation and planning / promotion stages. However, the company has little choice but to conduct these investigations of alternative and preferred schemes through AMP7 (and AMP8), given the scale of uncertainties the company faces in the next 10 years.

Our approach to **developing the strategy for the draft WRMP** in each of our supply areas is summarised in Figure 2 below. The first stage was to undertake an initial phase of scenario testing to help understand the sensitivity of the strategy to various possible constraints. The purpose of this testing was ultimately to inform the selection of the company's plan. This stage involved an **initial 'least cost' model run** to develop a 'basic solution', without further consideration of potential constraints.

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

From examination of the various model run outputs, and taking into account the pre-consultation discussions with regulators and stakeholders, consultation representations, and policy decisions, refinements were introduced to reflect a **'constrained' least cost strategy**. The policy decisions applied were in regard to the inclusion of water efficiency assumptions (the company's target to help our customers achieve an average per capita water consumption of 100 litres per person per day by 2040 – the 'Target 100' policy), the policy of leakage reduction (aiming to achieve a 15% reduction by 2025 and 50% reduction by 2050) and the availability of Drought Permits / Orders to relax abstraction licence conditions in severe and extreme drought events.

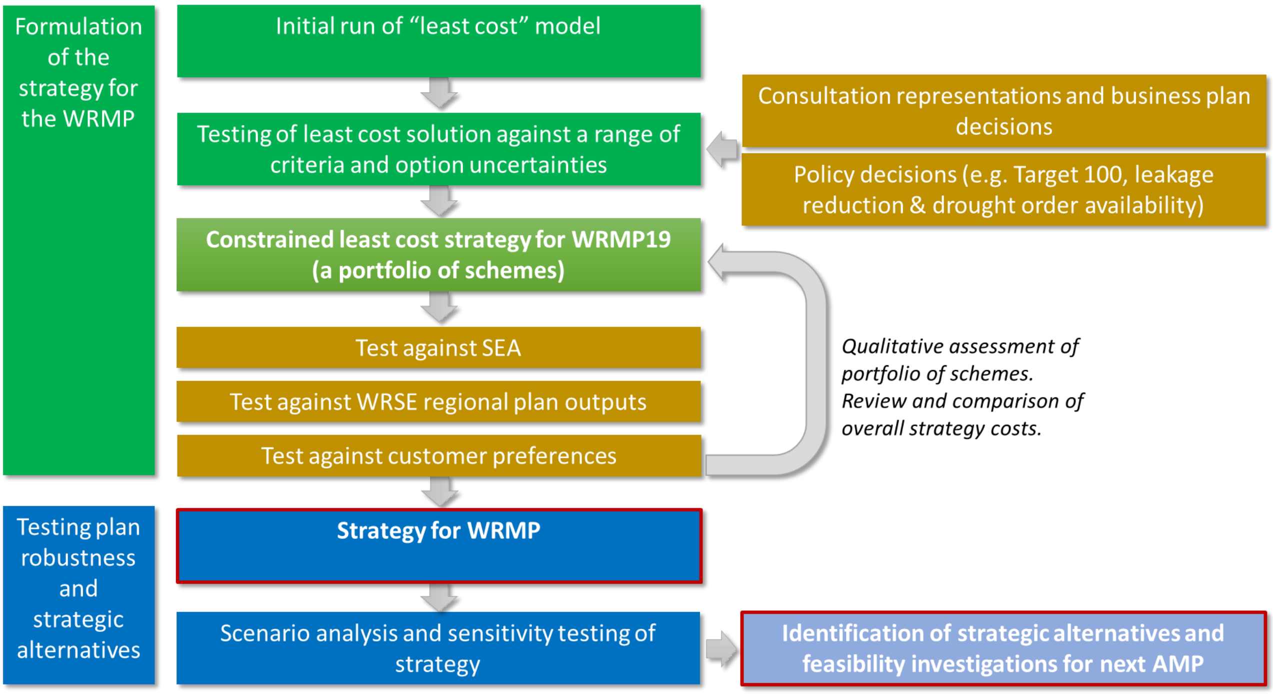
The constrained least cost strategy was then examined and tested against:

- Environmental criteria
- Outcomes from regional planning exercises (Water Resources in the South East – WRSE
- The preferences arising from customer engagement activity

The testing of the constrained least cost strategy against the environmental, regional and customer preferences criteria effectively led to an iterative loop. Another key element considered was the relative impact of the changes influenced by testing against criteria in terms of the overall strategy cost, compared to the least cost model and to the constrained least cost strategy. Where there is little cost difference, and the change of option provides a more positive outcome to one or more of the testing criteria, then there is a stronger case for including the option change in the preferred strategy.

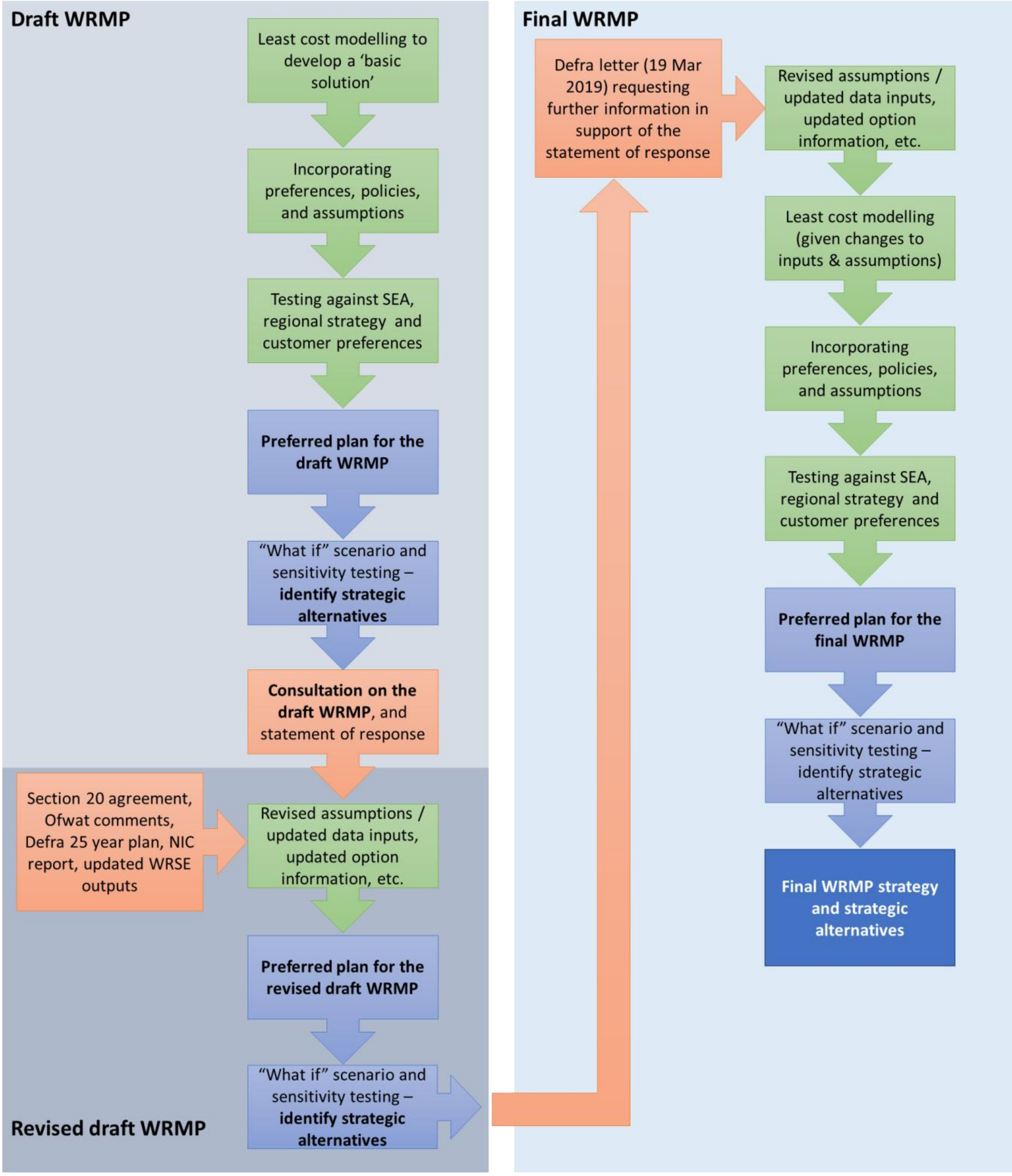
Following this review and testing process, any refined assumptions of the feasible options set were fed into the Real Options model to derive the **strategy**. The strategy was then subjected to **scenario and sensitivity testing** to understand what **alternative strategic schemes** may be needed, should it not be possible to implement the schemes in the preferred plan. This is particularly important for those schemes in the strategy that are required early in the planning period, in AMP7 or AMP8.

Figure 2 Development of strategy for the draft WRMP



The draft WRMP strategy is published for consultation with customers, stakeholders and regulators. The responses received during consultation may result in changes to the assumptions or inputs used to derive the supply-demand balances, as well as to the set of options that are available to meet forecast deficits. Consequently, elements of the strategy may be reviewed or refined as we move from the draft plan to our final plan. This process is summarised below in Figure 3.

Figure 3 Development of the strategy from draft to final plan



2. Investment modelling

2.1 What is investment modelling and why is it used?

The objective of a Water Resources Management Plan (WRMP) is to ensure that there are always enough supplies available to meet anticipated demands in all water resource zones (WRZs) under every planning scenario or design condition, even under the conditions of greatest water supply stress, throughout the planning period. The planning period we are focused on for the WRMP is from 2020 to 2070.

Therefore, where we have identified that there is a supply-demand balance deficit for a WRZ during the planning period, we must identify what options can be developed to address that deficit. To do this, we use an economic least cost model (the “investment model”) to help select the combination of options – the **portfolio of options** – which maintains the supply-demand balance at least cost (discounted), given the assumptions for each planning scenario.

The investment model is a **decision making tool** that helps the company identify the optimum set of options based on cost, but it does not necessarily identify the final strategy we adopt in the plan, as there may be other criteria that need to be considered and addressed to identify the final strategy. These criteria may include customer preferences of different option types, outcomes from environmental assessments of the options, and regional planning initiatives. We then use the investment model to also test the robustness of our final strategy, and to identify key alternative options that we may need to investigate in parallel to the preferred set of options.

