# Appendix A29
# Capital investment to deliver a class leading service

# Contents

# 1. Introduction

**Summary**

The health and operation of our non-infrastructure and infrastructure assets for the period 2020-2025 and beyond will directly influence our ability to provide clean, high-quality and reliable water supplies to our customers now and in the future.

We strive to maintain our existing assets, and, develop a flexible and diverse asset base to enhance our ability to respond to unexpected events and maintain our service to our customers. We need to invest to maintain and enhance our existing asset base to ensure we improve our service in a constantly changing environment.

As with our previous business plans, we have used a risk based approach to identify our capital investment needs for 2020-2025 and beyond. Our plan is focused on reducing our biggest risks to our customers, our people and our wider business, the environment and our compliance with the various regulatory standards.

To capture all of our assets over the short, medium and long term, we have used a combination of top down and bottom up approaches to identify our investment needs for the period 2020-2025 and beyond. Our top down approaches include our decision making framework and zonal risk and resilience modelling and bottom up approaches include deterioration modelling, condition based assessments and risk elicitation workshops. Combining both approaches in this way has enabled us to identify both our base maintenance and enhancement needs and ensures that we capture the full range of timescales over which we need to invest to provide clean, high-quality and reliable water supplies to our customers now and in the future.

We have used our investment optimisation tool to analyse a wide range of investment options, appraising their costs against our customers' priorities in relation to our performance. Through this process, we have developed a plan that will deliver the service our customers expect and pay for.

Over the period 2020-2025 we will invest £152 million net capital expenditure to maintain our assets for the long term. This includes investment in our non-infrastructure assets to; reduce risks to raw water quality; maintain our boreholes, pumping, treatment and control system assets; inspect, clean and maintain our storage assets and improve operational efficiency. And, we will invest in our infrastructure assets to; rehabilitate 321 km of mains across both of our regions; undertake mains diversions; replace communication pipes; undertake air valve maintenance, pipe bridge maintenance and cathodic protection.

We will also invest a total of £139 million net capital expenditure to enhance our assets. This includes investing and spending £63 million net total expenditure to upgrade our Hampton Loade and Seedy Mill water treatment works and cleaning approximately 100 km of strategic trunk mains leaving both works. In addition, we will deliver a combination of regulatory driven and 'choice' enhancements covering five key work programmes; water quality, resilience, supply side enhancements, demand side enhancements and the environment.

We will continue to invest to meet our regulatory requirements including those of the DWI and the Water Industry National Environment Programme (WINEP) and we will invest in mains diversions, meter optants, new developments and communication pipe replacements to improve pressures.

We will also enhance our assets to improve the service we provide to our customers by, investing in new treatment plants, improving resilience of our water production and network assets, reintroducing three groundwater sources to supply, building a new service reservoir, reducing leakage and improving water efficiency.

This Appendix details how we will invest in our assets to deliver the class leading service we have promised to our customers (highlighted below). The health and operation of our assets for the period 2020-2025 and beyond will directly influence our ability to provide clean, high-quality and reliable water supplies now and in the future.


How we are making water count – our promises to our customers – our service commitment.

Our promises to our customers relating to our service in particular are summarised in Table 1 below.

## Table 1 Our service performance commitments

| Making water count for… | Our commitment to our customers | Name and ID of our performance commitments | Short description of our performance commitments | The targets we will meet by 2024/25 |
| --- | --- | --- | --- | --- |
| Our service<br>We will provide clean, high-quality and reliable water supplies now and in the future | Delivering upgraded water treatment works | D8: Water treatment works delivery programme | This measure supports our cost adjustment claim, protecting customers against non- and late delivery of our water treatment works upgrade programme and associated expenditure | Complete second-stage filtration at Seedy Mill by 31st March 2023<br>Complete second-stage filtration at Hampton Loade by 31st March 2024<br>Complete the strategic mains cleaning programme by 31st |

| Making water count for… | Our commitment to our customers | Name and ID of our performance commitments | Short description of our performance commitments | The targets we will meet by 2024/25 |
|---|---|---|---|---|
| | | | | March 2025 |
| | Always meeting water quality standards | D1: Compliance Risk Index | Compliance with drinking water quality regulations, as measured using the Drinking Water Inspectorate's Compliance Risk Index (CRI) metric | 100% compliance with Drinking Water Inspectorate quality standards (Compliance Risk Index) |
| | | D6: Customer contact about water quality | The number of customer contacts we get each year about the appearance, taste and odour of water, or perceived illness | 0.8 contacts per 1,000 population |
| | Making sure water always comes through customers' taps | D2: Supply interruptions | Average minutes of interruption each connected property experiences for interruptions of three hours or more | Average supply interruptions of 04:50 mm:ss per connected property |
| | | D3: Risk of severe restrictions in a drought | The percentage of customers at risk of severe supply restrictions in a 1 in 200-year drought scenario | Zero customers at risk, assuming our water resources management plans are implemented |
| | Reducing the number of water production failures | D5: Unplanned outage | Water production capacity lost through unplanned outage | 1.7% of our total capacity is unavailable |
| | Finding and fixing visible leaks more quickly | D7: Visible leak repair time | The number of days that we take to repair 90% of visible leaks on our network, measured from the time the leak is found or reported | 90% of visible leaks repaired within four days |
| | Reducing the number of burst mains | D4: Burst mains | Number of burst mains | 120 bursts per 1,000 km of water mains |

Delivering these promises requires investment across our asset base. The two high level asset types that most significantly influence our service provision are what we classify as:

- non-infrastructure assets; and
- infrastructure assets.

## 1.1 Our non-infrastructure assets

Our non-infrastructure assets are those related to the production, storage and transfer of water. They are the assets that take water from the ground and our rivers, make it fit to drink and move it into our pipe network. As such, the maintenance of these assets is fundamental to our business – fundamental to ensuring our customers are provided with clean, high-quality and reliable water supplies now and in the future.

Our non-infrastructure asset base consists of the following high level asset groups:

- **Groundwater source pumping stations** where boreholes abstract water from underground aquifers and where we treat the water before pumping it into the distribution network;
- **Surface water treatment works**[1] where the raw water from our surface water storage reservoirs is treated and pumped into the distribution network;
- **Wholesome water storage assets** - service reservoirs and towers where potable water is stored within the distribution network; and
- **Booster pumping stations** where water is re-pumped within the distribution network to transfer water between service reservoirs or maintain supplies and pressures to customers.

A summary of the number of our high level asset groups in each of our regions is shown in Table 2 below.

Table 2 Our non-infrastructure Water Production assets

| Asset group | Number in our South Staffs region | Number in our Cambridge region |
|---|---|---|
| Surface water treatment works | 2 | 0 |
| Groundwater source pumping stations | 26 | 23 |
| Booster pumping stations* | 54 | 27 |
| Service reservoirs** and towers | 32 | 31 |

*Note this figure includes three raw water pumps at Nethertown and a priming pump at Yoxall
**Note this is the number of storage units. More than one unit may be present at one site.

In addition to these high level asset groups, we have other much smaller types of non-infrastructure assets such as meters, boundary boxes, loggers and valves.

## 1.2 Our infrastructure assets

Our infrastructure assets are those related to the transfer of water around our network, between our source stations, treatment works, service reservoirs and towers and to the boundary of customers' properties.

Our infrastructure asset base consists of the following high level asset groups:

- **surface water storage reservoirs** where large volumes of raw water from rivers is stored before it is treated. Though these assets are related to water production, they are classified

[1] Our groundwater pumping stations (including groundwater treatment works) and surface water treatment works are sometimes referred to more generally as source stations.

as infrastructure assets due to their infinite asset life. We have two of these in our South Staffs region;

- **water mains** are the pipework by which water is distributed around the network. These can be separated into two main types, large diameter mains (trunk mains) and smaller diameter mains;
- **pipe bridges** are above ground pipes that transfer water above railways, rivers and other obstacles; and
- **communication pipes** carry water between the water mains and the boundary of customers' properties.

There is approximately 6100 km and 2400 km of main in our South Staffs and Cambridge regions respectively. In real terms, combined, this length of main, if laid end to end, would stretch half way to Sydney, Australia. In both regions, the average age of main is approximately 50 years old.

## 1.3 Our assets and our service

Our South Staffs region and our Cambridge region operate as two water resource zones with each area divided into multiple Water Supply Zones (WSZs). There are 20 WSZs in our South Staffs region and seven in our Cambridge region. The zones are diverse and unique in the context of their asset base (non-infrastructure and infrastructure), the customers served, how the respective assets perform individually and collectively, their current and historic asset health records and how each WSZ is linked with adjoining WSZs. All of these factors contribute to our level of service. When combined, these factors determine our resilience to short term shocks and stresses and contribute to our ability to respond to unexpected events and maintain our level of service regardless of the circumstances.

The diversity of our supply system has evolved over time. Over the years we have identified risks to our service and invested to mitigate these risks – we have invested to improve resilience at a range of scales, from the individual asset scale to the supply zone scale and the regional scale. Such operational resilience is achieved through varying levels of mitigation:

- At the individual asset level - for example, having duty standby arrangements on our pumps;
- Site level - for example, having a power generator on site;
- Supply zone level – for example, the ability to reconfigure the network when required and move water within zones; and
- Regional supply zone level – for example the ability to transfer water between supply zones.

The result of this long term process to improve resilience is two highly flexible and integrated supply networks. Both our South Staffs and Cambridge regions are configured in such a way that failure of an asset can usually be accommodated by another. And, while some assets may be of more significance to our service than others (for example, produce a higher volume of water, be more strategically placed within the network or feed a higher number of customers), we continue to work to **maintain** our existing assets, and, develop a more flexible and diverse asset base to **enhance** our ability to respond to unexpected events and maintain our service to our customers.

# 2. Developing the best plan for customers

Continuous maintenance of all of our assets is required to ensure that our supply networks remain operational and resilient - so that customers continue to receive the level of service they pay for under all circumstances. This continued maintenance requires continued investment. And while maintaining our assets is critical, we need also to improve and enhance our existing asset base to ensure we improve our service in a constantly changing environment. The process by which we have identified where we need to invest to maintain and improve our service to customers is detailed below.

## 2.1 Core risk based approach

As with our previous business plans, we have used a risk based approach to identify our capital investment needs for 2020-2025 and beyond. This approach ensures that our plan is focused on reducing our biggest risks to our customers, our people and our wider business, the environment and our compliance with the numerous regulatory standards.

The route by which an investment makes its way into our plan follows a core process of risk assessment; identification of need; identification of solution(s); and investment optimisation.

Risks have been considered in terms of the likelihood (or probability) of a risk being realised and the impact (or consequence) of the risk should it occur - in particular the risk to our service and therefore our performance commitments. If a **risk has been identified** and deemed to be of sufficient likelihood and/or magnitude to warrant mitigation in the period 2020-2025 and beyond, an **identification of need** has been raised. An identification of need is the stage at which a risk is turned into the need for a solution. For example, a risk assessment may identify a high risk of a power outage at a site leading to customers going without water. The need identified from this risk would be to implement mitigation to reduce the risk of power outage affecting customers.

Following on from an identification of need is the **identification of a solution or solutions**, in other words, how we propose to address the need and in turn, mitigate the risk. In the case of the power outage example used above, one solution may be to site a permanent generator at the site in question with auto changeover capability so that no supply interruptions would result from a power outage. Another solution may be to undertake some electrical works at the site so that we can deploy a mobile generator to the site more quickly in the event of a power outage. So, whilst supply interruptions may not be mitigated entirely with this latter solution, we would be able to respond to the event more quickly and therefore reduce the duration of a supply interruption.

Each of the proposed solutions would have a slightly different impact on our service performance commitments. The effect of the first solution (site a permanent generator) would eliminate a supply interruption in the event of a power outage whilst the second solution (electrical works to enable faster mobile generator hook up) would reduce the duration of a supply interruption.

We did not constrain the number of investment solutions that could address a given need. Instead, we were keen to encourage innovative thinking in terms of how we continue to deliver the efficient service our customers expect and pay for, both now and in the future. To this end, we generated around 450 investment needs and 1,450 solutions to potentially address those needs. We also recognised within our approach that it was important to quantify and include a ‘do nothing’ position for our needs, to understand the relative benefit of proactive investment. We are mindful that it is not simply a case of carrying on doing something simply because it has always been done.

And it is with these investment needs and solutions that we have undertaken investment optimisation. The core function of this process is to allow us to take a balanced and transparent approach to identifying the best options for investment, providing a common platform to appraise the costs of an investment against the service benefits that investment will provide in relation to our performance commitments. The investment optimisation process is detailed in Section 2.5.

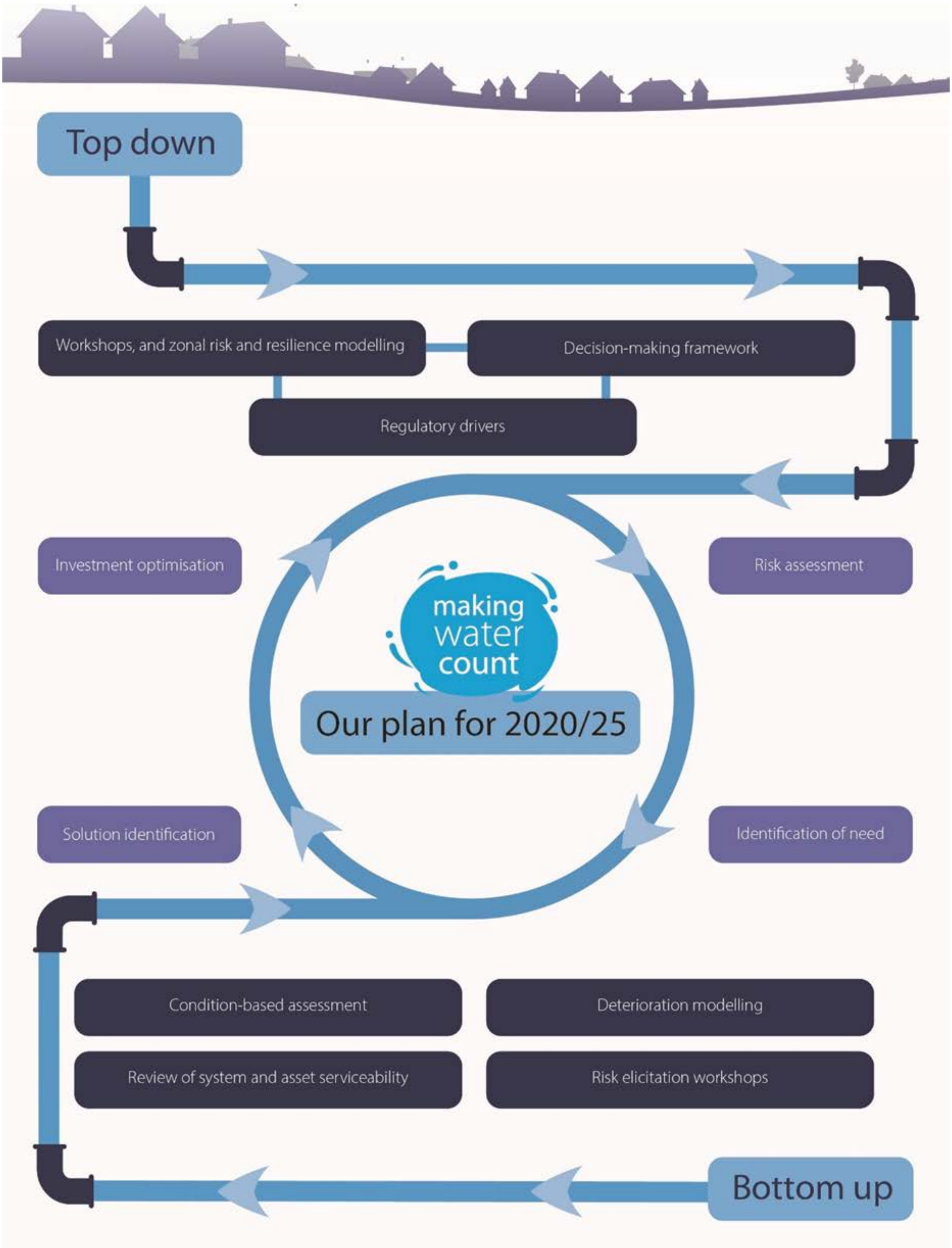
The core process we have followed, from risk assessment through to investment optimisation is illustrated within the graphic below. The graphic also illustrates the different approaches by which we have assessed risk and identified needs across our business which relate to our service, influenced by both our non-infrastructure and infrastructure assets. As noted above (Section 1), the main asset types impacting our service are non-infrastructure and infrastructure assets.

The variety of approaches we have used to establish our investment needs reflects the diversity of our asset base and the need to plan over the short, medium and long term to ensure we deliver a class leading service now and in the future. To capture all our assets over this range of timescales, **we have used a combination of top down and bottom up approaches to identify our investment needs for the period 2020-2025 and beyond**.

By top down we mean starting with the big picture, taking a wide strategic view of our assets, and then working down towards the smaller, finer details of our systems, assets and processes. It follows that this more overarching, strategic approach is particularly focused on planning for the **long term**. In contrast, our bottom up approach - starting with the smaller, finer details and working up to the bigger picture, is more focused on planning for the **short to medium term** - 2020-2025 and the next planning period 2025-2030. In both instances, we followed the staged process of risk assessment; need identification; solution identification and investment optimisation as illustrated.

Within each of the top down and bottom up approaches, sits a further level of detail on how we have ascertained our investment needs for the period 2020-2025 and beyond. Each approach is outlined in further detail in the following sub-sections.

In each instance, the approach used to identify risks and investment needs for the different asset types was considered to be the best available, using data and/or expert judgement where it was available or required. The combination of data and expert judgement has given us a plan that is risk based and verified by our people. We have also found that common themes and needs for investment have emerged consistently across the different approaches we have used. This has given us even further confidence that our plan includes the most important investments to meet the needs of our customers and our business.




Our approach to identifying our investment needs for the period 2020-2025 and beyond

## 2.2 Internal and external challenge and assurance

Multiple stakeholders across our business have been involved in reviewing the risks and magnitude of risks identified, the needs put forward, the solutions proposed and the costs and benefits assigned to each proposed investment. Ensuring challenge at the multiple stages of the process has enabled us to refine needs and solutions as we have progressed throughout the process. The challenge has ensured we have chosen an internally validated and supported plan with the highest priority investments included. Subsequent validation of the portfolio options has also been key to ensure that the capital expenditure proposed delivers the required level of service at an acceptable level of risk within the affordability constraints set by the business.

The governance and assurance that our plan has undergone is further detailed in Chapter 7 – Governance and Assurance.

## 2.3 Top down

The top down approach was used to focus on our investment needs for the long term.

### 2.3.1 Decision making framework

To help us address the more strategic, longer term needs of our business, we have adopted a different and innovative approach to that of previous business plan submissions.

We have taken a more holistic view of the long-term supply capabilities of our network, talking with and listening to our customers to understand what they really want – and what they can afford to pay. We have done this for two reasons.

- We recognise the importance of looking beyond Ofwat's five-year regulatory cycle in favour of considering both our immediate and long-term planning and investment needs.
- Using more co-creation, we want to identify whether there are alternative approaches that might help our customers now – and our customers in the future, who will benefit from the long-term investment that everyone pays for in their bills.

So, we have reviewed and evaluated all our existing operations across the water resources in both regions. We have also used credible, leading independent experts to collaborate with us and each other to help shape our plans. Looking at our operations in the round in this way has enabled us to identify the optimum mix of investment options going forward, and ensure we are making water count by continuing to meet all our customers' needs and expectations.

As part of this, we appointed Arup to help us develop a robust and flexible decision-making framework that would guide our long-term planning strategy, and to help us select the optimum portfolio of investment options that form the basis of this plan. We also followed water sector best practice by taking into account guidance from UKWIR, the water sector's main research body, on decision making for companies' long-term water resources management plans[2].

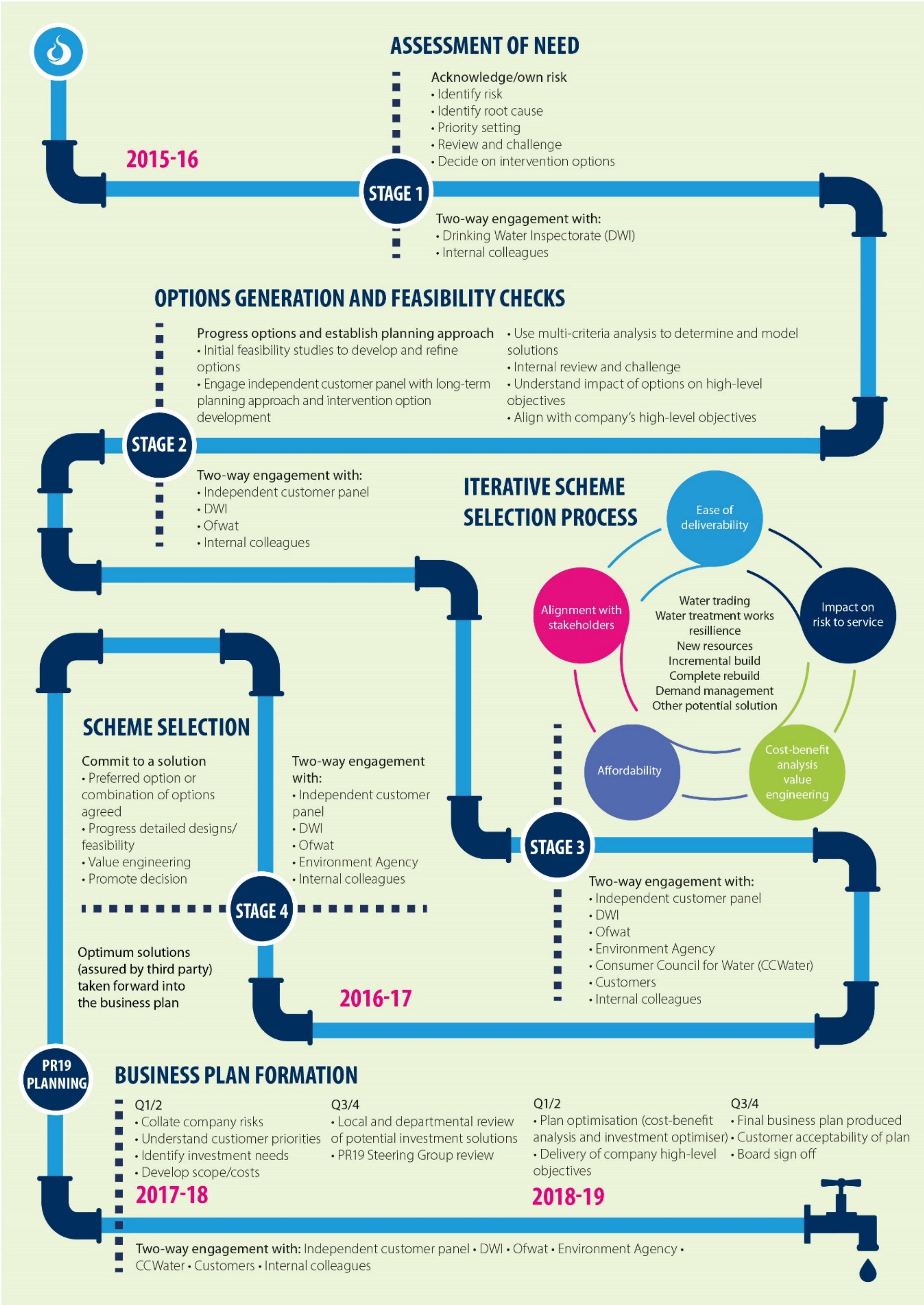
We wanted a framework that enabled the full range of options available to us to be compared against each other so that we could select the best combination for our customers and our circumstances – now and in the future. As such, our approach has enabled us to consider a wide range of options, which we identified through internal engagement with our people and external engagement with other key stakeholders in the areas of:

- **water resources and water trading** – that is, considering all our water sources and making arrangements with neighbouring companies to ensure reliable supplies to customers can always be maintained;
- **demand management**, which includes things like reducing leakage on our network, and educating and informing our customers about the benefits of switching to a water meter and the need to use water wisely;
- **refurbishing or rebuilding our major assets**, such as storage reservoirs and water treatment works; and
- **groundwater**, which is the water we take from our boreholes in both regions.

This was so we could be sure we were taking a rounded view that represents the best plan for customers – and one that is robust, flexible and responsive to their changing needs and requirements over time. Throughout the process, we engaged continually with all our key stakeholders – including customers, regulators, neighbouring water companies and the independent customer panel – to ensure a robust and transparent approach.

The main stages of the decision-making framework are illustrated below and further detail can be found in Arup's detailed Decision Making Framework modelling report[3] in Appendix 33.

[2] 'WRMP 2019 Methods – Decision Making Process: Guidance', UKWIR, May 2016.
[3] Decision Making Framework for South Staffs Water - PR19 Investment Programme, ARUP, November 2017




Our decision making framework

Our decision-making framework moves away from a 'one size, fits all' approach and recognises that least-cost investment options are not the only ones we should consider.

This represents a step change for us. It has meant combining our approach to how we manage our assets with our long-term water resources management plans to give us a clear line of sight between our preferred plan and the services our customers expect us to deliver.

As such, it is a more innovative, leading-edge approach that represents a move towards considering all our assets in the round, through our core objective scoring against our:

- customers' preferences;
- operational resilience;
- environmental sustainability and deliverability; and
- totex requirements.

Although it is fairly difficult to quantify these core objectives, as a result of our extensive engagement with stakeholders, we recognise that they are crucial to making a robust decision. Our decision-making framework allows us to effectively and consistently capture a wide range of investment solutions and appraise them against these core objectives in terms of:

- their **operational resilience**, to ensure a stable, high-quality water supply for customers now and over the long term. This includes:
  - flexibility, to ensure an integrated network that enables us to switch easily between different water sources as and when required;
  - reliability, to ensure our critical assets are available as and when they are needed; and
  - diversity, so that we have enough water sources available to help us deal with a range of different drought scenarios;
- their **environmental sustainability**, to minimise the impact of our business on the environment;
- their **deliverability** – that is, how easy the option is to deliver and over what period of time; and
- **customer preference**, to ensure that we are delivering what our customers have said they want, and which we have checked against other data sources so that we can be sure our engagement process has been transparent and robust.

### 2.3.2 Multi – Criteria Analysis

The outputs from the decision-making framework feed into an innovative multi-criteria analysis (MCA) model, developed in conjunction with specialist management consultancy Hartley McMaster. It is this step between capturing and scoring investment solutions in our decision-making framework and deciding on a final investment portfolio that takes us further than the cost-benefit analysis we have used with previous business plan submissions. We think that the complexity of the model and the way that we have applied it in an adaptive and responsive way is at the leading edge of the sector.

Aligned with Ofwat's preferred method of considering 'real options' in long-term resource planning, our approach follows UKWIR guidance in terms of being the most effective and appropriate method of decision making for the scale and complexity of the challenges facing us.

We consider this dual approach has given us the capability to enable customers to co-create and shape our plan. We then triangulated this with further customer insight, including priorities and willing to pay data, so that we could be sure the final portfolio of investments add up to a 'best' plan for our customers, now and in the future.

It is this clear line of sight from customer engagement through to output investment portfolios that has been at the heart of our approach. And it is demonstrated both in the process of generating planning options and within our complex modelling capability to understand the final selection of investments we are putting forward in our plan.

Our MCA model incorporates qualitative and quantitative stakeholder appraisals of the investment options across the broad range of core objectives described above. It also evaluates how effectively they deliver in the short and long term. We do not consider it appropriate to constrain our analysis to 5 years or even 25 years. Instead, we have taken a much longer view of the challenges we may face in terms of water quality, changes in demand and climate change.

This led us to ask ourselves the following questions:

- How do we ensure we meet our future demand requirements for water across a range of different scenarios[4]?
- How do we make sure we are minimising water quality risks across our network?
- How do we ensure the robustness of our decisions – and what they will deliver for our customers – now and in the future?

The advantage of using an MCA model is that it allows us to assess and evaluate trade-offs between investment options across competing objectives while considering a wide range of scenarios to ensure we are being flexible in our ability to adapt to a changing future. This is a key component of real options analysis.

To give a sense of the range and scale of our analysis, we have considered more than 1,000 different investment options over an 80-year timeframe – ultimately equating to about two million potential options (taking start times and different demand scenarios into account) to feed into our model.

We had two key parameters that any modelled output had to deliver against. These were:

- the level of deployable output – or DO – from supply sources. The 'deployable output' is the volume of water we can access under the worst historic drought conditions for our South Staffs and Cambridge regions[5]; and

[4] We consider our future demand for water against three scenarios – 'normal year annual average', 'dry year annual average' and 'dry year critical period'. The normal year annual average is the total demand for water in a year (measured in millions of litres) with normal or average weather patterns. The dry year annual average is the average level of demand for water over one year. It is a 'dry year' when demand averages are higher than in a normal year because the weather has encouraged more people to do things like water their gardens, use paddling pools or take more showers. The dry year critical period is usually in the summer and is related to the weather. It refers to the peak volume of water used for the activities outlined for the dry year annual average ratio.

- our ability to provide the resource at the required quality.

These parameters were a firm constraint for any of our model runs. So that we could be sure we made the right investment decision, we also challenged our base case assumptions around demand, resource availability and drought scenarios when modelling potential future extremes.

This enabled us to understand how different the future would need to be to change our plans. For example, when we looked at groundwater levels in our Cambridge region, our model suggested that bringing previously abandoned sites back into supply would provide the required additional resource (Section 3.2.3).

By using the core objective scores for resilience, customer preference and deliverability, we were further able to stress test our plans. In doing this, we included a number of revised options so that we could be sure our preferred plan was resilient and had customers' priorities at the heart of it.

We also included an additional water trade and reinstated a number of underground water sources to improve our operational resilience. And we increased our demand management options as we know from our engagement and co-creation that our customers have a strong preference for such approaches.

## 2.3.3 MCA Model outputs

To enable us to effectively demonstrate the outputs of our multi-criteria approach, we developed parallel co-ordinate plots that display the relative impact of a range of portfolios upon each of the modelled objectives described above. These visuals allowed us to compare the outputs of each of the modelled scenarios. We were then able to interrogate the portfolios to understand the individual investment options that were driving the best balance across the objectives.