Separate investment models were developed for each of the three sub-regional supply areas (Western, Central and Eastern), which are geographically separate. Each supply area consists of between three and seven WRZs. Although the building blocks for the strategy are the individual WRZs, there are inter-connections (either current or potential) between them, and thus actions in one WRZ can have an impact on other inter-connected WRZs within that sub-regional area. The model must take account of the supply-demand balances for each planning scenario, including transfers and bulk supplies, in all the WRZs in each supply area at the same time in order to develop a consistent solution for the supply area.

The investment model incorporates all the feasible supply-side, water trading and demand-side options. These were all made available within the model to solve the supply-demand balance deficit in each of the planning scenarios.

Existing inter-company bulk imports and exports were included within the investment model as ‘fixed’ baseline transfers, so they were fixed assumptions in the supply-demand balance that the model aimed to solve. The reason for this is that bulk supplies are treated as contractual volumes of water to be supplied, except where the severity of the drought affects the ability of the donor company to provide the contractual amount, and some form of ‘pain share’ is introduced. It is therefore prudent to plan on the basis of meeting the bulk supply commitments. This is explicitly stated in the company’s Drought Plan. New water trading options are treated like any other option – the model may select them freely to solve the planning problem. The volumes associated with the new water trading options were also ‘fixed’ as a contractual volume of water, and these volumes were agreed in discussion with the donors/receivers under each of the relevant planning scenarios.

Inter-zonal transfers were treated differently within the model. These are internal transfers between Southern Water’s own WRZs. As such, all inter-zonal transfers were included as options for transferring between zones and were then selectable as part of the optimisation process. This is because an internal transfer does not affect the overall water balance for the supply area; they are just a different way of balancing the water available across the inter-connected WRZs. The model was therefore allowed to vary transfers from zero up to the capacity of a given transfer within the optimisation process to derive an optimal least cost solution. This allowed the model to select the least cost overall strategy for all water trading and transfers, resource development, catchment management and demand management options.

The key inputs needed to allow investment modelling can thus be summarised as follows:

- The surplus or deficit for the supply-demand balance across the planning period under each of the design conditions and for each WRZ
- A list of feasible options with associated information on costs and volume of water these provide in each of the design conditions

2.2 Selection of investment modelling approach

There are various different investment modelling approaches that a company could use to support its decision making for its WRMP (UKWIR, 2016). As described previously in Annex 1, the company has set out its approach to deciding on its preferred decision-making approach. Two potential options were identified from the problem characterisation assessment; these were:

- Real Options using modified EBSD (Economics of Balancing Supply and Demand) models
- Adaptive pathways

The adaptive pathways methodology is most closely aligned with the company's adopted 'risk principal', preferred approach and key challenges. There are a number of key uncertainties that are yet to be resolved either in the magnitude of their impact on our supply-demand balance, the timing of impacts, or both. An adaptive pathways methodology would explicitly recognise that such uncertainties exist and track them. As the uncertainties are resolved over time, the plan and subsequent future actions could then be appropriately adapted to ensure an optimal cost-benefit plan. However, as noted by UKWIR (2016) this methodology has not yet been applied to a water resources problem and hence the techniques remain untested and highly uncertain. Therefore, the company intends to instigate a research project to further investigate how an adaptive planning methodology can be developed and applied in the context of water resources planning in the United Kingdom with an aim of further developing the approach in our next WRMP (known as WRMP24).

In AMP5 the company tested a pilot planning approach using a Real Options methodology to examine the potential schedule of investment options associated with uncertain sustainability reductions in the Western area in order to establish 'no regret' investments, although this work was not completed until after the WRMP14 planning was undertaken, so was not part of the WRMP14 submission. **For this current plan the company decided that it will employ the Real Options methodology** across all three supply areas.

The company also identified a preference to develop a multi-criteria analysis (MCA) approach to developing a best value plan alongside the Real Options methodology. This considers, in particular, environmental assessment outcomes, regional planning and customer preferences for different option types, with the objective to derive a best value plan from the initial least cost solution. We are looking to further develop and refine this ahead of the next WRMP in 2024.

2.3 The Real Options investment model

Our WRMP14 used a conventional investment modelling approach in line with the EBSD methodology, with sensitivity analysis and stress testing to inform the selection of the company's preferred plan.

The investment model used for WRMP14 comprised a Mixed Integer Linear Programme to optimise the selection of options to meet a specified deficit on a least cost basis. Thus the WRMP14 investment model had to solve a single objective – namely least cost (which included financial, environmental and carbon costs) – whilst satisfying a single constraint to ensure that supplies would be greater than demand plus headroom in each year of the planning horizon under different 'states of the world' (which were used to provide better utilisation calculations relevant to variable operating expenditure, or variable 'opex').

There are limitations to using a conventional EBSD (and also to using a more simplistic Average Incremental Cost, AIC) approach, particularly where there are **substantial uncertainties over time** – which is the case Southern Water face, particularly during the 2020s with sustainability reductions, and beyond that with demand growth and climate change impacts on supplies. In such cases, a Real Options decision making approach is considered a better tool, as it provides a framework for improved learning about, and consideration of, the uncertainties, and thus the flexibility to adapt plans to reflect this learning. Real Options approaches are most appropriate where the level and nature of uncertainties at different points in the future could change the optimal investment decisions today[1]. The real options approach concentrates on understanding what a company has to do in the near term, against the context of what might happen in the future – i.e. it aims to identify a 'least regrets' solution set.

A real options approach incorporates planning for a wider range of plausible futures compared to the previous EBSD approach and thus aims to ensure that the plan is more resilient against a range of uncertain, yet possible, futures, in addition to allowing development of greater plan flexibility.

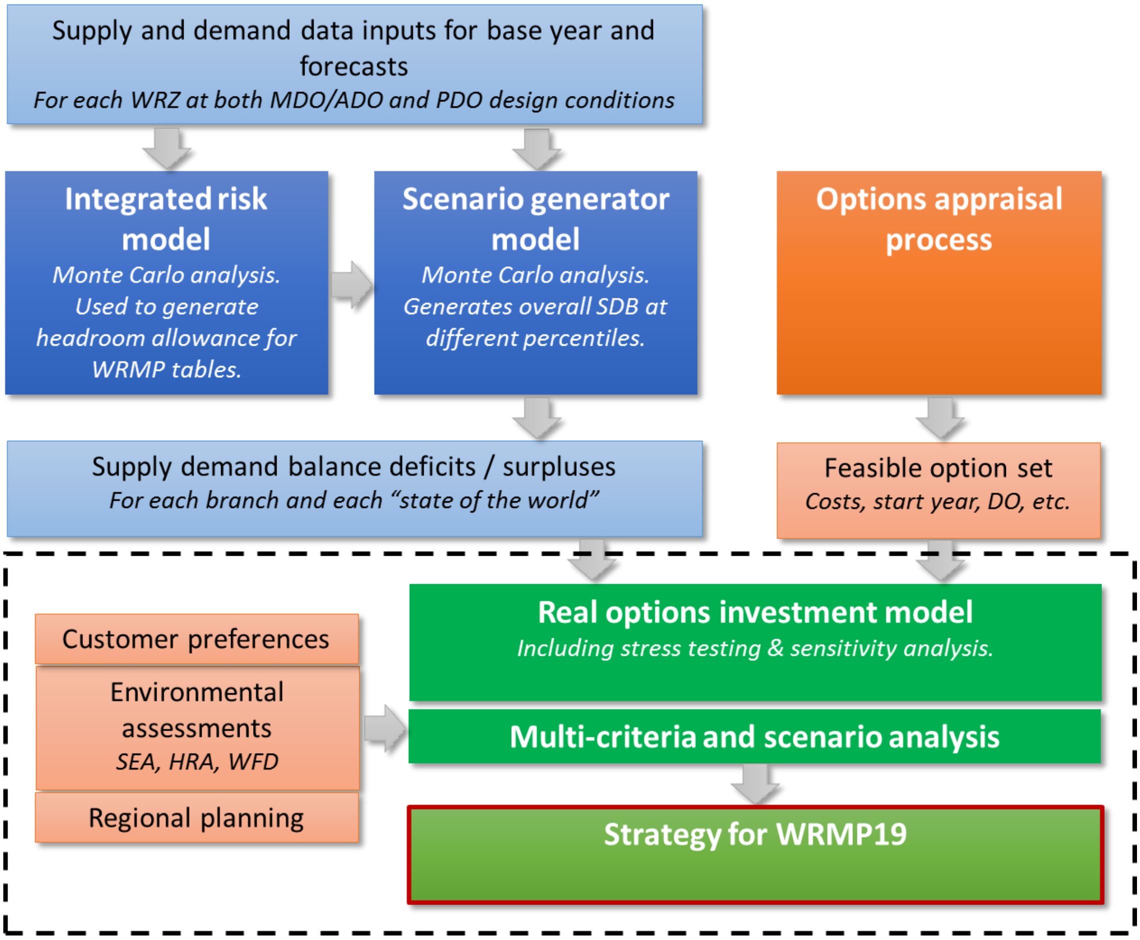
Southern Water undertook a pilot study at the end of AMP5 to demonstrate the principles of Real Options and multi-criteria analysis. This was not published as part of WRMP14. The investment modelling for this plan has therefore built on the work undertaken in AMP5, as well as utilising current industry best practice in terms of:

- UKWIR (2016), WRMP19 methods – decision making process, 16/WR/02/10
- UKWIR (2016), WRMP19 methods – risk based planning methods, 16/WR/02/11

Figure 4 sets out a high level overview of the decision making approach followed for this plan. There are a number of models used to generate the required supply-demand balances that are then used as inputs to the Real Options model. The outcome of the options appraisal process – a feasible list of costed options with associated volumes under different drought return periods – provides the other key input to the Real Options model.

[1] UKWIR (2016) *WRMP 2019 Methods – Decision Making Process: Guidance*

Figure 4 High level overview of decision making approach, inputs and tools for this plan



The Integrated Risk Model and Scenario Generator Model are used to generate the supply-demand balances that need to be solved by the Real Options model, as described more fully in Annex 5.