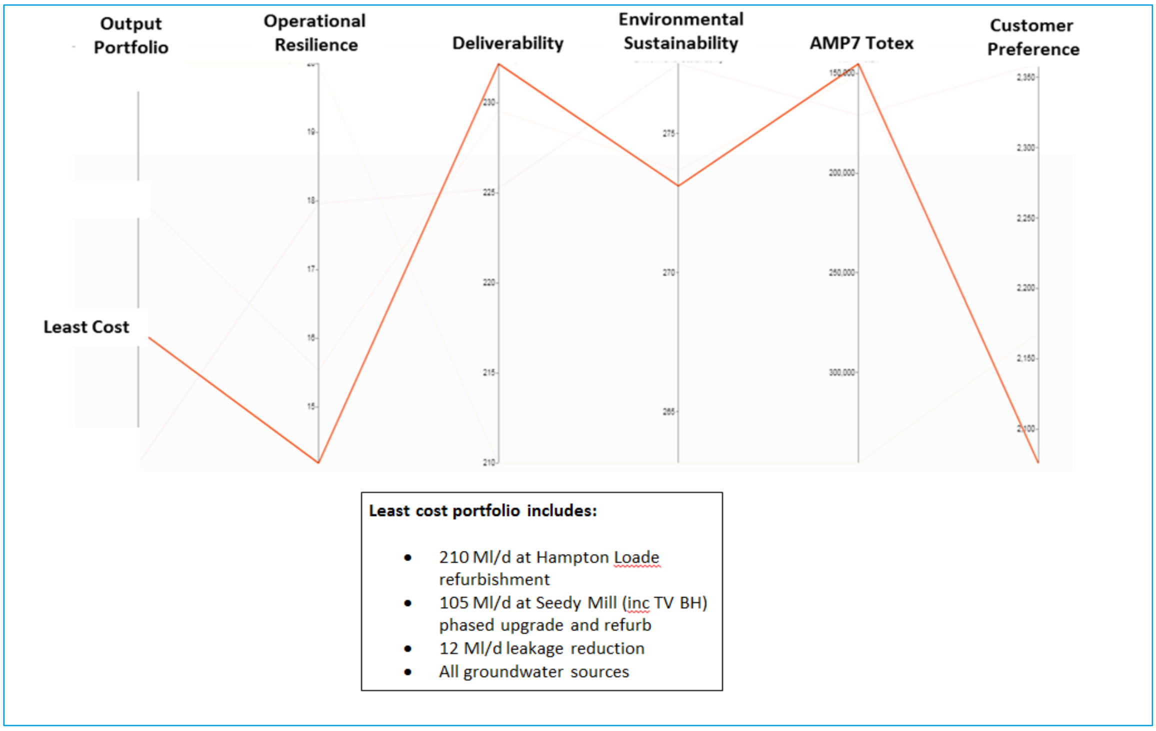
Each portfolio comprises a range of investment options across the entire asset base – it is important to note that while every output portfolio shown below impacts differently against the range of objectives in the graphs, they all deliver against an 80-year demand profile that includes forecast AMP7 WINEP reductions and provide the quality of water our customers have said they want.

While we ran many different scenarios and sensitivity checks on these outputs, we consider the graphs below illustrate most effectively our approach in defining the optimum portfolio in terms of delivering the water quality improvements that are necessary.

Figure 1 below shows the performance of a least cost portfolio (red line) – as our starting position, we wanted to understand those investment options being selected when the only constraint applied was that of minimising whole life totex to meet the demand and quality targets. The graph clearly demonstrates that despite meeting these targets, it scored relatively unfavourably on resilience and customer preference.

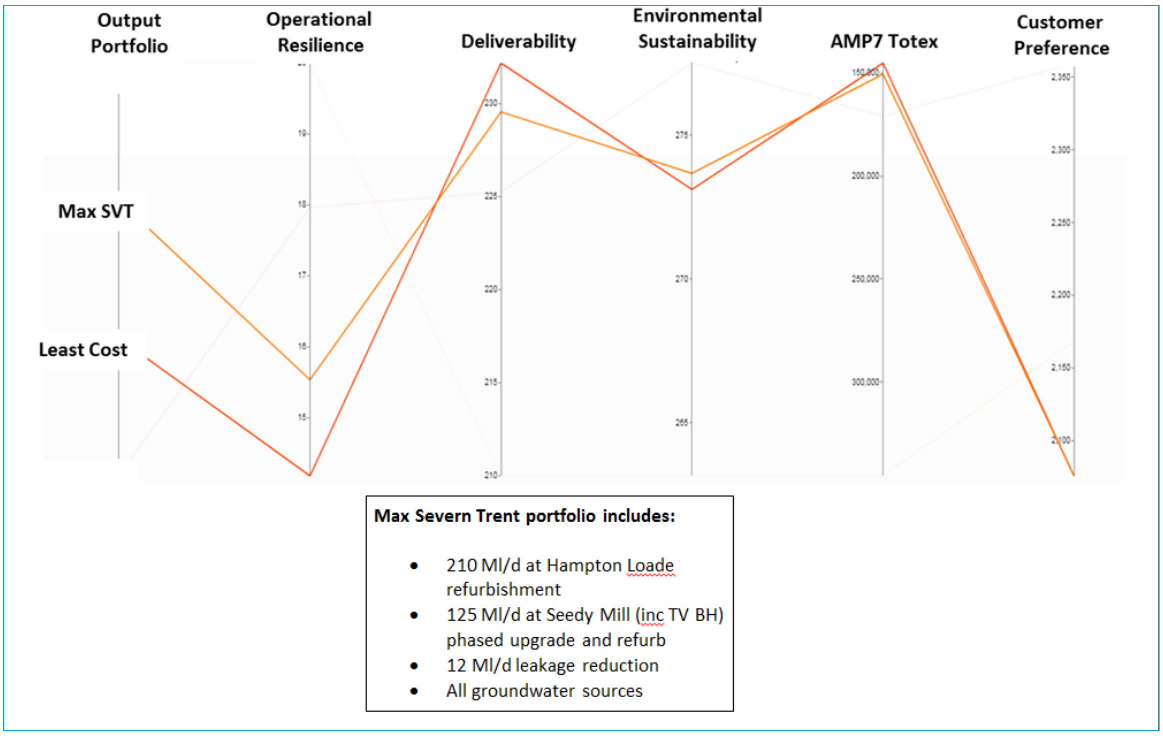
[5] Deployable output is also constrained by a number of other factors, including the volume of water we can legally take from the environment, the quality of that water, the treatment processes we use and how we move water round our network. Specifically, our level of service deployable output is based on those historic droughts where we require additional measures to manage our water resources, and the likelihood of us needing to introduce restrictions on how much water customers can use.

Figure 1 Performance of a least cost portfolio (red line) – as our starting position




Having obtained the least cost portfolio outputs, we then looked at sensitivity around demand – specifically an increased Severn Trent Water's utilisation at Hampton Loade. The least cost portfolio was demonstrated to be no longer sufficient to resolve this new demand profile. Instead, the model outputs indicated the portfolio below in Figure 2 below (orange line) as the lowest cost way in which it could be achieved. Compared to the least cost scenario, the model selected a larger output from our Seedy Mill Treatment Works, increasing the portfolio totex, and adversely impacting the score against deliverability. The operational resilience was shown to improve with this increased output however.

Figure 2 Performance of a least cost portfolio under increased Severn Trent Water use at Hampton Loade

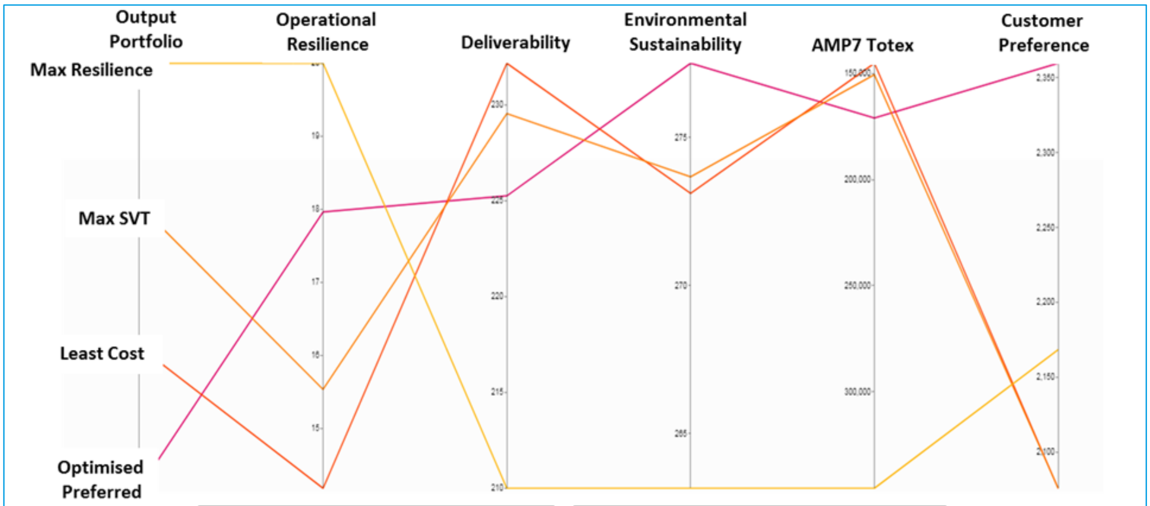



The graph in Figure 3 below overlays the result of a maximum resilience portfolio (yellow line) and also brings in our preferred portfolio (purple line). The former shows the output of an optimisation that looks to achieve the demand and quality targets in a way that includes those investment options scored as most resilient over the long term. Because of this, the associated scores against deliverability and the overall AMP7 totex value rank lower in comparison to other portfolios. The preferred portfolio represents an optimisation deemed to deliver a resilient portfolio, at relatively low cost and that is scored highly by our customers in terms of their preferred options. Tested with a range of stakeholders, it represents an optimum balance across the objectives.

This gave us a preferred portfolio of investment options to take forward for 2020 to 2025 and beyond, which we outlined at the start of this plan. We then tested and reviewed these options rigorously with key stakeholders so they could understand the outputs clearly. This included carrying out extensive and in-depth scrutiny with our Board, the independent customer panel and a dedicated sub-group of the panel. These final outputs were integrated within our wider investment optimisation process outlined in section 2.5 below.

Further detail concerning our extensive options appraisal, modelling and portfolio selection process is outlined in the sub-appendix to this document – A29.1 ‘WRMP 2019 – Deciding on future options’ (page 92 onwards).

Figure 3 Performance of a maximum resilience portfolio and our preferred portfolio




**Max resilience portfolio includes:**

- 230 Ml/d at Hampton Loade refurbishment
- 140 Ml/d at Seedy Mill (inc TV BH) phased upgrade and refurb
- 12 Ml/d leakage reduction
- All groundwater sources

**Preferred optimum portfolio includes:**

- 210 Ml/d at Hampton Loade refurbishment
- 125 Ml/d at Seedy Mill (inc TV BH) phased upgrade and refurb
- 12 Ml/d leakage reduction
- Introduction of a live network
- All groundwater sources
- Increased demand management activities around metering and water efficiency
- Trade with Severn Trent to support resilience

## 2.3.4 Regulatory drivers

A large proportion of our investment needs are driven by regulatory factors – investments we are required to make to meet our statutory obligations. The main regulatory bodies affecting our non-infrastructure and infrastructure assets are Ofwat, the Drinking Water Inspectorate, the Environment Agency (EA) and the Health and Safety Executive. Our investment needs relating to our statutory obligations were put forward by the relevant owners across the business throughout the planning process.

## 2.3.5 Supply investment group (SIG)

We have formed a supply investment group (SIG) across our business which consists of asset owners, analysts, engineers, managers and heads of department across the breadth of our wholesale business. Subject matter experts from Production, Water Resources, Water Quality, Networks, Asset Management and our Capital Investment Delivery teams have met together on a monthly basis to discuss each of our WSZs in turn. The diverse range of expertise provided by our colleagues offers a well-rounded approach. While the focus of the workshops has been on the top down strategy of each zone, insight provided by our colleagues on the operation of our specific assets has proved invaluable also.

The overall aim of the workshops was to, at the WSZ scale, identify issues and risks which are impacting and are likely to impact our service, then, to identify needs and subsequent solutions to take forward into our business planning process. This was achieved through a structured process. In summary:

- we reviewed mean zonal compliance (now the Compliance Risk Index (CRI))[6] and acceptability of water (taste and odour) within the supply zone in question. We also reviewed areas that may be at risk from low levels of free chlorine[7] and potential risks to the acceptability of water that may arise from us transferring water between zones;
- we reviewed previous unplanned outages or interruptions to supply covering:
    - **non-infrastructure assets** – we reviewed source station outages and trips at booster stations since 2015 as identified from our telemetry records in terms of both frequency and root cause;
    - **infrastructure assets** – we reviewed both trunk mains and small diameter historic burst rates and the number of bursts per kilometre of main within each zone. The trunk mains data we used dated back to 2000 and the small diameter data used dated back to 2015. The trunk mains data dating back to 2000 was the same data as that used in the modelling discussed in Section 2.3.6 below;
- we reviewed the long term position for each zone, including:
    - future demand forecasts encompassing all new proposed housing and commercial growth contained in Council Local and Structure Plans;
    - our Water Resources Management Plan (WRMP) in terms of our deployable output, supply demand balance and leakage position;
    - emerging trends in raw water quality at our source stations;
    - regulatory changes (pertaining to licence changes and water quality); and
    - between zone water transfer capabilities and constraints (for example mains sediment and turbidity risks); and
- we reviewed previous and current proposals for investment in order to confirm what actions to mitigate the risks identified are already planned and when they will be delivered so we could ensure any outstanding mitigation identified as being required could be added to the business planning process.

With so many of our colleagues involved in the process, the outputs of the workshops were diverse, ranging from specific non-infrastructure assets, specific infrastructure assets; strategic supply capability, and, more generic strategies relating to our internal procedures such as emergency planning. The process was valuable in sharing people's knowledge and experience, in highlighting areas for improvement - both to our service as well as our internal processes and, in facilitating joined up thinking and communication across our business.

The outputs from the series of workshops held were:

- a list of risks identified;
- a list of needs to mitigate the risks identified;

[6] Mean zonal compliance which has now been replaced by the Compliance Risk Index are measures developed by the Drinking Water Inspectorate (DWI) to measure company performance on drinking water quality.
[7] Free chlorine is the recognised metric for measuring the level of chlorine in the distribution network. We used it in SIG as a service level risk indicator for potential areas of water quality failure.

- a range of solutions proposed to address the needs identified and to improve resilience; and
- timescales required for implementation of the proposed solutions.

In addition to the above, the outputs from the SIG workshops were cross referenced with the outputs of our detailed network resilience modelling (outlined below in Section 2.3.6). The modelling has provided a means of independently verifying the risks identified by our experts in the workshops, and, has provided an objective means of quantifying the risks. To complete the engagement process, the findings from the modelling were fed back to the SIG to keep all stakeholders informed and involved in the process, to share the knowledge gained and to verify the outputs.

## 2.3.6 Zonal risk and resilience modelling

We have undertaken an extensive review of the resilience of our supply network to help us identify where we need to invest to improve it further in 2020-2025 and beyond. This review has been undertaken using a detailed hydraulic modelling exercise.

The main aim of the modelling has been to determine how single and multiple asset failures would impact customers so we can, in turn, identify capital investment requirements to mitigate the risks to our service and improve our resilience.

The thorough and systematic modelling process has identified the strengths and weaknesses of our asset base and has enabled us to quantify our operational supply resilience by assessing the security of supply to our customers.

Though our risk and resilience modelling is included here in our explanation of our top down approaches, we consider our modelling to be a combination of both top down and bottom up risk assessment. The modelling is top down in the sense that we have looked right across our supply zones to assess our overall resilience from a strategic perspective. However, the models are built from the bottom up - they depict all of our assets (both non-infrastructure and infrastructure) and the interactions between them. For example, within a model for one supply zone, the model depicts our pumping stations, our storage assets, the mains network between these stations and our customers, and, any booster stations in between that may help with moving the water around the network.

### 2.3.6.1 A step change

Using these detailed hydraulic models to assess our resilience constitutes a step change from previous price reviews. In our previous business planning, we have looked at our non-infrastructure and infrastructure assets separately from one another and our needs have been obtained mainly through expert judgement. Whilst this approach has met our needs at the time, it has not enabled us to fully capture our ability to respond and recover to events and/or asset failures. This is because in reality, our resilience covers all of our assets and cannot be realistically separated into these two high level asset groups. For example, failure of a pumping station in one zone could, in reality, be mitigated by increasing the output from another pumping station (a non-infrastructure asset) or, by moving water in from an adjacent zone (via our infrastructure assets - pipe network).

The hydraulic models we have used for this price review represent our entire supply network and its integrated nature. Because the models depict both our non-infrastructure and our infrastructure assets and the complex relationships between them, we have been able to methodically assess our resilience in the round. We have been able to simulate asset failures, imitate our existing mitigations and quantify the impacts of an event and/or asset failure and our likely responses, on our service. This has enabled us to objectively quantify our resilience. This objectivity constitutes a further step change from the focus on expert judgement we have used previously.

In the following sections, we explain the modelling approach we have used. We have separated the outline of our approach into non-infrastructure and infrastructure assets because of subtle differences necessitated by the modelling tools we have used for each. As explained above, however, the analysis undertaken in each instance was cross cutting with regards to these high level asset groups - enabling us to assess our supply zone resilience in the round by simulating the relationships between these assets in the event of simulated asset failures.

#### 2.3.6.2 Modelling approach

We use a proprietary software package that is used throughout the water industry (InfoWorks) to model hydraulics across our supply network and we have constructed and calibrated our models in accordance with our internal Technical Specification for Hydraulic Models. Our technical specification was developed by our in-house experts and aligns with Industry best practice for hydraulic modelling. We have detailed hydraulic models covering all our WSZs and maintain and update them on a rolling three to five year programme.

Before using the models to assess the resilience of our existing supply networks, however, we updated them further to include all capital investment schemes we have planned for the remainder of the current planning period (to 2020). This was to ensure that our modelling reflects how the supply systems will be operating in the period 2020-2025 – to avoid assessing risks that we already plan to mitigate. We also reviewed Local Council Plans and the forecasted growth in demand to ensure that we captured the future demand on our supply networks.

#### 2.3.6.3 Zonal risk and resilience modelling - non-infrastructure assets

Using our hydraulic models, asset failures were simulated to assess the impact to our service. Asset failures were firstly simulated one at a time to determine the impact of a single point of failure, then, multiple failures were simulated within each zone to determine the potential impact of cumulative failures. Asset failures were simulated by systematically ‘switching off’ assets within the hydraulic modelling software – so our source stations, booster stations and service reservoirs and towers.

For source stations and booster stations, we simulated asset failures under an average demand, peak hour scenario to reflect the worst case scenario risks we have to manage on the most frequent of occasions - a daily basis. For storage assets (service reservoirs and towers), however, we modelled asset failures under a peak demand scenario. A peak demand scenario was deemed more appropriate for storage assets because we regularly take our storage assets out of service for routine inspections and maintenance works. When we do this, we do so under average demand conditions (or less) so we know there will be no impact to customers. Therefore, by simulating failure under a higher demand scenario, we were able to assess potential impacts to customers that we have not already quantified.

After simulating each asset failure (single or multiple), we documented the impact on service level to customers in terms of low pressures and no waters. We then added existing mitigation measures to the model, for example, opening valves between zones or operating transfer boosters. Not all of our WSZs have storage assets within them, so in these cases, we modelled the impacts to customers where they may be reliant on storage within adjacent zones. We had to combine WSZs with our modelling in this way to ensure all our existing resilience was captured.

Once our existing resilience was added to the models, we documented the residual service impacts to customers again - still in terms of low pressures and no waters. If service level impacts remained after implementing our existing mitigation measures, a need for improved resilience was identified. Solutions were then generated to address the need and mitigate the risks of service impacts.

The modelling demonstrated that we already have a high level of resilience across our WSZs with regards to our non-infrastructure assets. This reflects the value of the strategic investments we have made to date. We have tried to reduce the number of single points of failure where reasonably practicable (for example duty standby on pumps at source stations and booster stations) and maintaining a level of redundancy[8] within our supply network provides us with the ability to respond to and recover from unexpected events and so minimises service impacts.

As a result of our existing resilience, only a small number of potential investment requirements were identified. Two examples of the investment requirements we did identify are summarised in the case studies below - Norman Road resilience scheme and Glascote Reservoir. The decision making framework (Section 2.3.1) also highlighted the strategic importance of Glascote Reservoir within our South Staffs supply network.

[8] Redundancy refers to our ability to supply customers from elsewhere within our network – by an alternative route to the way we would normally supply them.

**Case Study - Norman Road Resilience Scheme**

Smethwick booster supplies 6847 properties. We categorise this as a Category 1 booster which means that it boosts 24 hours a day into a zone that has no alternative source of supply. Therefore, if the booster were to fail (which would require failure of both the duty and standby pumps), then there would be a significant impact on service within the zone. If the booster were to fail during a peak hour scenario and we undertook some valve operations as a result to try and mitigate the impacts as far as is possible with the current infrastructure, 559 properties would experience no water and 2089 properties would experience low pressures.

The range of work we have undertaken to identify investment needs has informed us that:

- there is a medium risk of low or no flow coming into the booster site – this risk was identified during our risk elicitation workshops (Section 2.4.5);
- the booster's delivery main has been identified as a critical link – from our critical link analysis; and
- there have been numerous unplanned outages over the past four years ranging from 30 minutes to three hours in duration.

As a result of the risks we have identified across our asset base, we have proposed an innovative and cost effective solution to reduce the risk to our service as a result of asset failure (the booster and/or network around it).

The proposed investment will provide an alternative and immediate means of supplying the currently boosted only zone. The system will be configured in such a way that when losses in pressure are detected, the supply of water from the booster will be switched to input from the adjacent zone, via the newly installed main and valves. This resilience will enable us to maintain service levels in the event of an asset failure in this area of our network.

**Case Study – Glascote Reservoirs**

**Glascote No:1 (1880)**

**Glascote No:2 (1975)**

Glascote Reservoir site in Tamworth consists of two service reservoirs which collectively provide water to 15,422 properties. The combined volume of the two reservoirs is 21.4 Ml which equates to about 2.5 days of storage under average demand.

The full capacity of Reservoir 1 is 3.4 Ml and the full capacity of Reservoir 2 is 18 Ml. However, due to the relative water levels of the two structures, when Reservoir 1 is in supply, only 71% of the 18 Ml storage capacity of Reservoir 2 is usable. This reduces the total available storage volume from 21.4 Ml to 16.2 Ml. The reduced storage volume of 16.2 Ml equates to about 2.1 days of storage under average demands – almost half a day less than the full storage volume would provide under average demand.

Glascote Reservoir 1 has, however, been out of supply since December 2016. It is the oldest storage asset within our South Staffs region (1880) and deterioration modelling has predicted that it has a 94% probability of failure. Both reservoirs have also experienced increased frequency of water quality failures – one in 2010 and one in 2014 suggesting that an increased risk of unplanned loss of Reservoir 2 exists which would result in the storage at this site being lost from supply entirely.

Our hydraulic modelling analysis identified that should both storage reservoirs be out of supply, 6361 properties would experience no water and 5122 properties would experience low pressures. And, this service impact would be after we had done all we could operationally to mitigate the impact - increasing source station pumping and undertaking strategic valve operations.

We plan to invest in 2020-2025 to mitigate the significant risk to our service that we have identified and, to address the illogical loss of storage volume we experience when both reservoirs are in supply. We will do this by:

- undertaking remedial works at Reservoir 1 to return it to supply; then
- once Reservoir 1 is returned to supply, undertake works to compartmentalise Reservoir 2; then
- abandon Reservoir 1, removing it from supply.

This staged approach will enable us to:

- mitigate the risk to our service during the undertaking of works;
- provide two storage units that we can remove from supply one at a time when required, for example, during our inspections in the future, or to undertake remedial works; and
- maximise the useable storage volume of this site.

### 2.3.6.4 Zonal risk and resilience modelling (infrastructure assets)

The critical link analysis tool which sits within the InfoWorks software we use to model our network hydraulics was used to assess the ability of our infrastructure assets to supply customers from elsewhere in the event of a burst water main – bringing focus to our operational resilience.

We used this tool to model our resilience with particular regard to our infrastructure assets – namely our trunk mains. However, as explained above, because the models include all our assets, this process still incorporated our non-infrastructure assets, both in terms of how they may be impacted by failure of an infrastructure asset but also in terms of how they may be used as mitigation in such an event. We refer to this process as our critical link analysis.

Trunk mains are typically large diameter pipes involved in the strategic transfer of water across the network. For the purpose of our critical link analysis we defined trunk mains as all pipes with a diameter of 300 mm and above. There were three main stages to our critical link analysis:

- stage one – simulate a burst;
- stage two – simulate mains isolation to fix the burst; and
- stage three – simulate the impact of operating boundary valves to restore water to affected properties.

The first stage of the assessment to simulate a burst was undertaken by increasing the flow rate of the main in question. We increased the flow rate as a function of the cross-sectional area and the normal working pressure of the pipe. We documented the number of properties that would experience service impacts (low pressure or no water) as a result of the burst.

The second stage of the assessment (modelling the impact of isolating the main in order for us to fix it) was simulated based on an average day peak hour supply. We modelled this by simulating closure of the valves either side of the burst pipe – this action would be required in order for us to repair the main. We also simulated the automated operation of additional mitigation measures, for example, opening strategic valves and increasing or operating booster pumps - as would be the case when fixing a burst in real life. We constrained such mitigations to known operational limits, for example, to minimise the risk of further bursts or discolouration's. This was to ensure that our modelling accounted for the ways we currently manage the risk to our service during a similar event. We then documented the number of properties that would experience service impacts (low pressure or no water) following the implementation of any mitigation.

The third stage of our analysis was to simulate the impact of operating boundary valves in order to try to restore water to affected properties. Again, we documented the number of properties that would experience service impacts (low pressure or no water) as a result of this final stage. Documenting the number of properties that would experience low pressure or no water throughout the process gave us a measure of potential service impact to customers.

To give an overall measure of risk, we then had to determine the likelihood of such an impact occurring. We did this by assessing the historic burst rate of mains that are of a similar age, material and diameter. We then multiplied the resultant likelihood by the potential number of customers affected by the typical duration of a repair on a trunk main to give a risk score for each main. This risk score was then converted into property minutes by dividing the risk score by the total number of customers in the region, giving us a measure of supply interruptions specifically related to our performance commitments (Table 1).

Our analysis demonstrated a wide range of likelihoods and potential impacts should our trunk mains fail. The number of properties with service impact ranged from zero where we could supply our customers by an alternative route, and/or use other assets, to around 15,000 where we do not have the capacity within our asset base to maintain supplies during a peak hour. The highest modelled impact (number of properties impacted) was attributable to a ductile iron main. This main, however, had a low likelihood of burst owing to a historically low burst rate for ductile iron mains, therefore, although the impact would be high, the low likelihood reduced the overall risk score. The mains with the highest likelihood tended to be trunk mains made from Polyvinyl Chloride (PVC). These mains, make up a relatively small proportion of our trunk main network, however, owing to the probability of failure, we intend to invest to reduce this overall risk to our service.

We then used the final risk scores to identify our most critical trunk mains by the extent to which our Interruptions to Supply ODI would be impacted. From this, we identified the options for improved resilience around a number of mains, and generated solutions to address the risks. For example, installing a booster / mobile pump connection, laying new mains or installing new valves. An example of one of the high risk critical links we identified and generated options for is summarised in the Winshill supply zone case study below.

In addition to identifying resilience investment requirements for the period 2020-2025 and beyond, we are using, and will continue to use, our analysis to develop emergency plans and prioritise our on-going maintenance. Targeting condition assessments, trunk mains inspections, surge analysis, valve replacements and cathodic protection[9] on our most critical mains, all of which will help us to reduce future risks to our service levels. In addition to this, we used the critical link analysis to highlight areas of the network where a burst could result in a service reservoir emptying and therefore impacting supply to customers. In other words, if a critical link were to fail what will be the likely impact to the water level of the associated storage facility, and will this in itself cause additional supply problems.

[9]Cathodic protection (CP) is a technique we use to control the corrosion of some of our steel trunk mains. CP prevents corrosion by converting the anodic (active) sites on the metal surface of the pipe to cathodic (passive) sites. There are two methods of CP that we use - one called impressed current CP and the other called sacrificial anode CP. Impressed current CP works by using a power transformer unit and ground bed anodes to induce a small electrical current into the steel main. In sacrificial anode CP, magnesium or zinc anodes are connected to the steel main which forms a galvanic cell. These anodes ‘sacrifice’ themselves to protect the steel pipe from corrosion.

**Case Study – Critical links in the Winshill Supply Zone**

There are two main inputs to the Winshill supply – Chilcote groundwater pumping station and Saxon Street booster station. Within the zone, there is also a 4.5 Ml storage capacity service reservoir (Overseal) which provides around 13 hours storage under average demands.

The trunk main network within this zone can be coarsely separated into two sections;

- a section to the north mainly comprising of a 18 inch steel main which was installed in 1936; and
- a section to the south mainly comprising of 400 mm-500 mm ductile iron (DI) mains which were installed more recently in 2007-2008.

When we simulated failure of the southern section of the main during our critical link analysis, the model indicated that failure would not result in a major service impact because we would be able to supply customers in the North via Saxon Street booster and the majority of the properties in the South through Chilcote pumping station and Overseal Reservoir.

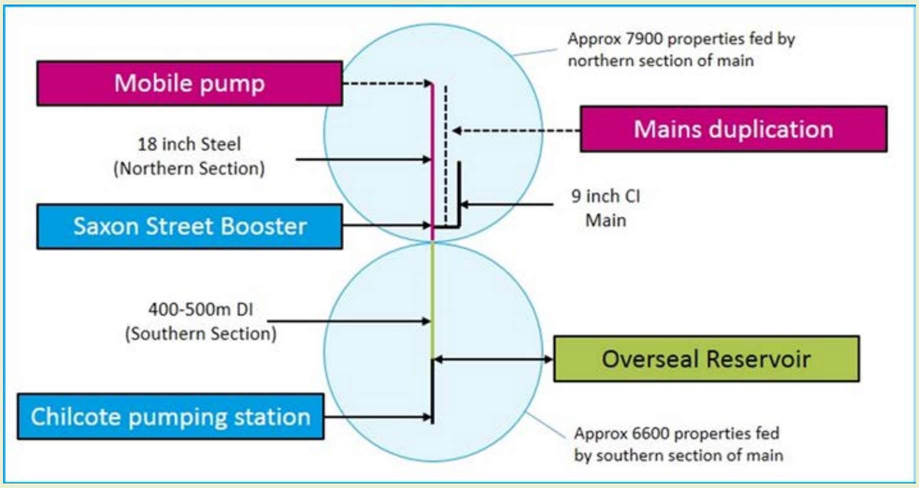
In contrast, however, when we simulated failure of the northern section of the main, the model indicated that around 1900 properties could be supplied through the 9 inch Cast Iron (CI) main from Saxon Street booster and the remaining properties could not be supplied from elsewhere in the network. Indeed, failure of the northern section of the main would result in between 3000 and 6000 properties experiencing no water during a peak hour, with the exact number of properties depending on the exact location of the burst.

Our critical link analysis highlighted this northern section of main to be one of the highest risk mains within our South Staffs region. This is owing to the potential impact of failure (high number of properties potentially affected), and, the likelihood of mains failure (owing to the age and material of the main).

The configuration of the network within this zone is illustrated in the schematic below. The schematic also illustrates the solutions that were fed into the investment optimisation process to mitigate the risk of failure associated with this asset.

The potential solutions identified were to include redundancy in the network by:

- installing a mobile pump connection that would enable water to be transferred into the Winshill zone from the adjacent Outwoods zone; or
- duplicating the 18 inch main to provide an alternative means of moving water to the properties that would potentially be affected by a failure of the original main.