The feasible list of options with costs, earliest start dates, etc. are generated from the options appraisal process, described in Annex 6.

The Real Options approach used to inform the decision making for this WRMP **solves the supply-demand deficits simultaneously** for seven different **'states of the world'** across five different '**futures' or 'branches**'.

- 'States of the world': represent a snapshot of different climatic conditions and intra-annual pressures on water resources and demands, from normal year through to severe and extreme droughts, looking at periods when water supplies are at their minimum, and at periods of peak water demand during summer months
- Different possible 'futures' modelled by different 'branches': represent a plausible set of future supply-demand balances for a range of possible future scenarios, for which different solutions may be required

The investment decisions are optimised to ensure we can meet our target level of service across a range of drought severities at different times of the year, whilst still considering the operation of schemes during normal climatic conditions. The use of different futures in the Real Options approach effectively recognises that the future is not certain, and so the method tries to identify how solutions may change through time in the face of different possible future water resource pressures. The approach therefore tries to ensure that the plan is resilient against a range of uncertain, yet possible, futures that the company may face. This is particularly important where the scale of the uncertainties is large (for example from potential 'sustainability reductions' of licensed abstractions). The objective of our approach is therefore, to ensure that the plans cover a wide, yet appropriate, range of futures to ensure that all the key strategic options are identified. This is critical because there may not otherwise be sufficient time from when the sustainability reductions are confirmed for implementation to develop appropriate schemes. These uncertain futures are a key reason why we have adopted the Real Options approach – so that key schemes and alternatives which address these uncertainties can be investigated and progressed in parallel to the preferred plan. Should the magnitude of the future uncertainties be less severe, then some of the schemes would not need to proceed past feasible investigation and planning / promotion stages. However, the company has little choice but to conduct these investigations of alternative and preferred schemes through AMP7 (and AMP8), given the scale of uncertainties the company faces in the next 10 years.

The plan is **tested against a range of criteria** to ensure that it represents best value, not just least cost. This included inputs from regional planning exercises, customer preferences for different option types, and environmental considerations informed by the Strategic Environmental Assessment, Habitats Regulation Assessment screening, and Water Framework Directive assessments. This is discussed further in the section 3 below.

We have also included a 'conventional' EBSD assessment alongside the Real Options approach to provide a comparison between the approach adopted previously for WRMP14 (the EBSD approach), and the new approach for this plan. This is discussed further in the section 3 below.

2.3.1 States of the world

The supply-demand balance will vary throughout the year, as available supplies and customer demands for water fluctuate. This '**within year**' **variability** highlights the need for assessment of a number of different design conditions or '**planning scenarios**' that must be considered for each year of the planning horizon. As described in Annex 3, the planning scenarios that the company looks at are:

- The **annual average** (AA) – which may also be referred to as the average deployable output (ADO) planning scenario. This scenario compares the average daily demand over the year against the average daily supplies that are available over the year
- The **critical period** (CP) – corresponds to the **period of peak water demand**, which normally occurs during the summer months of June, July and August. The peak period of demand is generally defined in terms of the average day peak week (ADPW) demand. The peak demand is compared to the supplies available during that same summer period. This may also be known as the peak-period deployable output (PDO) planning scenario. During these summer peak periods, it is generally not the availability of water resources to meet peak demands that is the constraining factor, but the capacity of the infrastructure
- The **minimum deployable output** (MDO) period – used to assess the period where available supplies are expected to be at their lowest or most stressed – i.e. it represents the '**minimum resource period**'. This MDO period normally occurs during late summer/early autumn when river flows are at their minimum following the summer, and groundwater levels are at their lowest prior to the onset of winter recharge. The demands under this scenario are based on the minimum rolling 30-day average daily demand over the same relevant period

The Western area is most susceptible to the 'minimum resource period' and to the critical period (i.e. peak summer demand period), as the two largest WRZs within the area have a significant proportion of supplies from run-of-river abstractions and there is no surface water reservoir storage.

The Central area is similar to the Western area, as the Sussex North WRZ takes a significant proportion of its supply from a run-of-river source although there is a surface water storage reservoir. The two Sussex coastal WRZs are supplied entirely by groundwater, although there is also a transfer from Sussex North to Sussex Worthing.

The Eastern area differs from the other two supply areas, as the Bewl-Darwell reservoir system provides the ability to manage seasonal drought events. Hence the Eastern area is most susceptible to the annual average and critical period (summer demand) planning scenarios.

The various states of the world allow **differing drought conditions** to be considered in combination with inter-annual variability in supplies available to meet demand for water. Each state of the world therefore has its own supply-demand balance – i.e. its own profile of surpluses or deficits over the planning period. The **model must solve each of the states of the world simultaneously** (ie so that any deficit in any state of the world is solved).

Inclusion of the states of the world is useful for a number of reasons:

- It ensures that the plan is robust against a range of supply and demand conditions that could be faced by the company in any given year across the planning horizon
- It allows consideration of how the water available from different options may vary in different drought events
- It allows additional drought intervention options to be considered alongside the water resources options in more extreme droughts
- It ensures that the costs are appropriately weighted in relation to how options are likely to be used under each state of the world (known as 'utilisation' – see section 2.4.3). Hence an option that is only required to meet an extreme event is likely, on average, not to have significant total variable operating costs, as it would only be required to supply water very infrequently (note that the capital costs of the option and any fixed operational costs would still need to be paid for regardless of how frequently the scheme may actually be used in practice – i.e. the capex (capital expenditure) and fixed opex are independent of the utilisation)

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

- **Normal** year – 50% annual probability – relating to typical non-drought climatic conditions, with average customer demand
- **Drought** condition – a 1 in 20 year drought, or 5% annual probability
- **Severe** drought condition – a 1 in 200 year drought, or 0.5% annual probability
- **Extreme** drought condition – a 1 in 500 year drought, or 0.2% annual probability

For each of these drought climatic conditions there is a state of the world for each of either the **minimum resource period or annual average** (depending on the supply area we are modelling) and for the **peak demand period** planning scenarios. The exception to this is for the normal year, for which there is not generally a deficit. Under this condition only the annual average period is used (not the critical period). The inclusion of the normal year annual average state of the world ensures the appropriate calculation of variable costs based on expected utilisation (as explained in section 2.4.3).

Section 39B(2) of the Water Industry Act, requires the company when planning for drought, to plan to supply adequate quantities of wholesome water, with as little recourse as reasonably possible to drought orders or drought permits. In ensuring compliance with this, previous Water Resource Planning Guidance (WRPG) only required planning to be based on the worst historic event and water resource planning was not required to take into account wider severe drought conditions. The WRPG for this plan (Environment Agency and Natural Resources Wales, 2017) has changed to now recognise the need for resilience in a severe drought condition (a 1 in 200 year drought event). Our previous WRMP14 already planned to a severe drought (1 in 200 year drought event) without any recourse to drought permits and orders. **Planning in line with the WRPG therefore already reflects a continuation of our level of service**. We have therefore chosen our States of the World to carefully reflect the levels of service.

However, in this plan, we have also sought to understand the impacts of more extreme drought events (1 in 500 year drought event), as this aligns with the latest thinking around drought resilience (e.g. as reported in the recent National Infrastructure Commission report which highlighted the need for increased drought resilience to reduce or minimise the significant economic impacts of 'level 4' drought restrictions (stand pipes and rota cuts)).

In line with our continued practice of moving water resource planning forward, we have only allowed drought permits and orders to be selected in the investment model in an extreme drought event (1 in 500 year drought event) so as to ensure that the WRMP can be resilient to a level in line with guidance, in line with our levels of service and in line with the requirement to plan with as little recourse as reasonably possible to drought orders and drought permits. It also means that the selection does not drive excessive infrastructure; but it still allows a progressive and pragmatic approach to exploring extreme drought events.

It is important to recall that all the states of the world must be solved simultaneously in the Real Options model. What we are examining when we look at both the severe and extreme states of the world is thus the balance in the solutions between the portfolio of options needed in severe droughts without drought interventions (except in the short term), with that same portfolio of options in combination with drought interventions in extreme droughts. We are effectively examining whether we have sufficient options to meet differing levels of drought when considering that drought interventions would be used in more extreme droughts. But we are also recognising that these drought interventions may not be available in all WRZs in a supply area, and that the existing connectivity between WRZs may be limited. Our analysis therefore considers the resilience of transfers between the WRZs, and the potential need for increased connectivity.

Our sensitivity testing includes a scenario where the drought permits and orders are not available in the extreme drought to demonstrate the impact this assumption would have on the options to maintain the supply-demand balance. We have also included a sensitivity test where we remove the extreme drought states of the world from the Real Options model, to demonstrate the impact that solving for extreme droughts has on the plan. This effectively helps to identify whether the severe or extreme droughts are driving the investment in water resources options.

2.3.2 'Branches' to represent the range of plausible 'futures'

The Real Options approach is used to understand how a plan would vary against a range of future scenarios that result from uncertainty about forecasting the future. Despite the uncertainties with different possible futures, the WRMP must present a preferred set of options, and as a result a number of schemes may be needed in the short term before the uncertainties have been better understood. The company wants to ensure that the plan for the short term is flexible enough to be optimal against a wide range of possible, yet plausible, futures.

The Real Options method seeks to provide the flexibility to act on new information that becomes available over time, whilst ensuring that schemes that are needed in the near term are implemented and do not become rapidly redundant (i.e. it seeks to develop a 'no regrets' solution). This is the key component of a Real Options approach; it effectively recognises that the future is not certain, and so it tries to identify how solutions may change through time in the face of different possible future water resource pressures.

The different futures (also referred to through this Annex as ‘branches’) are built up from a combination of possible scenarios relating to demand growth, climate change impacts on water supplies, and sustainability reductions (changes to the licensed volumes of water that a water company is authorised to abstract, with the aim of ensuring that the abstraction does not pose an unacceptable risk to the water environment).

The baseline supply-demand balance forecast is generated as a series of probability distributions from which the company can select different percentiles to represent a range of possible futures. As the branches are a combination of the probability functions of the three key uncertainties it is not possible to say what any given branch represents (i.e. you cannot say that branch A is a high sustainability reduction scenario, branch B high demand growth, etc.) These supply-demand balances are used as the input to the Real Options decision making model with selected percentiles making the ‘branches’ of the Real Options model.

The development of the branches and their underlying assumptions and generation of the subsequent range of supply-demand balances (surpluses or deficits over the planning period) for each of the futures is described in Annex 5.

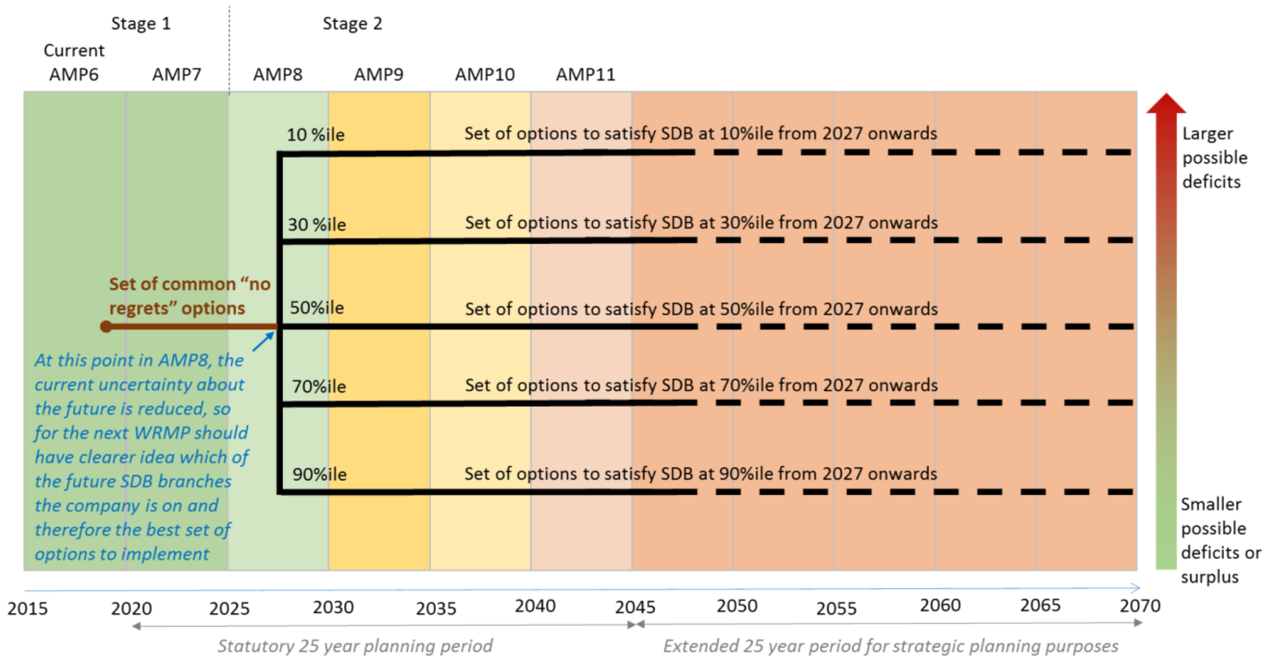
An indicative Real Options branch plot (described more fully in Annex 5) is shown in the figure below, which demonstrates the range of possible supply-demand futures of the five branches.

The supply-demand balances used as the ‘futures’ or ‘branches’ in the Real Options model reflect the following percentiles[2]:

- 10th percentile (larger deficits)
- 30th percentile
- 50th percentile (the middle branch – representing the more traditional supply-demand balance that would have been investigated through a traditional investment modelling approach)
- 70th percentile
- 90th percentile (smaller deficits, or in surplus)

[2] For the draft WRMP, the Western area was treated differently to the Central and Eastern areas, because the scale of sustainability reductions faced on the rivers Test and Itchen was considered to far outweigh the other uncertainties. However, following the conclusion of the River Itchen, River Test and Candover abstraction licence Public Inquiry in March 2018, the scale and timing of these two sustainability reductions was clearer. We have subsequently had our licences changed (in March 2019). Therefore, the approach in the Western area has been revised to align with the Central and Eastern areas, so including the remaining uncertain sustainability reductions with demand growth and climate change impacts on supplies probabilistically to develop a range of plausible futures.

Figure 5 Indicative branching of Real Options for different percentiles of supply-demand balance



We assume that there is a single branch in the short term, based on the middle branch – the 50th percentile. This allows a common solution in the short term. The branches then diverge at a branching point, which for our WRMP, was selected to be 2027. The selection of this branching point was based upon a number of factors, primarily it was the point at which the large uncertainties relating to potential sustainability reductions are likely to be realised (as discussed in Annex 3). The sustainability reductions could represent a significant step change in the supply-demand balance, and hence it seemed an appropriate point to explore how the solution would vary from this point onwards in different futures.

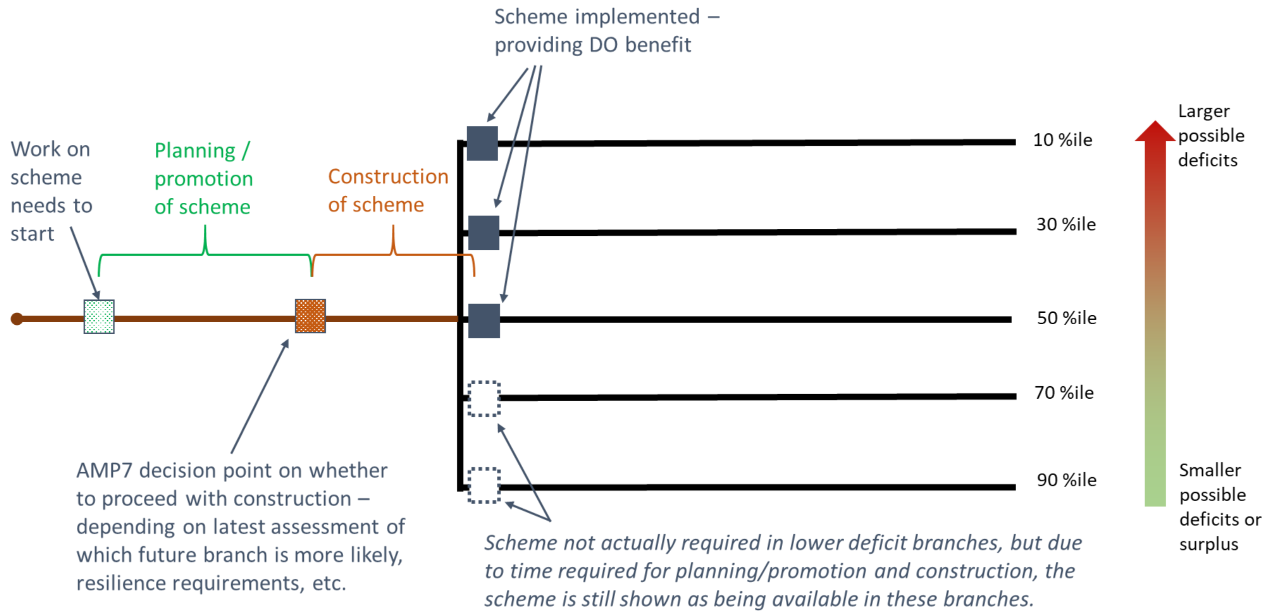
However, any solution that is needed at, or just after, the branching point, will actually have a **decision point** earlier in planning period, due to the need for planning and promotion activity and construction of the schemes. Hence, some schemes may not actually be needed in lower deficit branches, but because of the time required to plan, develop and build them, they will show up in all 5 branches at the decision point.

The statutory process for WRMPs requires them to be reviewed and updated at a minimum every 5 years. At the point when the next WRMP is prepared, it is expected that some of the uncertainties around the impact of sustainability reductions (in particular) will be better understood. By this point some of the schemes identified for implementation in 2027 may not be required or may be deferred until later in the planning period. In such cases, the scheme would have already gone through a certain amount of promotion, investigation, and planning. But no further activity would be taken on these tasks for the scheme once it was identified that it was no longer required.

However, if at the point of reassessment in AMP7, the future does look more like one of the higher deficit branches we have identified in our current plan that have driven the selection of some of the schemes in 2027, then the work in early AMP7 on promotion and planning will have enabled the scheme to be successfully implemented in 2027, to address the supply deficit. If the promotion and planning activity had not taken place in AMP7, there would be a significant risk that the scheme could not be implemented when needed in AMP8.

This is summarised in the indicative diagram in Figure 6 below.

Figure 6 Process of scheme selection and development under different branches



This is a critical aspect of the real options approach. In summary, with reference to the example in Figure 5:

- By the middle of AMP7, as part of the company's preparations for its next plan (WRMP24), some of the uncertainties we currently have about the future (in the short to medium term) may be better understood. For example, environmental investigations may be completed and so the scale of sustainability reduction impacts better understood. Hence the company should have a clearer indication as to which of the possible supply-demand balance future branches is most likely
- In the meantime, the company will have been able to start to implement the 'no regrets' options required in the short term, and undertake feasibility investigations and planning preparations for the next set of options required in AMP8 under the different potential futures

As the potential **'futures' are selected from the probabilistic combination of the scenarios**, it is **not possible to identify exactly what is contributing to a given future**, as represented by one of the five percentile branches. The key point is that **the branches represent plausible potential future deficits in the face of uncertainty, and we try to solve these, without needing to know exactly what might be driving the future deficit**. We have purposefully not chosen the most extreme combination of futures (which would represent the worst case for all of the drivers combined); instead we have curtailed the selection to 'plausible' futures within the 10th and 90th percentile ranges.

For our main model runs, we have assumed that each future is equally plausible, as we do not have any evidence to the contrary. The cost of solving each branch is therefore weighted equally. We have, however, included different assumptions for sensitivity testing of the preferred plan, where different weightings have been applied to each branch, to understand the impact that this can have on the plan. These sensitivity tests are presented in Annexes 9-11.