## 2.4 Bottom up

The investment needs we have derived from the bottom up were identified using asset information, condition data, deterioration modelling[10] and expert judgement risk assessment. The bottom up approach was used to focus on our investment needs in the short to medium term. Covering both our infrastructure and non-infrastructure assets, we have ensured that we have drawn upon both data and expert judgement to form our plan for 2020-2025 and beyond. The following sections detail further the bottom up approaches we have used to identify our investment needs.

### 2.4.1 Mains renewals (infrastructure assets)

Implementing a rolling programme of mains renewals (also referred to as mains rehabilitation) is the primary way in which we manage the long term serviceability of our network – our infrastructure assets. Simply repairing these assets when they keep bursting at the end of their useful life is not a sustainable solution without customer supplies being impacted on an increasingly frequent basis. Therefore, there comes a time when we need to replace the mains in their entirety – the process we call mains renewal.

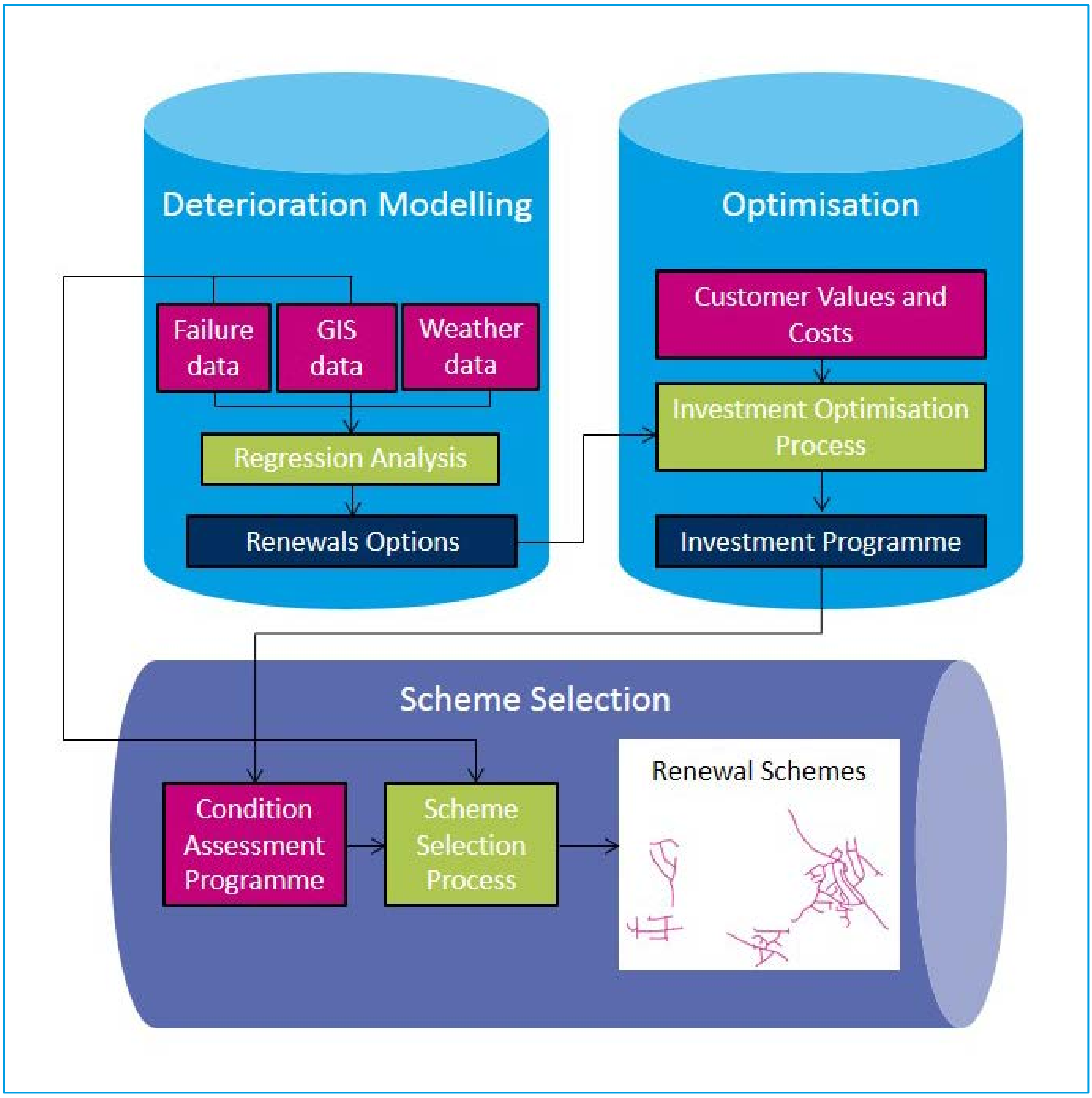
The following sections detail how we establish the extent of mains renewals investment required to deliver a certain level of service.

There are three main stages to how we establish the extent of mains renewal activity required to deliver a certain level of service. These are summarised in the graphic below and detailed in the following sections.

- Stage 1 – deterioration modelling.
- Stage 2 – investment optimisation.
- Stage 3 – scheme selection.

We review the outputs of stages one and two annually to assess how the assets performance throughout the planning period affects the levels of deterioration and optimal levels of investment. Stage three, however, is reviewed more routinely a number of times per annum throughout the planning period. The third stage is when we decide exactly which mains will be renewed. We consider this approach to be the most appropriate because it enables us to make best use of up to date information and data. We, along with the whole of the industry, continue to learn more about the likely behaviour of our assets as we acquire longer datasets on asset failure and asset condition - in the case of mains renewals, burst data. As such, deciding which mains to renew closer to the time enables us to make best use of the most up to date information and target our investments most effectively to deliver the long term serviceability of our network.

[10] Deterioration modelling is the process by which we analyse historic trends in burst data to infer mains deterioration, and then apply this trend forward to predict future burst rates.




Our three phased approach to identifying the extent of mains renewal activity

### 2.4.1.1 Overall approach

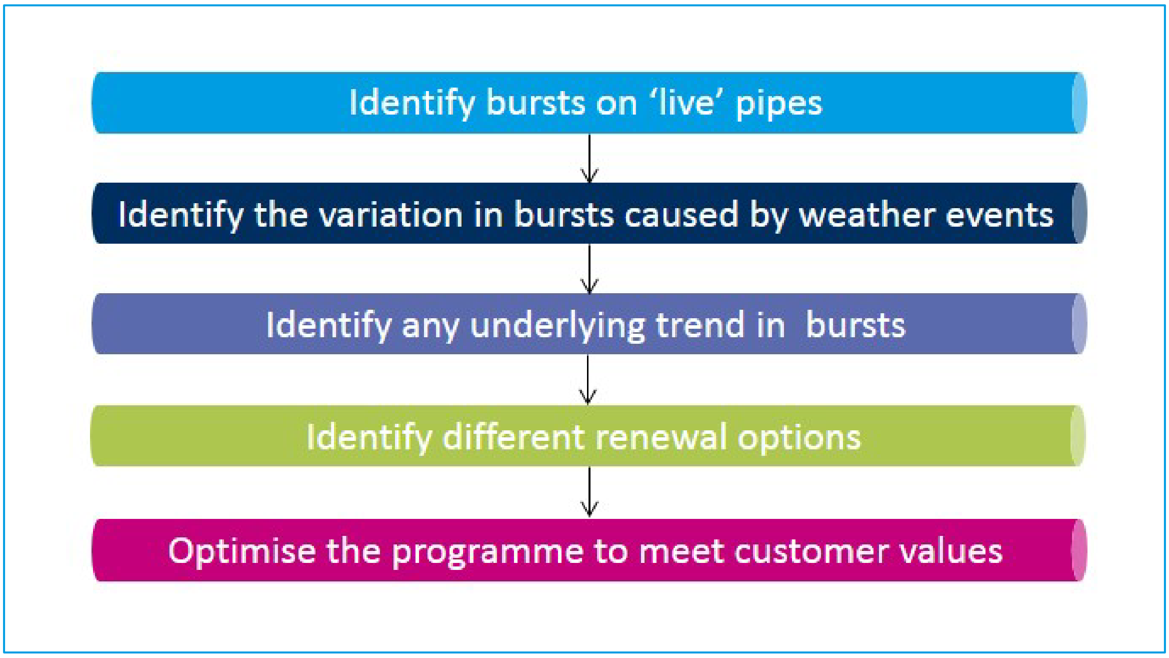
The number of bursts on the network is used as a proxy for mains condition. We hold a reliable dataset of bursts that have occurred historically across our pipe network. The data cover 22 years in our South Staffs region and 29 years in our Cambridge region. These datasets provide an excellent basis for producing robust deterioration models.

The number of bursts that occurs on a pipe is influenced by multiple factors – there are pipe specific factors and more external factors such as environmental and operational influences. Pipe specific factors include the material of the pipe and the age of the pipe because the material decays over time. More external factors include the weather (temperature and soil moisture deficit

(SMD)[11] in particular). The potential impact of weather influences was observed in March 2018 with the freeze thaw event following the Beast from East. Other influential factors include soil type, bedding condition, traffic loading and network operation such as pressure management.

By analysing burst data and inferring the mains condition from it, we can model its likely deterioration and failure over time. It is this modelling of deterioration that we use to establish the extent of mains renewal required to prevent deterioration, or, improve overall condition beyond its current level. However, because there are multiple factors with the potential to influence burst rates, we need to separate the underlying deterioration in the condition of the pipework from the other external factors, such as the weather, as noted above.

The overall process by which we have undertaken our deterioration modelling is summarised in the graphic below and each step is detailed in turn in the following sections.




Our deterioration modelling process

### 2.4.1.2 Identifying bursts on 'live' pipes

As our burst data dates back to the 1990s, they include information on pipes that are in use currently ('live' pipes), and, information on pipes that are no longer in use (decommissioned) since the dataset began. The primary reason for decommissioning pipes is when they have been replaced under previous mains renewal works.

As we are interested in the mains we will want to renew, we are interested in the burst rates on our 'live' pipes only. Therefore, step one of our process was to identify bursts on decommissioned pipes, and then only consider bursts on 'live' pipes in our subsequent analysis.

[11] Soil moisture deficit (SMD) refers to the amount of water that is stored in the soil.

The overall split between bursts on live and decommissioned pipes is illustrated below for our South Staffs and Cambridge regions respectively in Figure 4 and Figure 5.

In our South Staffs region (Figure 4), a significant proportion of our historic bursts have been on pipes that are no longer in use. What is illustrated also in Figure 4 is the general overall decrease in the number of bursts in our South Staffs region between 2003-2004 and 2015-2016. Since 2015-2016, there has been an increase in the number of bursts.

Figure 4 The number of historic bursts within the South Staffs region split between 'live' and decommissioned mains

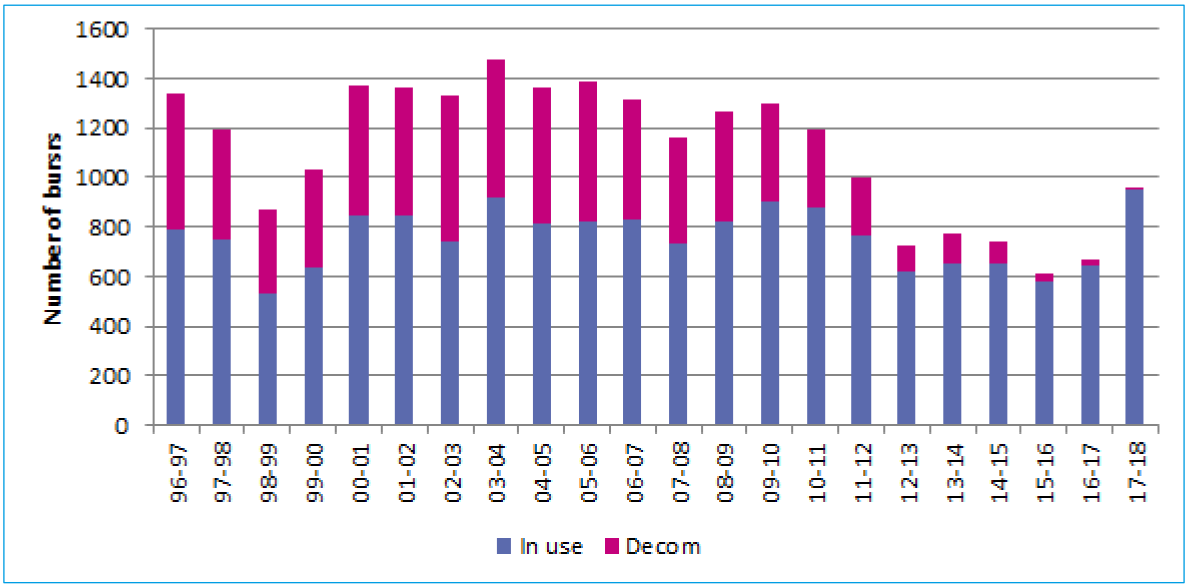
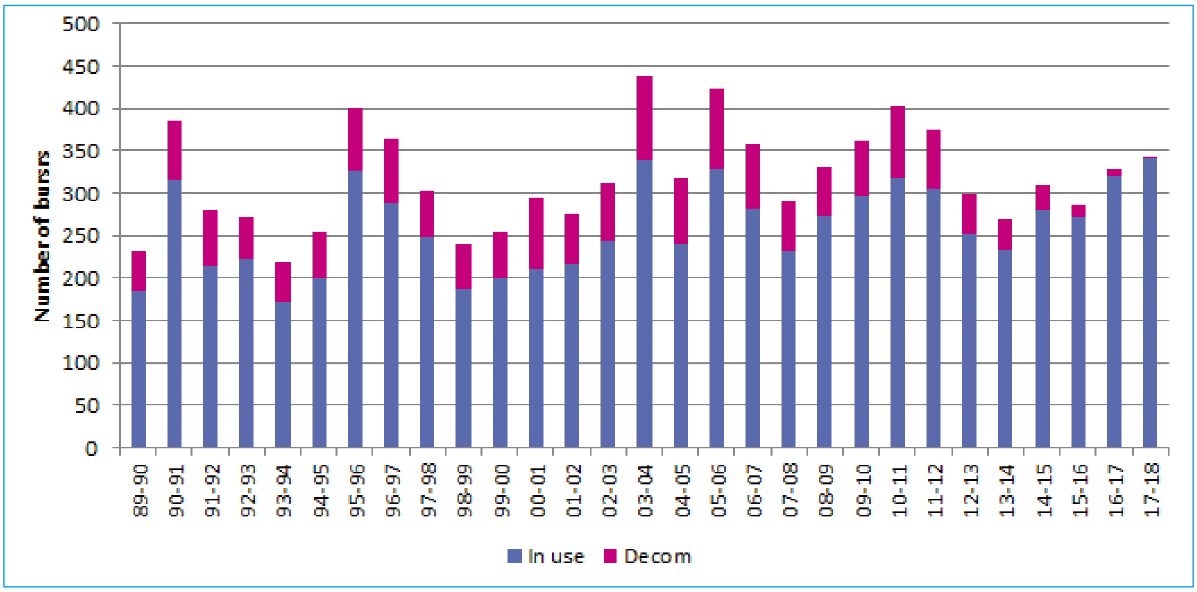



Figure 5 The number of historic bursts within the Cambridge (CAM) region split between 'live' and decommissioned mains



In our Cambridge region (Figure 5), bursts on decommissioned pipes make up a much lower proportion of the total number of historic bursts shown. There is also an underlying general trend of an increasing number of bursts over time.