2.4 Modelling inputs and considerations

2.4.1 Discount rates and net present value (NPV)

Discounting is a technique that is used to compare costs and benefits that occur in different time periods. It is based on the principle that people generally prefer to receive goods and services now rather than later, which is a concept known as 'time preference'. For individuals, time preference can be measured by the real interest rate on money lent or borrowed. The concept can be expanded to society as a whole; where there is also a general preference to receive goods and services sooner rather than later, and to defer costs to future generations. This is known as 'social time preference'. The 'social time preference rate' (STPR) is thus the rate at which society values the present compared to the future (HM Government, 2003).

When undertaking an economic appraisal of feasible options over the entire planning period it is important to account for this social time preference. Discounting is therefore the process by which all the future costs and benefits are converted to today's (present) value, so that they can be compared on a like-for-like basis. By summing the present values of all the costs and benefits associated with an option, the Net Present Value (NPV) (of both costs and benefits) of that option is derived. This is used to compare all feasible options in the investment model, and hence to derive the least cost set of options which are needed to meet a given supply-demand balance deficit.

All costs and benefits in the options appraisal and least cost economic model were discounted according to the time-varying Treasury Green Book discount rates, i.e. 3.5% for years 0-30 of the appraisal period, 3% for years 31-75, and 2.5% for years 76-125, as specified in the EA's WRPG.

2.4.2 Option costs and earliest start years

Annex 6 describes the information compiled for feasible options including the development of costs and earliest start years for implementation of the schemes.

Options which could have a variety of sizes (e.g. a desalination plant could be 10Ml/d, 20Ml/d or 30Ml/d) are represented in the Real Options model as modular components. This provides flexibility for the model to select increasing increments of such schemes – i.e. 0 to 10Ml/d in year *x*, then increasing from 10 to 20Ml/d in year *y*, etc.

2.4.3 Utilisation

All schemes and interventions in the model can be categorised into those that could be turned off when they are not required or run at a minimum capacity (e.g. desalination, water reuse), and those that are maintained at a constant output (e.g. leakage). For the former set of schemes, a **'utilisation factor'** is applied to each of the states of the world to reflect the reduced operational costs that could be obtained by only operating the schemes when they are needed (i.e. during the lead in to and during design drought conditions).

The utilisation factors are only applied to the variable operating costs (opex) and not to any fixed costs. This is because fixed costs (capital costs and fixed opex) must be incurred if the option is implemented, regardless of how much that option is actually used. However, for variable opex, which is generally expressed as a cost per unit of water produced, the cost has to be weighted to reflect the proportion of the year covered by each 'seasonal' condition (critical period or minimum resource period), as well as the different drought design conditions that are examined. The states of the world therefore have different utilisation factors to reflect this cost weighting.

The Real Options investment model includes utilisation within its calculations by solving simultaneous supply-demand balances across all the WRZs in each area for all the states of the world. The utilisation factor that is assigned represents the frequency with which a given state of the world is expected to occur.

The investment model is set up to minimise the fixed and variable opex costs while satisfying all the supply-demand balances and their respective utilisation factors. The optimiser thus seeks the overall least cost for the plan that allows for the expected amount of time that the system would operate under each state of the world throughout the planning period. Under most circumstances new schemes do not have to be operated during ‘normal’ climatic conditions, so the scheme only incurs the fraction of the variable opex costs that would be required to meet the drought conditions under the various planning scenarios. (Note, however, that some schemes are assumed to be run continuously at a lower rate regardless of whether they are needed to solve a deficit in a given state of the world; so will still incur some variable opex in states of the world when they are not actually required to solve a deficit – e.g. desalination options have been assumed to be run at a minimum of 25% capacity in all time periods).

The design drought conditions each have an assigned return period, which is converted into a probability – i.e. the severe drought is up to a 1 in 200 year event, which equates to 0.5% probability. The ‘normal year’ condition was equal to the 50% probability. The drought utilisation is calculated as the change from moving from one drought state to the next – for example, the extreme drought utilisation recognises that any event exceeding the 1 in 200 year event will effectively be an extreme drought condition, so the drought utilisation was calculated as an average of the two drought probabilities.

The utilisation factors used for each state of the world must then take account of the ‘within year’ variability, which reflects that the supply-demand balance will vary throughout the year as available supplies and customer demands for water fluctuate. We have assumed that the annual average or minimum resource period will be the representative level on which to base utilisation for three-quarters of the year, while the critical period peak demand period will cover the remaining three month period (i.e. the summer months June to August). However, the peak demand is not expected to last for the whole three-month period, so a peaking factor is used to account for this.

Table 1 below shows the derivation of the utilisation factors as applied to each state of the world.

Table 1 Derivation of utilisation factors for the states of the world

Name	Return Period	Probability	Drought utilisation	Utilisation (CP)	Utilisation (MDO/AA)
Normal year	2	0.5	0.694	n/a	69.40%
Drought	20	0.05	0.275	6.21%	20.72%
Severe drought	200	0.005	0.0275	0.62%	2.07%
Extreme drought	500	0.002	0.0035	0.08%	0.26%

The Real Options model has also been developed to be able to assign a probability to each of the potential futures or branches to represent the perceived likelihood of that future. This probability is applied as an expected cost weighting to the total cost calculation. We have assumed that each branch will have an equal probability, because there was little information on which to base an alternative weighting scheme.

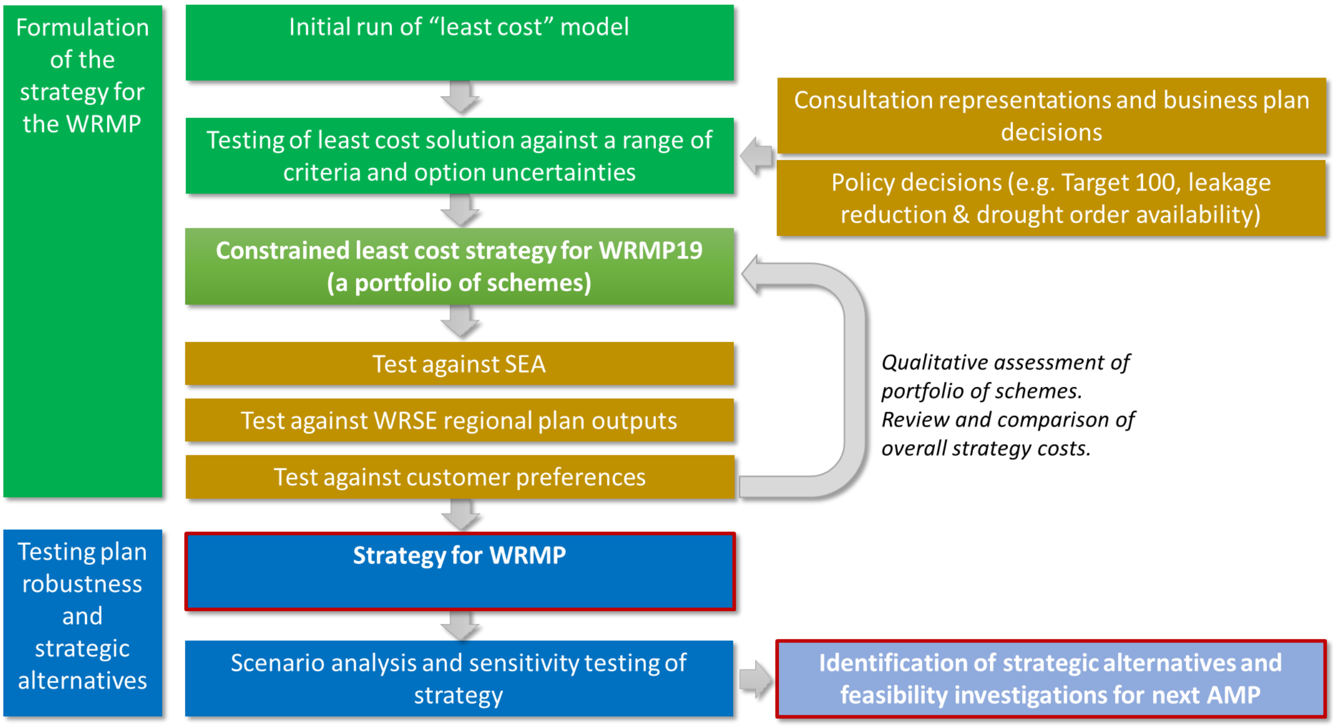
3. Our strategy

The plan has been formulated through an **iterative process** of economic least cost modelling. The ultimate objective of this process is to define a strategy, comprising a portfolio of schemes that:

- Provides secure supplies of water
- Protects the environment
- Represents best value for customers and reflects their preferences

Our approach to developing a strategy for the draft WRMP in each of our supply areas is summarised in the figure below.

Figure 7 Development of strategy for the WRMP



The first stage was to undertake an initial phase of scenario testing to help understand the sensitivity of the strategy to various possible constraints. The purpose of this testing was ultimately to inform the selection of the company's plan. This stage involved an **initial 'least cost' model run** to develop a 'basic solution', without further consideration of potential constraints.

This was then tested by, for example, modifying assumptions about the availability of certain options to progress our understanding of the impacts that these assumptions might have on the strategy. From examination of the various model run outputs, and taking into account the company's policies, business planning decisions, and pre- and post-consultation discussions with regulators and stakeholders, policy decisions and refinements were introduced to reflect a **'constrained' least cost strategy**. The key policy decisions applied were in regard to the inclusion of water efficiency assumptions (the company's target to help our customers achieve an average per capita water consumption of 100 litres per day by 2040 – the 'target 100' policy), the policy of leakage reduction (aiming to achieve a 15% reduction by 2025 and 50% reduction by 2050) and the availability of Drought Permits / Orders to relax abstraction licence conditions in severe and extreme drought events.

The constrained least cost strategy was then examined and tested against a number of criteria:

- **Outputs from environmental assessments of the options**. To address whether the combination of options and timing of the need for them present significant risks or have planning and promotional issues that might affect the deliverability of a scheme or schemes. This represents a second stage of the environmental screening process included as part of the options appraisal process, to develop a feasible set of options; however, timing of option implementation and cumulative impacts are clearly important additional considerations, as well as feedback from consultation responses on certain options
- Outcomes from **regional planning** exercises (Water Resources in the South East – WRSE). A cross-check against the outputs from the WRSE modelling scenarios and review against bi-lateral discussions held with neighbouring water companies covering bulk supply needs and timing, schemes that could be jointly developed, the reliability of the bulk supply to the different drought design conditions, and the costs associated with the development of sources that support a potential new bulk supply
- The **preferences for different option types arising from customer engagement** activity. To reflect the ranking of option types from customer preferences surveys conducted during pre-consultation and during the consultation period. This also takes account of consultation responses on specific options.

Note that overlaying the Strategic Environmental Assessments (SEA), regional planning and customer preference considerations on the constrained least cost strategy does not necessarily mean it will need to be changed – i.e. it may already adequately address key considerations from these criteria. Additionally, although some schemes may be less favoured by the SEA, regional plans or customers, the availability of suitable, better alternatives, or the deficit faced may mean that some options need to be retained in the feasible list regardless. It is also possible that these criteria could sometimes contradict each other – e.g. a scheme identified from WRSE may not align with, say, customer preferences; in which case, the company must exercise its judgement to weigh the pros and cons of a given scheme and the alternatives that would otherwise be needed. This represents a process of **qualitative multi-criteria assessment**.

The original intention for applying multi-criteria analysis had been to develop monetised costs or 'penalty values' to allow the Real Options model to take account of these preference costs in a quantitative way along with the feasible options costs, when optimising the plan against a least cost objective.

However, at the time of formulating the draft WRMP, there was limited information available on which to develop suitable shadow costs (i.e. penalty / reward functions linked to environmental metrics) to apply to the outputs from the environmental assessments SEA, Habitats Review of Abstractions (HRA) and Water Framework Directive (WFD). We will continue to develop the Natural Capital approach to determine if this technique can help provide a better way of determining the penalty cost function for the environment. As described below in the section 3.3.1, there are also potential issues and limitations with monetising the environmental and social costs/benefits for each option directly. It was therefore decided that the best approach for this plan was to use the outputs from the environmental assessments (without any attempt to monetise them) applied to the initial 'constrained' least cost strategy, to inform the conclusions on the preferred portfolio of options in the strategy.

There was a similar rationale with regard to the inclusion of customer preferences values. A number of different ways were selected to derive the preference costs based on YouGov surveys (see Annex 1). Whilst the customer preference surveys did elicit some monetary values, the unit costs for different option types were not available to use for this plan – further work is being undertaken on this. In order to include allowances of customer preferences, we reviewed the customer preferences from the surveys and engagement activities, and reviewed the options selected in the constrained least cost model to identify preferential option types, where there were suitable alternatives available. This helped the company to decide on the option types that should be included in the strategy, and also where other option types should be excluded or their use minimised. However, it may not be possible to exclude a least favoured option entirely, if there are limited alternative options to solve a given supply-demand balance deficit. We intend to undertake further work to develop suitable penalty functions based on customers' preferences for different types of options for the next AMP (for WRMP24).

The process of testing the constrained least cost plan against the environmental, regional and customer preferences criteria was therefore iterative. The other key element considered was the relative impact of the changes influenced by testing against criteria in terms of the overall strategy cost, compared to the least cost model and to the constrained least cost strategy. For example, where there is little cost difference and the change of option provides a more positive outcome to one or more of the testing criteria, then there is a stronger case for including the option change as part of the strategy.

Following this review and testing process, any refined assumptions of the feasible options set were fed into the Real Options model to derive the **strategy for the WRMP**.

The strategy for the WRMP was then subjected to **scenario and sensitivity testing** to understand what **alternative strategic schemes** may be needed, should it not be possible to implement the schemes in the preferred plan. This is particularly important for those schemes in the strategy that are required in AMP7 or AMP8.

Where there is uncertainty around the delivery of these schemes, the company may need to conduct feasibility investigations of alternative schemes (and potentially environmental surveys and planning activities) in parallel to developing the portfolio of schemes selected in the strategy, to ensure that there will be a scheme in place to solve an identified future deficit.

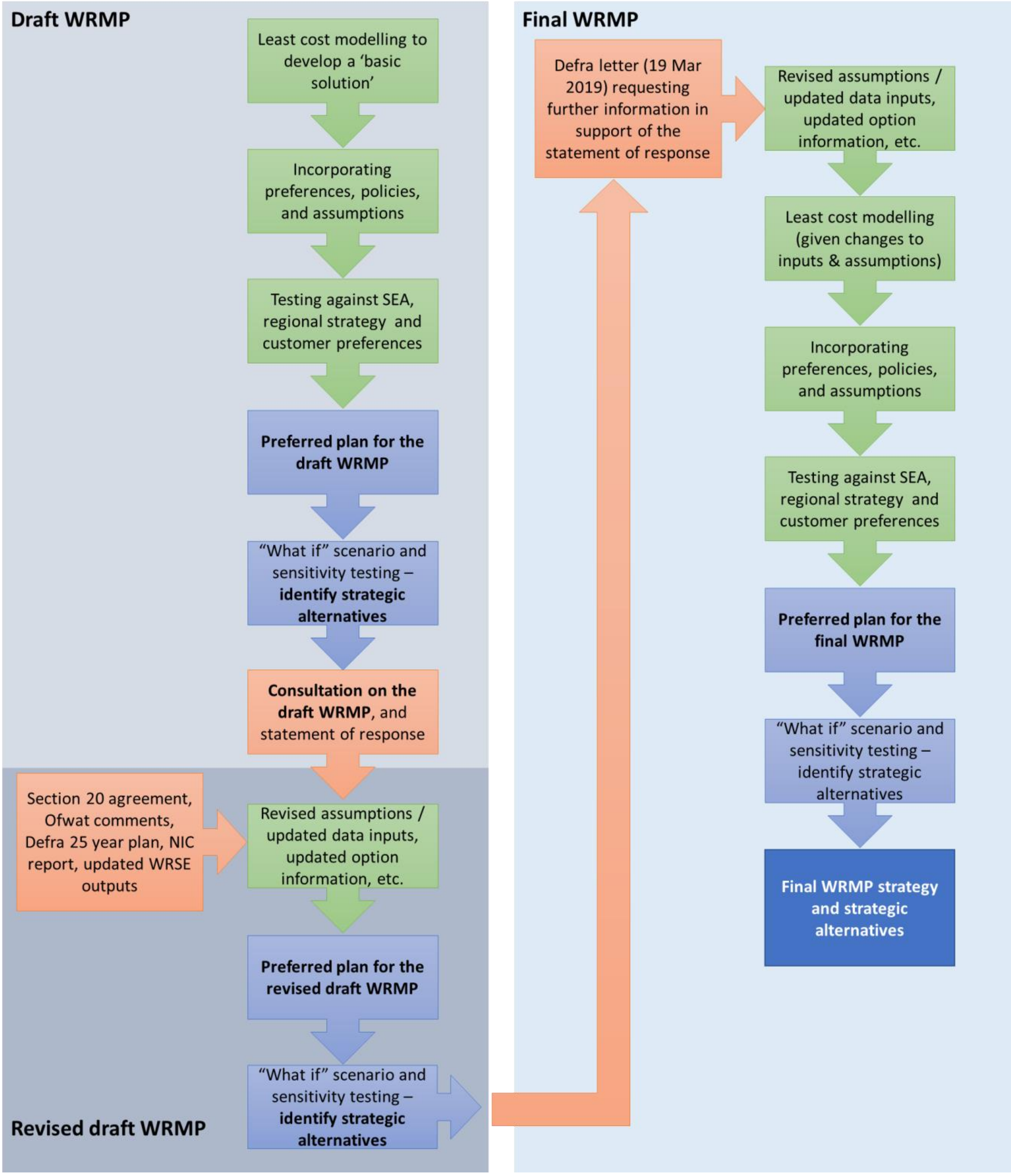
For comparative purposes, we have also undertaken investment model runs using a conventional EBSD approach (which was the approach used in the previous WRMP published in 2014). The area-specific detail provided in Annexes 9 to 11 also includes a summary of option rankings based on average incremental costs, to help explain why different options are being selected compared to others.

3.1 Refinement of the strategy from draft to final plan

The draft WRMP strategy is published for consultation with customers, stakeholders and regulators. The responses received during the consultation may result in changes to the assumptions or inputs used to derive the supply-demand balances, as well as to the set of options that are available to meet forecast deficits. The development of the plan as presented in the final WRMP is thus an iterative process, in which the above decision making approach is repeated and refined in production of a revised draft WRMP and then a final plan following consultation on the draft WRMP.

Consequently, elements of the strategy may need to be reviewed or refined as we move from the draft plan to our final plan. The process that we followed for the production of our WRMP is summarised below.

Figure 8 Development of the strategy from draft to final plan



3.2 Inclusion of customer preferences

The company has undertaken a process of engagement with stakeholders and customers to learn about their priorities, seek views on the development of our plans, find opportunities for collaboration and learn from examples of best practice. This formed a key part of the process of preparing the plan, and is described fully in Annex 1.

The ‘pre-consultation’ process also included engaging the regulators to keep them informed on the developments of our plan, to explain our proposed methods and approaches, refine these depending on feedback received, report results, and provide the regulators the chance to engage and influence the development of the plan throughout the process.

The pre-consultation survey and a second survey of customers preferences following completion of the draft WRMP were important to better understand customers’ views. In addition, consultation representations were received from a range of stakeholders and regulatory bodies.

Both quantitative and qualitative analysis was conducted. The results of the quantitative survey conducted during consultation on the draft WRMP are presented in the table below. This shows the ranking of schemes by customer preference, based on the average that customers increased or decreased the amount of an option in comparison to other option types – i.e. they could adjust the composition of the solution from the default draft WRMP solution setting. The costs of these adjustments were notified to them in terms of the impact on an average household bill. The column for average bill change therefore shows the average of customers’ relative acceptance of changes to their bills from the adjustments they were making to the option compositions, across all respondents. This gave an inferred ranking of the option types.