### 2.4.1.3 Identifying the variation in bursts caused by weather events

The overall decrease in the number of bursts in our South Staffs region between 2011-2012 and 2016-2017 has been attributed to a series of milder winters. This highlights the need to understand the impact that the weather can have on burst rates. Identifying and understanding the external influence of the weather is the second step in our deterioration modelling process. This is necessary so that we can then identify the deterioration that is attributable to decay in the material of the pipes only.

Within our South Staffs region, analysis of the historic burst data indicated that cold weather was a major factor influencing the number of bursts – a marked uplift in bursts with lower temperatures can be seen. This is shown in Figure 6 which compares the monthly average number of bursts and the average monthly minimum temperature.

Within our Cambridge region, analysis of our burst data showed that cold weather tended to be less influential on the number of bursts (Figure 7). In contrast, the number of bursts tends to increase throughout the summer months which (in conjunction with using industry knowledge) has been attributed to the increase in SMD that occurs throughout the summer months.

Understanding these different trends has enabled us to strip out these more external factors and focus on quantifying deterioration as a result of the decay in the material of the pipes only (Section 2.4.1.4 below).

Figure 6 Average monthly bursts and average minimum temperature April 1996 to March 2017 in our South Staffs (SST) region

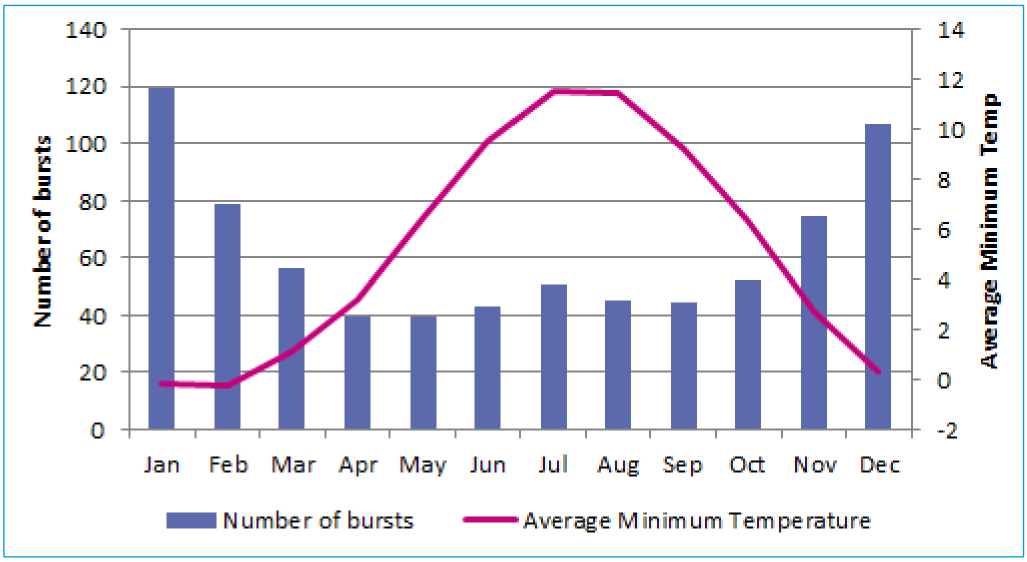
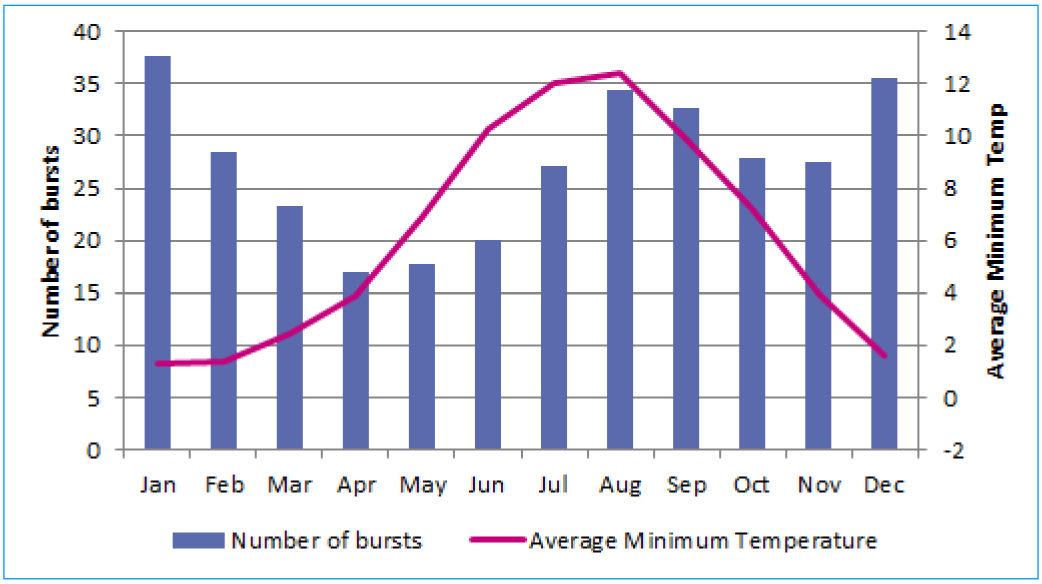


Figure 7 Average monthly bursts and average minimum temperature April 1996 to March 2017 in our Cambridge (CAM) region




### 2.4.1.4 Identifying any underlying trend in bursts

Step three of our process is the point at which the underlying trends in bursts attributable to decay of the material of our pipes can be assessed. The rate at which pipe material decays is highly dependent on what the material is as outlined in Section 2.4.1.1 above.

We have regional differences in the dominant pipe materials of our networks, and therefore, different emerging trends in deterioration. Our South Staffs region has a high proportion of cast iron mains whilst in our Cambridge region, there are a greater proportion of asbestos cement (AC) pipes. Broadly speaking, cast iron pipes are more prone to bursting in winter whereas AC pipes are more prone to bursts in summer.

To strip out the burst data attributable to deterioration of the pipes themselves, we sub-divided the networks into 'cohorts' consisting of mains of similar characteristics such as material, diameter and their surrounding soil type. We then undertook regression analysis[12] on each cohort to establish the relationship between bursts and other potentially influential factors within the cohort, for example, age and where appropriate, SMD. The regression analysis relating to pipe specific factors was then taken to represent the deterioration rate of that cohort.

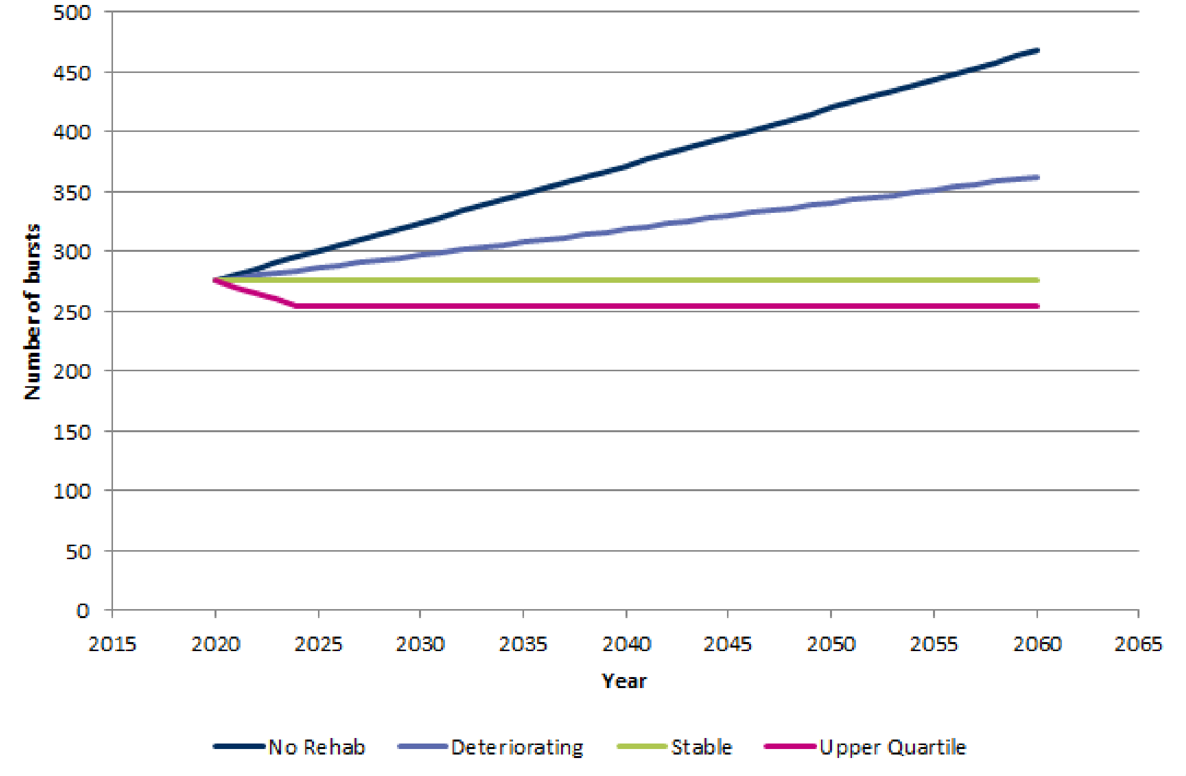
### 2.4.1.5 Identify different renewals options

Step four of our process was then to establish our potential options for mains renewals. We did this by adding the predicted deterioration rate (the annual increase in the number of bursts) to the current burst rate to give a picture of what the burst rate would be like in the future in the absence of any mitigation - in the absence of us undertaking any mains renewals activity.

[12] Regression analysis is the process by which the relationship between two factors is quantified so that it can then be used to model the relationship over a period for which data are not available.

We then modelled how much mains renewal activity we would have to undertake (in kilometres) to prevent any deterioration (maintain the current level of service, also referred to as a stable level of service) and then to improve burst rates to achieve upper quartile performance within the industry. We modelled these scenarios by simulating the effect of replacing the mains cohorts that had the highest burst rates within each year. Figure 8 shows an example of the modelled number of bursts by renewal scenario.

Figure 8 Number of bursts with different renewal scenarios in our Cambridge (CAM) region




### 2.4.1.6 Optimise the programme to meet customer values

The final stage of our process was to feed the options for the different extent of renewals activity into our investment optimisation process. The options were evaluated in terms of the likely effect each renewals activity option would have on our performance commitments. In the context of mains renewals, the main performance commitments affected are discolourations, unplanned supply interruptions and leakage. The number of potential customer contacts and cost of repairing mains should they burst were also factored into the cost benefit appraisal.

### 2.4.1.7 Scheme selection

Scheme selection is the process by which we then decide where we will undertake our mains renewals activity. As outlined in Section 2.4.1, this process does not feed directly into our price review planning process but instead, is undertaken within the planning period itself when it comes to deciding exactly which mains to renew.

At this stage, factors in addition to the deterioration rate of the mains we have modelled must be considered, in particular, the cost effectiveness of renewing the pipes with the highest rates of deterioration as identified by our model. Ranking pipes based solely on their deterioration rates can result in a large number of short lengths of pipe that are spatially distributed over large distances being identified as the highest priorities for renewal. This presents challenges relating to cost effectiveness because the cost per metre of new main comes down if more metres within the same place are being renewed.

Also, renewing multiple, spread out short lengths of mains creates the potential for the problem of bursts just to be moved elsewhere – to the pipes directly around the renewed main. Therefore, we have to consider larger scales of replacement to ensure the benefit of renewal is realised whilst maintaining cost efficiency. However, where we know there are smaller, particularly problematic lengths of pipe that do burst regularly, we do ensure that our scheme selection process does not overlook these. At this stage, we especially value the input and experience of our operational colleagues – workshops undertaken with them have been fed into our process (Section 2.4.6.4).

We use our Geographical Information System (GIS) to spatially assess the mains burst data and identify mains renewal schemes. A scheme will be targeted to a deteriorating length of main as identified by the model but we then assess the lengths of main around the deteriorating main where there would be additional benefit in renewal. This process is achieved on a case by case basis, working outwards from a concentration of bursts and assessing the condition of the surrounding mains – again indicated by burst data and pipe specific factors such as material and age. By overlaying other datasets onto the GIS as well (such as water quality and leakage), we also look to select schemes that could offer additional service benefits.

To maximise cost efficiency, we are exploring options to align mains replacement with other interventions such as replacing supply pipes at the same time as replacing associated mains. This can provide additional benefits such as improved water quality, improved pressures and reduced leakage. In addition to this we are looking to encourage meter optants whilst we are doing mains rehabilitation works.

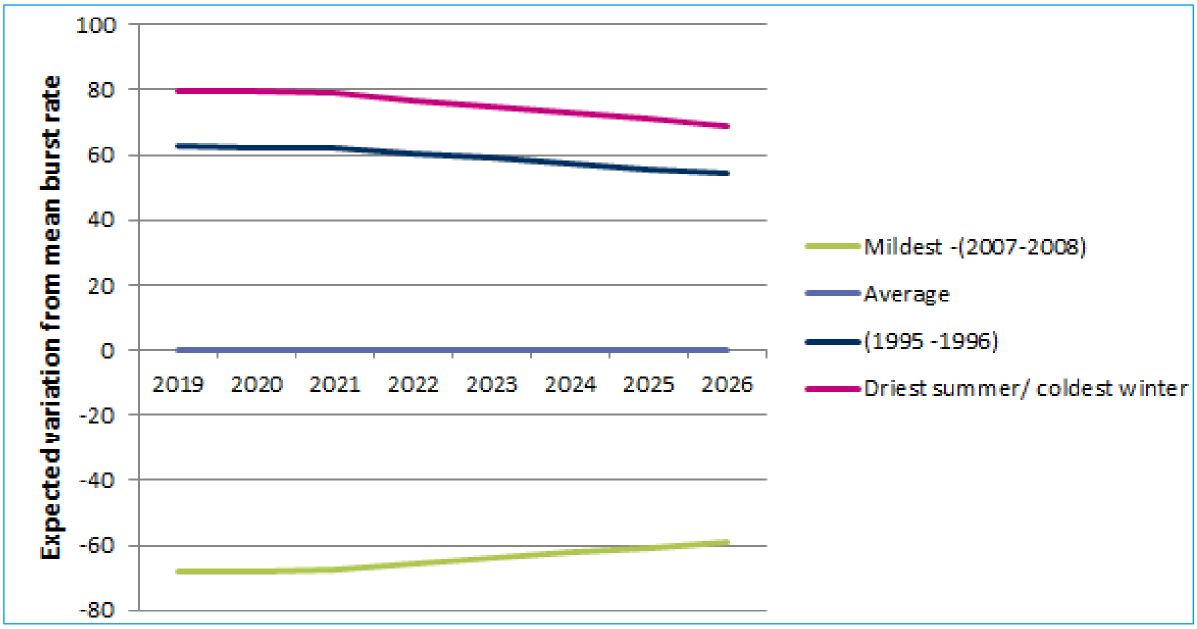
To address these limitations of the cohort model, within GIS we have identified connected pipes with the materials that have the highest burst rates (such as Asbestos Cement, Cast Iron and PVC). The deterioration rates of the cohort model were applied to these connected pipes in order to anticipate the burst rate of these schemes in the future.

The analysis showed that by targeting the specific schemes with the higher burst rate we could potentially reduce bursts and hence provide an enhanced service for the same cost, with the exact extent dependent on the scheme size.

#### 2.4.1.8 Sensitivity testing involving weather conditions

The proposed rehabilitation option was simulated with a range of weather scenarios, in order to assess the resilience of the network in different weather conditions. An example of the variation expected is shown in Figure 9. The graph shows that by replacing mains there will be a decrease in the number of bursts in a cold winter and a dry summer. This is because we are replacing mains that have a tendency to burst in extreme temperatures and replacing them with mains that are less prone to bursting in extreme temperatures. This makes use more resilient to extreme weather events.