Table 2 Results of quantitative survey of customer preferences

Category	Average bill change	Average slider increase	
Water saving devices	£11.66	+4.14	Bill increase
New reservoirs	£2.40	+3.12	
Water re-use	£2.10	+0.44	
Tariffs	£1.88	+4.27	
Reducing leaks	£1.74	+0.38	
Drought orders	£0.42	+1.97	
Underground water stores	£-0.05	-1.09	Bill decrease
Helping customers use water more wisely	£-0.06	+0.23	
Trading water	£-0.42	-0.79	
Using sea water	£-2.22	-0.27	
Catchment management	£-3.49	-1.67	

Some key aspects that this analysis highlighted were:

- No options were rejected
- Many of the selections made by customers in terms of the optimum mix of options matched closely to our draft WRMP strategy. This suggested that customers broadly supported the strategy in terms of the mix of options. Some framing affects were noted, where we had already used all the available capacity of an option in the draft WRMP default setting, such as catchment management, their contribution was reduced to allow other options to appear
- Tariffs, new reservoirs and water saving devices had the biggest increases in terms of the selection of additional capacity, but these were not included in the draft plan because of the pre-consultation responses and better alternative solutions

- Water saving devices were used more extensively in the preferred strategy. This is contrary to the findings of the pre-consultation surveys which indicated that customers were not willing to let people in to fit devices to their appliances. This later point has also been noted in pilot studies that we have run before
- Options for water trading were generally reduced in terms of capacity by customers, indicating that they did not favour water trading as much as other in-house options, which is contrary to emerging regulation and policy in this area

The qualitative research may be summarised in general:

- Reducing leaks generates a desire for maximum investment in all areas and it is seen as a key priority for Southern Water to reduce its leakage level
- Desalination is a proven technology, which is understood to be widely used elsewhere in the world. More environmentally sophisticated areas (Brighton) are wary of high running costs. New reservoirs are seen to generate really attractive environments for people and social assets e.g. fishing, dog walking, sailing etc.
- Catchment management has a positive environmental / resilience benefit, so seems like a sensible thing to do
- Underground storage is a popular choice
- Low cost of helping customers use water more wisely generates maximum investment available in Southampton and Brighton in particular
- Tariffs are seen as being over complex and would be responded to negatively by bill payers.
- Trading water was not seen as a long term viable solution. Water saving devices are seen to be incredibly expensive

The findings from the qualitative research sometimes differed from the quantitative research, while the pre-draft consultation results differed in some respects from the surveys conducted during consultation. This is an interesting finding in itself – that customer preferences are not universal. The key areas of divergence between the quantitative and qualitative research are summarised below.

Table 3 Key areas of divergence between quantitative and qualitative research

Option type	Quantitative	Qualitative	Our response
Tariffs	Would like to see more of these in a future strategy	Do not like the idea of penalty type options	Continue to trial incentive-based tariffs and undertake further work in this area
Catchment management	Reduced the overall level of catchment management schemes in the plan	Think these are a good idea	We have continued to maintain the level of catchment schemes in the plan as they form a cost effective solution for customers. They also align with regulatory expectations.
Trading water	Reduction in the volume of water to be relied on for future solutions	Trading water not seen as a long term viable solution	Both of these opinions are counter to government policy. We will continue to develop a network to promote increased resilience across the South East region
Water saving devices	Would like to see more devices in the plan	Water saving devices are seen to be incredibly expensive	Our ‘Target 100’ policy sets out a broad strategy in which a range of options can be offered to customers

These studies and representations, and those from the previous WRMP (published in 2014), have informed the development of the company's stance on appropriate levels of service and, together with feedback from stakeholders, has helped us to understand views and preferences on the supply and demand management options that make up our options set. It has been applied to the development and formulation of our preferred strategy by excluding options that were not likely to meet customer or regulator expectations in the options appraisal. Where there are some differences in the outcomes from different customer research we have set out our proposed way forward which either involves aligning with Government ambition, regional strategies or the customer position with a provision to gain further insight to help deliver some of these options.

3.3 Environmental cumulative impact assessment and programme appraisal

A detailed environmental assessment (covering Strategic Environmental Assessment (SEA), Habitats Regulations Assessment (HRA) and Water Framework Directive (WFD) assessment) was carried out on the wide range of feasible options considered for inclusion in the strategy for each area to help inform decision making on the final strategy. In particular, the findings of the feasible option assessments were used to evaluate the environmental and social performance of a range of alternative strategies for maintaining a supply-demand balance in each area, with each alternative strategy comprising a different mix of options and option types.

For each alternative strategy, the likely scale of adverse and beneficial environmental and social effects for each option was considered, both on its own and in combination with the other options included in that strategy. The potential effects in combination with any other relevant projects, plans or programmes (for example, any planned major infrastructure schemes that may be constructed and/or operated at the same time and affect the same environment and/or communities) was also assessed. This appraisal of each alternative strategy also included consideration of the potential for any regulatory compliance risks associated with the Habitats Regulations and Water Framework Directive.

The environmental and social performance of each alternative strategy was used to help make decisions on which strategies to explore further through the Real Options modelling process and to finally determine the appropriate strategy for inclusion in the WRMP. Where appropriate, modifications to the potential strategy were made as part of this process where environmental and social effects were considered challenging.

As well as the adverse effects of options, we also looked at the beneficial effects of options to identify whether any options should be prioritised in view of the environmental or social benefits they may bring.

Once the final strategy had been determined, a final environmental assessment was carried out to examine whether there were any cumulative effects from construction and/or operation, and whether further mitigations measures may need to be adopted.

3.3.1 Environmental and social valuation

The company has not quantified the environmental costs and benefits of options in monetary terms (this approach is in accordance with the EA supplementary guidance note on environmental valuation, Nov 2016). Instead, the potential environmental impacts of options have been assessed through the Strategic Environmental Assessment, Habitats Regulation Assessment screening, and Water Framework Directive assessments, as outlined above. We also describe, in section 8.5 of Annex 14, how the SEA maps to an ecosystem services approach. We have used the SEA to provide the quantitative and qualitative assessment of our options and plan, and this has informed the decision making of the preferred plan (as we describe in Annexes 9-11).

This approach avoids the potential for 'double counting' environmental costs/benefits, and the difficulties historically experienced in quantifying the costs of environmental impacts. It is widely acknowledged that much of the valuation evidence included within the Benefits Assessment Guidance (BAG) is now relatively dated; however, the availability of suitable up-to-date studies is limited. The company is aware that this is a developing area and new Natural Capital valuation and accounting tools are under development for the water industry. These tools were not available to inform this plan; however, it is expected that suitable valuation approaches that are currently under development could be used for WRMP24.

3.4 Regional planning

We are part of the WRSE regional planning group, a sector-wide partnership that develops a south-east strategy for water every five years. The core membership comprises six water companies (Affinity Water, South East Water, Southern Water, SES Water, Portsmouth Water and Thames Water) working alongside the Environment Agency, Ofwat, the Consumer Council for Water, Natural England, the Department for the Environment, Food and Rural Affairs (Defra), the Canal and River Trust, the Greater London Authority, and other partners.

The aim of WRSE is to identify how best to share the water resources at a regional level. It also looks further afield, working with neighbouring regions of the UK and their water companies to explore the potential for inter-regional water transfers.

Our work focuses on exploring opportunities across the region for existing and new water resources to be shared in the most efficient way to provide reliable, sustainable supplies across the region, at best value to customers while also protecting the environment. This is because we expect the pressure on water supplies in south east England to increase in the future due to many reasons including climate change, population growth and the need to further protect the environment.

The water supply network within south east England is a complex pattern of different water company areas and WRZs. This is a result of the historic development and integration of local systems over more than a century, plus the fact that division of the region after privatisation did not necessarily align with catchment or water resource system boundaries. Therefore, the fundamental approach of the WRSE group is to ignore water company boundaries, to assess best ways to share available water from the perspective of maximising regional resilience.

Many of the WRZs across the South East currently, or in the future, will experience shortfalls in water availability. However, there are also areas that have water that can be shared. By looking at a regional scale we can try to maximise the benefits of sharing of water resources across the area, and in doing so, reduce the need for new water schemes or developments, and / or reduce existing abstraction.

Our planning work helps us to understand which options might be best for the South East in the long-term (such as identifying strategic schemes that can be optimised to provide benefit on a regional scale), which will help the region become more resilient to drought, outage and environmental risks.

For the PR19 planning cycle, WRSE looked over a long horizon of sixty years (from 2020 to 2080) exploring a range of different factors, including a greater range of future droughts of differing severities, different population growth forecasts, resilience to extreme events, and reducing water demand and leakage rates still further.

To inform the draft WRMPs, the WRSE group examined nine potential futures using an Economics of Balancing Supply and Demand optimisation model, selecting from ~1400 options to see what groups of options were the best choice to satisfy the deficit, and to test their resilience. This approach is more sophisticated than an average incremental cost approach (stacking the cheaper unit cost schemes together), but not as advanced as the Real Options approach adopted by Southern Water.

Following the close of the consultation period on the draft WRMPs, further regional modelling was undertaken, exploring more scenarios to assess the feedback from customers. In addition, the scenarios explored included a range of regional targets to assess the effect of meeting the recommendations from the National Infrastructure Commission and Defra on leakage and per capita consumption in terms of option selection.

Southern Water's WRMP is based on a higher water efficiency scenario, which is tested against a range of sustainability reductions set against a range of droughts up to and including a 1:500 year design drought, allowing for drought permits and orders to be used. Therefore, there is not an exact comparison / match with one of the WRSE scenarios.

Nevertheless, an analysis of individual company plans has shown that there is a high uptake of the WRSE regional outputs into company preferred plans; the precise number depends up on which of the scenarios are being compared with the company's WRMP. Transfers of water within the region contribute the most (mostly over 40%) to satisfying the regional water deficit.

There are two key aspects of regional planning that are particularly relevant to the preferred plan. The first is the potential for joint schemes – for example there are two potential schemes for the joint development of a water reuse option with South East Water. The second, and perhaps more common example relates to water trading – i.e. bulk supplies with neighbouring water companies.