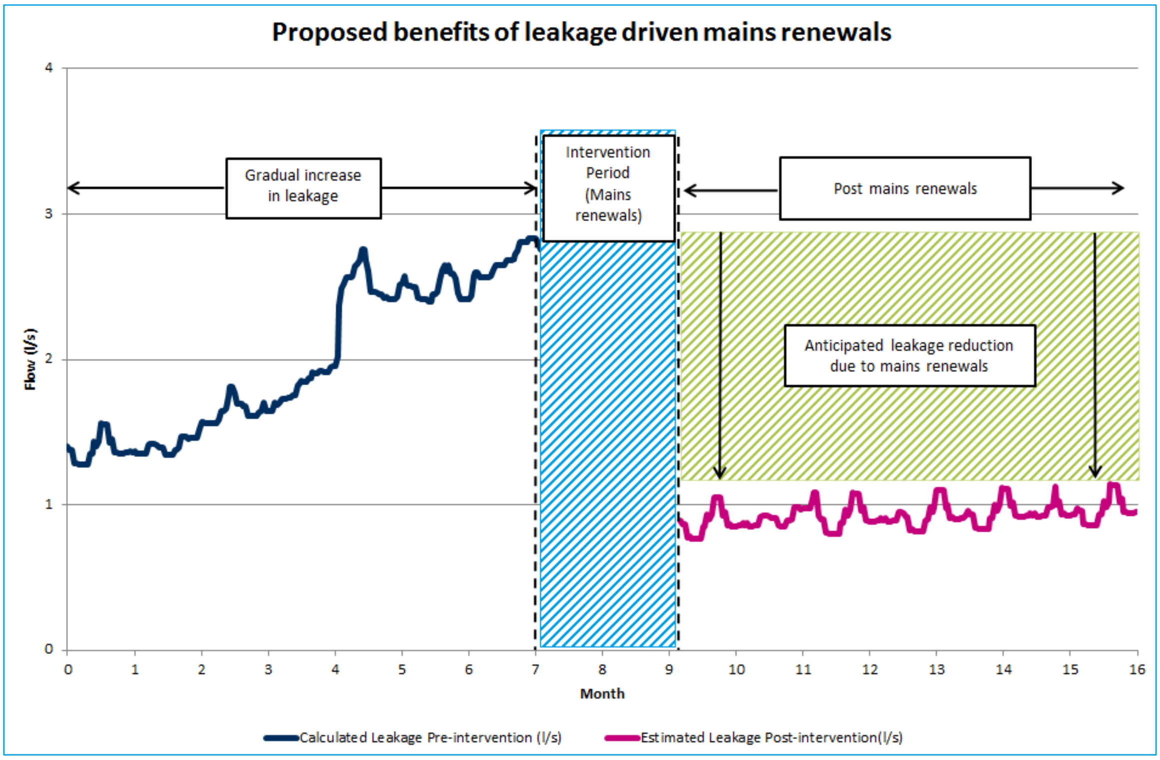
Figure 9 The expected variation of bursts with different weather profiles (Cambridge region)




## 2.4.2 Mains renewals (leakage based)

As well as replacing mains due to a high burst rate, we are also looking into replacing mains with a high level of background leakage. By replacing the mains we will benefit from reducing the leakage as well as reducing the costs associated with detecting and repairing the leaks. An example of the proposed benefits of mains renewal is shown in the following graph (Figure 10).

Figure 10 Proposed benefits of leakage driven mains renewals




## 2.4.3 Condition based assessment (non-infrastructure assets)

### 2.4.3.1 Storage unit inspections

Our service reservoirs and towers play a vital role in the service we provide to our customers. By storing wholesome water within the network they provide a form of local resilience and, depending on their location and relative elevation, also contribute to pressure management.

These long life assets have, by their nature, a low likelihood of failure, however, it is essential that we maintain these assets in a condition where structural integrity is upheld and wholesome water can be stored without risk of water quality contamination.

We implement a regular inspection and cleaning programme across our storage assets. The frequency with which we clean and inspect our service reservoirs and towers is dependent on the level of risk associated with each unit. We generally inspect our groundwater source service reservoirs and towers once in each five yearly planning period, and our surface water source service reservoirs annually. We may, however, choose to clean and inspect a storage unit more frequently should this be deemed necessary, for example, if water quality data indicate signs of deterioration, or if the unit is of particular strategic importance.

During each inspection, a risk based condition assessment is completed. Various components of a storage unit are scored against standard descriptors. The risk based assessment is then used to identify maintenance needs spanning various timescales dependent on the level of associated risk. For example, some may require immediate attention before the storage unit is returned to service, others may require attention in the following business planning period or beyond. The risk based recommendations made from our inspection programme undertaken to date that fall within the period 2020-2025 were used to form a programme of proactive maintenance for our storage assets.

#### 2.4.3.2 Failure data

Maintaining the accuracy of flow meters is essential to monitor the transfer of water and determine accurate leakage levels, manage variations in demand and to monitor flows for water quality purposes. Similarly, maintaining the control valves can reduce burst mains and manage the transfer of flows for water quality purposes, respond to the fluctuations in demand and unplanned emergencies. Therefore, on-going investment in these assets will help us to be more resilient to sudden fluctuations in demand.

Historic failure data related to strategic control valves has been used to give an indication of the level of risk with age. This has been used in conjunction with hydraulic analysis to assess the potential consequences of valve failure.

### 2.4.4 System and asset supportability (non-infrastructure assets)

#### 2.4.4.1 Background

Whilst asset condition or perceived asset condition (inferred from failure data) are commonly used to ascertain future maintenance requirements, a key consideration is asset supportability – if an asset fails, can we fix it, or replace it, or find a suitable alternative? And, can we do this within a timescale that does not affect our level of service?

Over the last 25 years our pumping stations and treatment plants have become more complex and, alongside a drive to improve operational efficiency, we are becoming ever more reliant on our operational technology (OT) assets – our control systems and the automation of our processes. We have an extensive control system asset base which enables us to monitor and control our sites. These assets have long asset lives and fail relatively infrequently, indeed, it is not uncommon to encounter an OT system approaching 30 years of age that still provides a reliable service. Whilst this is, in many cases, is a positive thing, we are increasingly faced with the challenge of supporting legacy systems.

Although risk of failure does tend to rise with asset age, it is not asset age or asset failure which present the biggest risk to our service provision in the context of our control systems. The greatest risk to our service stems from our ability (or inability) to support and maintain our OT assets that are no longer compatible with modern technologies. For example, many of the systems developed in the last decade would have been developed with Microsoft operating systems that are no longer able to run on modern computers. Examples are Windows 95/98 and even more recent operating systems like Windows XP. For many years we have managed this legacy estate with ageing computers or, more recently, newer computers running virtual operating systems that emulate expired operating systems.

Whilst this approach has been sufficient to mitigate the risks of failure of our OT assets to date, the risk to our service of continuing with this approach indefinitely is considered to be high. We have also found from previous experience that a piecemeal approach to maintenance – replacing only specific assets that fail or are no longer supported – presents challenges for operational efficiency and, as such, is not cost effective. We have, therefore identified the need for a more holistic approach to maintenance of our OT asset base to mitigate the risk of equipment obsolescence in the longer term. This approach involves looking across all the OT assets at our sites and moving towards a more proactive maintenance programme that will give us the control to better future proof our investments.

#### 2.4.4.2 Approach

To determine our proactive maintenance needs, we have developed a detailed risk register of our OT assets. Because of the unique risk of system supportability, we have developed a bespoke evaluation matrix with which to assess the level of risk associated with these assets. The risk matrix applied a red, amber, green (RAG) rating to each OT asset in respect to a set of defined risk factors. The risk matrix evaluated factors such as whether the product is still supported, whether we have spares available, a product's ability to connect to our communications network and product functionality. Evaluating such factors gave a measure of the likelihood and rate at which we could respond to a failure of an asset.

We undertook the risk categorisation per OT asset to give an overall assessment of risk across our entire OT asset base. A series of workshops were then undertaken with our OT and Production colleagues where each site and asset was worked through in turn to agree the appropriate course of action for each asset based on the risks identified. Our OT colleagues advised on the asset supportability as outlined above whilst our Production colleagues advised on how critical each asset was to site operation and how our service would be affected – the impact of asset failure. Combining the likelihood of being able to respond to an asset failure with the impact of failure was vital to developing a fully risk based proactive maintenance programme - to ensure that the assets with the greatest risk to our service were prioritised within our plan.

### 2.4.5 Risk elicitation workshops (non-infrastructure assets)

#### 2.4.5.1 Overall approach

A significant part of our bottom up investment needs relating to our non-infrastructure assets have been identified through an extensive programme of internal engagement with our Water Production colleagues[13]. Through a series of workshops, we gathered a lot of information from them about the risks at our Water Production sites, a structured process we termed 'risk elicitation'.

The approach complimented our top down decision making framework and the other bottom up approaches outlined above. Providing a granular level of detail about our assets, risks were considered at an individual asset scale, for example, boreholes, pumps, power generators, dosing equipment and circuit breakers.

Through this approach, we wanted to explore and better understand the risks that exist at our Production sites from our colleagues who operate the assets day-in day-out. The bottom up approach was favoured because:

- we saw the opportunity to capitalise on the invaluable knowledge and experience of our colleagues who work with our assets on a daily basis;

[13] Our water production colleagues are those responsible for the day to day operations of our non-infrastructure assets – those outlined above in Section 1.

- we recognise the need to develop our organisational resilience. By harnessing and documenting our expert's knowledge in a standardised and structured way, we will build up our risk database to use throughout the business in the future;
- we saw the opportunity to combine the risk elicitation outputs with our network resilience modelling (Section 2.3.6) in a more holistic way than we have before;
- we see the importance of engaging our operational colleagues in the business planning process. We recognise that early engagement instils a greater sense of ownership and will pave the way for more effective delivery in the future; and
- the business planning process has identified areas for continuous improvement around the collection, accessibility and usability of our asset data which we are pursuing as part of our ISO55001 accreditation.

The risk elicitation process provided valuable insight to our production sites from our colleagues who know the assets best, and provided information that could not be obtained by using a purely data driven approach.

We started by developing risk registers for our sites. The risk registers provided a structured and standardised means of appraising the risks associated with all processes and assets at these sites. Risks were considered by evaluating the likelihood and potential impact of a particular hazard, leading to an event, that could impact or cause issues with:

- security of supply;
- water quality (biological and chemical);
- water quality (aesthetics); and
- environment.

We know from our customer engagement work that the above factors are important to our customers. But, we also have internal obligations such as those relating to employee health and safety, compliance, security and maintenance of our buildings and facilities – our management and general (M&G) assets. Therefore, we used the risk elicitation workshops to encourage our colleagues to bring forward their knowledge of other potential risks to our operations and business – our resilience in the round. Potential risks identified by our Production colleagues were fed back to our relevant people across the business so that they could consider these risks and bring any additional investment needs forward with respect to our M&G assets. This supplemented the respective asset owners' risk based identification of M&G needs that were undertaken to develop our plan with regard to these central function assets.

During the workshops, we sought qualitative information from our colleagues about their assets through structured questioning and discussion which stimulated them to share their knowledge and experiences. They were encouraged to think about the risks associated with these assets, processes and their operations, for example:

- perceived asset condition;
- asset reliability;
- what action they would take if there was a failure;
- the implications of a failure on our operations; and
- how failures could impact the key areas listed above (security of supply, water quality, environment, health and safety, security, compliance).

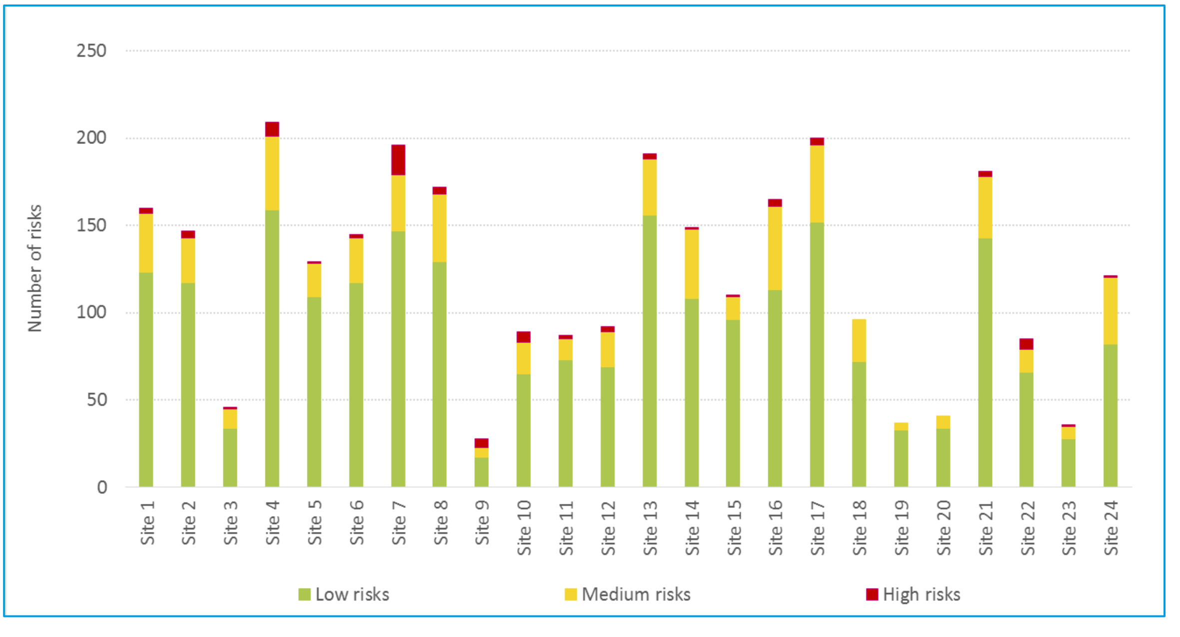
We then asked our colleagues to score the likelihood and potential impact of an event occurring, so we could assign risk scores to each potential risk using a standard 5 x 5 matrix[14]. Scoring was undertaken using defined level descriptors to maintain consistency throughout the process.

During the scoring process, we encouraged our colleagues to think about existing mitigation we have in place at our assets (such as, duty standby operation on pumps) and processes (such as automated site shutdown where water quality parameters may be exceeded). We asked colleagues to score each risk twice - firstly, as if mitigation was not in place, and secondly, accounting for any mitigation we do have. This dual scoring approach provided us with a measure of the value of existing mitigation, identifying areas where mitigation needs to be maintained and highlighting where further mitigation may be required.

The risk elicitation process provided us with a vast amount of data and information. We collated the information and data into a central dashboard where we could easily view and interrogate the information, site by site, process by process, asset by asset and risk by risk.

We went back to our colleagues to share the dashboard and present them with a summary of what they told us. The dashboard also included a number of graphs which were valuable in visualising the overall outputs from the workshops. Three example outputs are shown below (Figure 11, Figure 12 and Figure 13). Communicating the information in this way helped our colleagues to review the data and confirm that the information was representative of the risks they perceive to exist across our asset base.

Figure 11 Example output from our risk register dashboard - number of low, medium and high risks by site




[14] A standard 5 x 5 matrix was applied to derive a risk score. A 5 x 5 matrix multiplies the likelihood of an event (scored 1-5) by the potential impact of an event (scored 1-5) giving an overall risk score 1-25.