Water trading can provide greater resilience in the supply system which customers support. However, there can also be a number of limitations to water trading, such as:

- The timing by which transfers are available to provide supplies, compared to when we actually face a deficit that needs to be resolved
- The security of the supply of traded water, and particularly whether the source used to provide the supply could be at risk of a future sustainability reduction
- The extent to which the supplying company can provide a guarantee that the water supply will be available during the drought return periods that we are planning to
- The cost of the bulk supply – bulk supply options must be economic in comparison to our own resource development options, as it would not benefit our customers if trading options were significantly more expensive than our own options. This may occur where, for example, the supplying company charges for the development of a new water source and we then also face the cost of the pipeline from that source to our own supply area whilst also paying relatively high costs per unit of water supplied
- It is also important to understand that bulk supply agreements cannot be completely reliable in all drought events, as the donor company has a duty to maintain supplies to its own customers

Nevertheless, the company continues to discuss and explore water trading options with neighbouring water companies. We have led the development of more robust water resources planning by introducing stochastic modelling into the sector to provide insight into potential future droughts, and the use of real options methods to provide adaptive and scalable solutions. In the future the remit of the WRSE could be extended such that they would derive a regional plan that would then be provided to the water companies to incorporate into their business plan.

We are committed to support the development of a regional water transfer grid that will support water trades between companies and increase the level of resilience to drought and other incidents for customers in the South East. In Annexes 9, 10 and 11 we have provided further information on how our preferred strategies in each area support the development of this regional grid.

3.5 Development of strategies for each area

From the initial formulation of a constrained least cost strategy, through testing the plan, a portfolio of options (the strategy) was identified, as described previously. This differs from the least cost solution, as it takes account of other criteria and policy decisions to ensure that the plan represents the optimum balance of monetary and non-monetary issues, risks and uncertainties, and customer preferences.

The analysis also helped to identify the key investigations that will be required over the next 5 to 10 years to ensure that options can be introduced in a timely manner when required.

The strategies for each area, including key investigations and any associated risks and uncertainties, are presented in separate Annexes:

- Annex 9: strategies for the Western area
- Annex 10: strategy for the Central area
- Annex 11: strategy for the Eastern area

This plan presents an update of the strategies for each of the three supply areas, following consultation on the draft WRMP (which ended on 28 May 2018).

3.5.1 Options and strategy risks

Each strategy comprises a portfolio of options – a combination of resource development, demand management, bulk supplies and inter-zonal transfers. However, some options may present greater risks than others in terms of how easily they may be implemented due to, for example, planning or environmental risks, or technological complexity.

Therefore, Southern Water has sought to understand these risks and identify alternative options that may be required should the risks of a given option materialise. This was through a process of scenario and sensitivity testing, as discussed in section 3.6 below.

Annexes 9-11 present **timelines for the key strategic options** to demonstrate issues which could impact on the **deliverability** of the schemes. However, there will always be some deliverability risk where new large-scale water resource options may need to be developed. As a result, the timelines also show the alternative schemes that would get triggered in the event of a strategic scheme being undeliverable, and the impact this could have on the timing of the plan.

These timelines also highlight key decision points or triggers which might result in a change to a different 'branch', or a change of strategic scheme (i.e. remove the need for a scheme, trigger the need for a new or larger scheme, or a move to an alternative scheme).

Uncertainty in the supply and demand forecasts will increase through time, and so it is logical to divide the water resource strategy into key time periods over the planning period:

- The first identifies the next strategic schemes required for which funding for implementation must be sought through the forthcoming Business Plan (covering the period 2020-25)

- The second identifies those schemes for which implementation is not required in the next 5 years but which will require further investigation (because they may need to be implemented in the next 10-15 years) to ensure that they are feasible before the next WRMP is produced in 2022-23, and to ensure that any required planning permissions can be obtained and any environmental issues can be addressed and mitigated
- The third considers options that may well be required in the longer term. The purpose is to understand the strategic nature of schemes which may be required in the longer term, but which are subject to greater uncertainty and will need to be confirmed or revised in subsequent WRMPs

3.5.2 Resilience

Some options may provide improvements to the supply system's resilience to different drought events or other unplanned outages; i.e. they may provide the company with greater flexibility to respond to a range of unforeseen events.

There are four components of resilience: resistance, reliability, redundancy, and recovery. In very general terms, the WRMP provides more of a resistance component of resilience, while the recovery aspect of resilience is important for the environment after a drought event. The aspects of reliability and redundancy are also addressed in WRMPs – for example, through activities to minimise outages and options to refurbish/rehabilitate source works, and through greater connectivity between resource zones and through trading with neighbouring water companies.

Our plan focuses on a wide range of resilience measures:

- We have developed an approach that solves multiple drought events and inter-annual variability simultaneously. This includes assessment of extreme drought conditions, which aligns with the recent NIC3 report, to ensure we have a plan that is resilient to drought events to minimise the potential for 'level 4' type restrictions such as standpipes and rota cuts. These can have significant impacts on society and the economy
- Our demand management activity in the last AMP, and as proposed in this current plan will also contribute to our resilience to drought events. For example, during the summer 2018 heatwave, our peak week distribution was about 100Ml/d lower than the last really hot, dry summer spell in the South East in 2003. This represents demand reduction of around 15% against the 2003 peak week demands. We believe that this is driven largely by our high penetration of domestic metering, and associated water efficiency activity, in addition to ongoing leakage reduction activity. Our plan seeks to reduce demand further in future, which should continue to provide resilience to hot, dry weather events
- We have a strong focus on water trading in our plan in line with regional planning outcomes, in addition to improving the connectivity between our WRZs. In general, greater connectivity will provide greater resilience, and therefore reduce risks from outage and events such as extreme droughts, heatwaves, freeze-thaw, pollution or even terrorism.
- The above will contribute to increased resilience across the whole south east region, particularly where bulk supplies are designed to be bi-directional
- Our outage assessment, described in detail in Annex 3, has included identification of water quality risks from Drinking Water Safety Plans
- Our plan aims to reduce outage by the end of AMP7, and therefore to adopt measures, through the business planning process, to increase system resilience to outages
- We also have a wide range of catchment management schemes focused on increasing the resilience of our supplies (in combination with improvements to the treatment works) from nitrate and pesticide risks

[3] National Infrastructure Commission (April 2018), *Preparing for a drier future: England's water infrastructure needed*

- In addition to the water quality-focused catchment management measures in our plan, we have also included in-stream improvements and mitigation measures associated with the Lower Test and Itchen rivers. These measures together are aimed at improving environmental resilience
- We have tested our plan against winter peak demands, which are generally driven by freeze-thaw events which drive short term increases in leakage. A recent example of a significant freeze-thaw incident was experienced in early 2018. We have provided analysis of how our sources and the schemes selected in our preferred plan perform against freeze-thaw events for each area (in Annexes 9-11).
- The company has completed an assessment of all its water supply assets to identify those at risk of flooding events. Three sources were found to be at risk of a 1:200 year flood event, and as a result works are being progressed currently to address this at these three sources. Flooding risk is also included as part of the SEA assessment criteria in the assessment of our preferred options, and these options will be designed according to national Ofwat planning guidance relating to flood risk.

The company has documented those options which may provide additional resilience benefits in each of the Annexes 9-11 for each supply area.

3.6 Sensitivity testing of the strategy

Having developed the strategy or plan for the WRMP through testing a constrained least cost strategy against SEA criteria, WRSE regional plans, and customer preferences, as described previously, the next step is to undertake sensitivity testing of the strategy. The process of stress testing and sensitivity analysis helps the company to identify and understand the assumptions and factors that have the greatest influence on the plan, the key decision points, and range of potential alternative options, and thus ensure that the plan is robust under a wide range of uncertainties.

A Real Options modelling approach already allows for uncertainty around how different futures may evolve and thus trigger different options selection. Our approach therefore already provides some evaluation of alternatives in the strategy and therefore reduces the requirement of sensitivity analysis to some degree (UKWIR, 2016).

Nevertheless, sensitivity testing was performed on the plan. The purpose of sensitivity testing is twofold:

- To ensure the plan is as robust as possible in the face of uncertainties. This provides confidence in the portfolio of schemes selected;
- To understand the range of potential alternative options if preferred options cannot be implemented for whatever reason. This may require feasibility studies, investigations or planning activity to be carried out in parallel to the main portfolio of options in the strategy.

We developed a range of sensitivity testing model runs to compare against the strategy. The sensitivity tests could be specific to a given area, or applicable to all three areas. The sensitivity testing that was applied to each area is described in Annexes 9 to 11. The range of sensitivity tests applied was also refined as we progressed from the draft plan through to the final plan.

In general, we examined:

- Uncertainties around particular options or bulk supplies, or around policy assumptions
- Assumptions around Drought Permits/Orders to relax abstraction licence conditions, and their availability in severe droughts
- Cost uncertainties

- ‘Accepting’ deficits for the first two AMP periods to confirm that the options selected in the strategy are indeed optimal, and their selection is not driven purely by them being available for delivery before other options
- The impact of sustainability reductions
- Alternative outage allowances
- Comparison to a conventional modelling approach i.e. EBSD
- Comparison to the strategy developed for the previous plan, WRMP14 – which was based on a conventional EBSD modelling approach, but which would also have had different assumptions regarding the supply and demand components (and therefore have been a slightly different problem to solve)
- The impact of different branch weightings

The sensitivity testing allows the company to understand whether there are key alternative strategic schemes which may be needed, should it not be possible to implement the schemes in the preferred plan. This is particularly important for those schemes in the strategy that are required in AMP7 or AMP8.

Where there may be some uncertainty around the delivery of these schemes, the company may need to conduct feasibility investigations of alternative schemes (and potentially environmental surveys and planning activities) in parallel to developing the portfolio of schemes selected in the strategy.

4. References

- Environment Agency and Natural Resources Wales, April 2017, Water Resources Planning Guidance and supporting documentation: Interim update
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- National Infrastructure Commission (NIC) (April 2018), Preparing for a drier future: England's water infrastructure needs.
- Southern Water, 2014, Water Resources Management Plan 2015-40 Technical Report, Southern Water Services, Worthing.
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Water Resources Management Plan 2019

Annex 8: WRMP Strategy

Appendix A: WRMP Tables

December 2019

Version 1

RESTRICTED INFORMATION, AVAILABLE UPON REQUEST