Figure 12 Example output from our risk register dashboard for a groundwater pumping station - maximum risk score identified by process (one site)

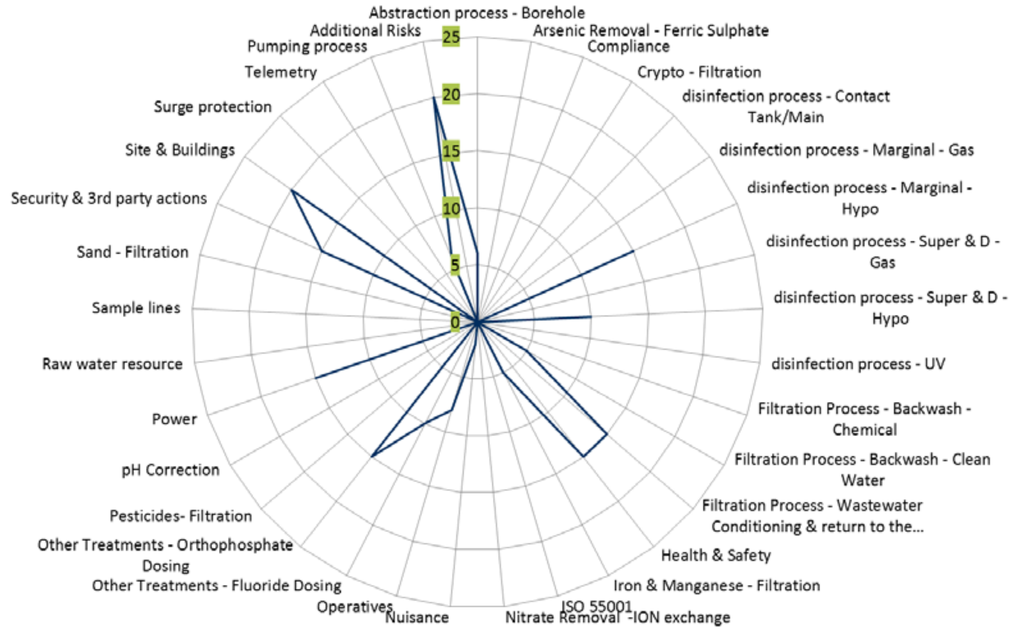


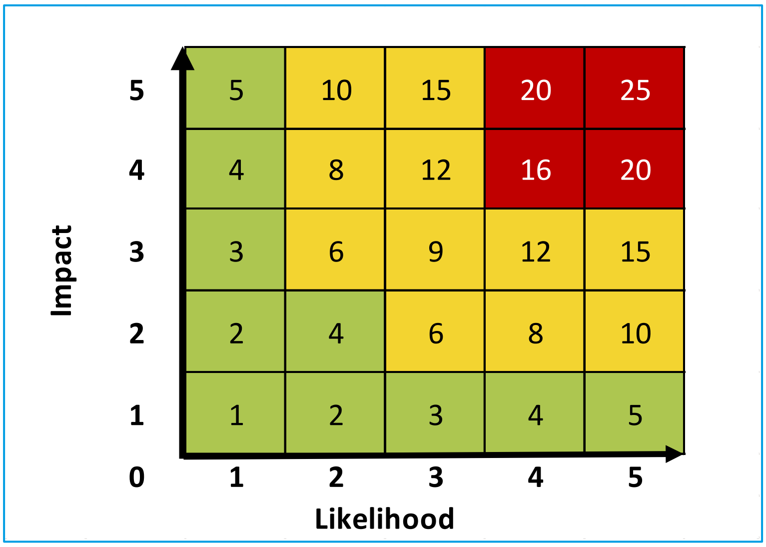

Figure 13 Example output from our risk register dashboard for a groundwater pumping station- maximum and average risk score identified by impact area (one site)

The scored risks (after existing mitigations were accounted for) were separated into High, Medium and Low risks as per the categorisation in Table 3 and the matrix shown in Figure 14 below. Further workshops were then undertaken to consider the high and medium risks in further detail.

Table 3 Categorisation of risk into High, Medium and Low risks

| 5 x 5 score | Guidance | Action |
|---|---|---|
| **1-4** | Low risk | Monitor and maintain mitigations |
| **5** | Extremes – be aware of the risks | Monitor and maintain mitigations |
| **6-15** | Medium risk present | Develop plans to reduce risk level where possible |
| **16-25** | High level risk present | Take immediate action to eliminate/ reduce the risk |

Figure 14 5 x 5 Risk matrix separated into High (red), Medium (amber) and Low (Green) risks

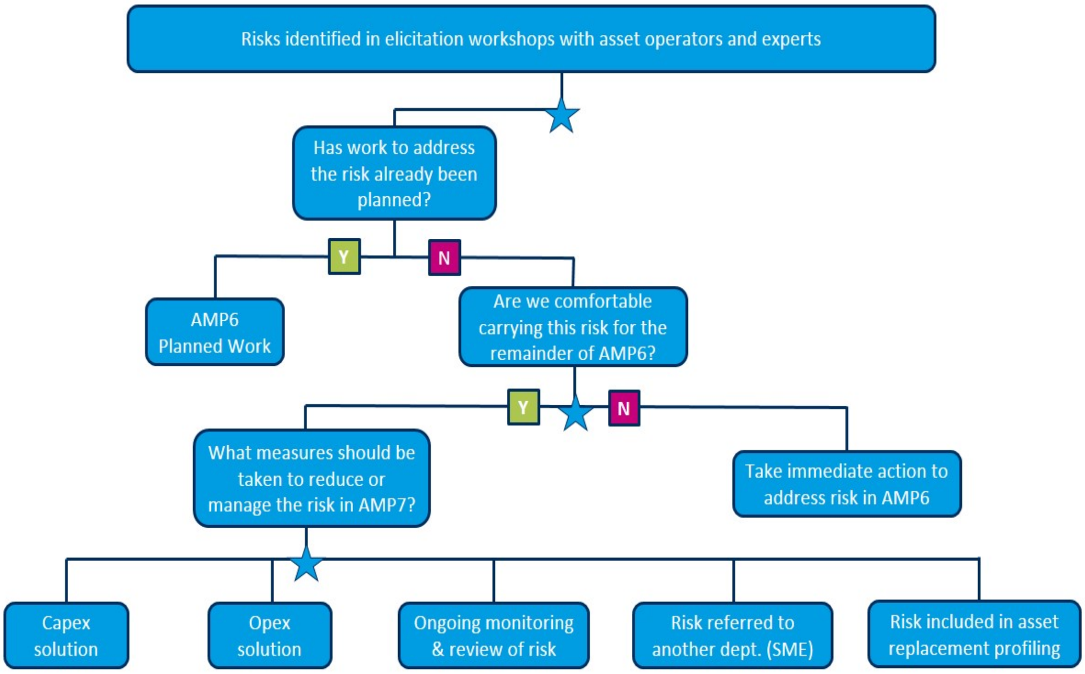



During these workshops, the high and medium risks were reviewed in turn following the process summarised in the graphic below. The process followed in these workshops took us from the identification and quantification of risk through to the identification of solutions to feed into our business plan.

We outlined in Section 2.2 above that our approach underwent series of challenge to give a validated and supported plan of the highest priority investments. The stages at which the risk elicitation process underwent internal challenge are highlighted on the graphic below. Internal validation at these stages was key to ensure that:

- all risks were captured;
- there was wider agreement regarding the likelihood and consequence of each risk;

- that the level of risk the business was willing to carry was agreed by all stakeholders; and
- the solutions proposed were the most appropriate mitigating actions to take to minimise the risks identified.




Risk elicitation process, risk identification through to solution identification (Y = yes, N = No, star = internal challenge)

#### 2.4.5.2 Appraising the costs and benefits of proposed solutions

All solutions as identified by the above process were then fed into our investment optimisation process with their costs and benefits. Costs included Capex and any associated Operational Expenditure (Opex) – whether this be an increase from current or a saving. We determined benefits in relation to our performance commitments, comparing service levels with and without investment. The performance commitments primarily associated with our source stations were centred around, deployable output, water quality and unplanned outage whereas the performance commitments associated with our booster stations were more centred around supply interruptions (no waters and loss of pressures), or, loss of deployable output where our ability to transfer water around our networks would be affected.

### 2.4.6 Risk elicitation workshops (infrastructure assets)

#### 2.4.6.1 Trunk mains

Trunk mains are a key part of the distribution network and failures can potentially have large scale consequences, such as long duration supply interruptions, road closures, property flooding and damage to third party infrastructure. The strategies for managing the risk include:

- surge protection;
- cathodic Protection;

- pipe bridge maintenance;
- pressure Management;
- condition Monitoring;
- mains renewals;
- alternative feeds;
- service reservoir storage;
- maintenance of valves and fittings;
- metering and control valves; and
- alternative supplies.

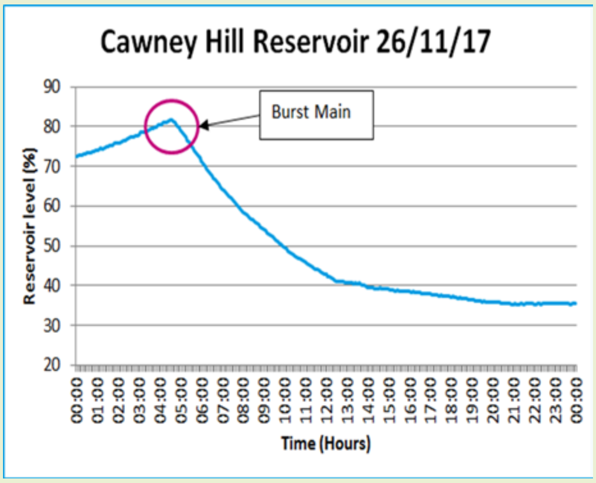
#### 2.4.6.2 PVC mains

Within the South Staffs region we have been renewing large diameter (9 inches or greater) PVC (Polyvinylchloride) mains since AMP5. PVC pipes have the highest burst rates of all the large diameter mains. They also have a tendency to split longitudinally, which results in longer repair times and so customers could potentially be without water for a longer period. Bursts on PVC mains can also cause considerable third party damage. We considered options to replace varying proportions of PVC mains during AMP7 to balance the risk against the affordability of bills.

#### 2.4.6.3 Steel/ Cast Iron Trunk Mains

The options for renewing Steel and Cast Iron trunk mains were obtained from a meeting held with network operations. The proposed mains that were identified for renewal were identified through a combination of asset health, burst rate and consequential damage. An example of one of the schemes highlighted is shown in the following Coneygre Booster case study.

**Case study – Coneygre Booster**




Coneygre Booster is the main feed into the Cawney Hill Supply zone. On 26 November 2017 a burst main occurred at the junction of Coneygree Road and Sedgley Road East, which caused considerable third party damage (£110,000 repair cost). The excavation identified a 3m split on the 18 inch main installed in 1949.

We received a total of 117 contacts which we could attribute to this burst main for either 'No Water', aeration or discolouration.

Due to the amount of water lost prior to the isolation of the burst main the levels in Cawney Hill reservoir reached as low as 35%. Isolation of the 18" main also resulted in a constraint on the volume of water that could be pumped from Coneygre booster to Cawney Hill reservoir. Thus, if the demand was in excessive of average conditions then there would have been an increased risk of emptying the reservoir, causing further widespread discolouration and approximately 13,000 properties would then have been without water.

### 2.4.6.4 Small diameter mains

In January 2018 numerous operational risk and resilience workshops were held with Customer Liaison Officers, Team Leaders and their line Manager. The objective of these workshops was to elicit from local experts any operational and supply risks that are either present at the moment or are likely to pose a risk in the future. The majority of the issues that were raised emanated from "what if" failure scenarios whereby supplies to customers were compromised, both in terms of response and recovery, upon the failure of a distribution main within the vicinity of population centres.

Capital solutions were identified to mitigate the impacts and ensure that the service to customers would continue via alternative feeds, thus providing additional resilience and security of supply. In some instances the proposed solutions also reduced the level of consequential damage that would be likely to occur, as well as improving water flow and quality, thereby reducing the likelihood of increased turbidity levels to customers.

In total some 14 individual investment solutions were identified and a desk top study, combined with hydraulic modelling, identified that an estimated 1,250 customers could benefit from these investments.

## 2.5 Investment optimisation

Having defined our top down and bottom up approach to identifying both our investment needs and potential solutions to address them, we wanted to ensure we adopted a balanced and transparent process in generating a final investment programme. And we wanted to visibly and consistently link our decision making in this regard to both customer and business requirements using an approach which balances service and cost.

So we updated and refined our existing investment optimisation process to align with our risk based approach to understanding our investment needs outlined above in Sections 2.1 to 2.4. The key components of this process are set out below.

### 2.5.1 Solution Manager

Working with Hartley McMaster, we developed an application called 'Solution Manager'. Utilising Microsoft SQL Server as its database management system, this allowed us to capture the detail within a consistent framework of our investment needs and solutions over a 40-year planning period and quantify them in terms of:

- **estimated costs**; initial capital outlay and forecast maintenance expenditure, impact upon operational expenditure of the investment and also any grants or contributions associated with either of these.
- **estimated benefits to customers**; service measures defined in terms of risk (frequency of failure, quantity by severity level) or in terms of absolute performance.
- **the timing of the investment**; important in relation to both a deliverable profile and its impact upon customer bills
- **estimated uncertainty** around the need for and cost of investment; and
- **dependencies** between proposed investments, that is, where we outline the interdependent nature of certain investment solutions within our decision making

We considered it important that we did not constrain the number of either investment needs or associated solutions that we were bringing into Solution Manager. We were keen to encourage innovative thinking in terms of how we continue to deliver the efficient service our customers expect and pay for, both now and in the future. To this end, we generated around 450 investment needs and 1,450 solutions to potentially address those needs. We also recognised within our approach that it was important to quantify and include a 'do nothing' position for our needs, to understand the relative benefit of proactive investment, and in terms of being a fundamental base position within any cost benefit analysis.

Running Solution Manager on a dedicated server has also allowed the cost assessment team across both our South Staffs and Cambridge regions to capture needs and solutions as they arise from the risk elicitation process, allowing ease of updating and refining information such as improved accuracy around costs, and governance in the form of version control.

## 2.5.2 Deriving costs

We have determined the costs associated with each of our proposed investments through a number of different means. We have followed a defined hierarchy for determining the cost associated with each investment. There are three approaches within the hierarchy - the first, most preferred approach, has the highest level of certainty associated with it. The costing approaches we have used to determine our capital expenditure, in order of preference are as follows:

- costs obtained either by internal or external experts based on a more detailed design scope of the proposed scheme;
- costs based on recent purchase or undertaking of the same or similar scheme; and
- costs modelled using an industry recognised tool such as TR61[15].

In the case of each investment, the costing approach we have used is considered to have been the best available for that particular instance. Whilst the preferred approach is to base costs on a detailed design scope of the proposed scheme, it is not always reasonably practicable to do this - the scope of a scheme may require further definition nearer the time of the investment, for example, because it is dependent on factors yet to occur, or, the scheme may be small and as such, the associated level of expenditure may not require such an extensive and detailed costing exercise. For this reason, we have used a combination of the above three approaches to determine our Capex needs for the period 2020-2025 and beyond.

We have ensured that the costs underpinning our plan are robust. We have done this by using the most detailed costing approaches with the highest level of certainty for our most complex and material investments – this includes, in particular, our enhancement spend. For our more 'business as usual' activity (our base maintenance spend), where the costs are less material in the context of our overall expenditure, we have tended towards using the costs of recently purchased or undertaken works and modelled costs. This has given us a level of certainty in our costs that is aligned with the level of complexity and risk associated with our investments.

We assigned cost confidence grades to all investment needs and solutions to ensure we could quantify the levels of uncertainty in our investment optimisation outputs.

## 2.5.3 Valuing service benefit

Underpinning our approach to defining our final investment portfolio is our approach to defining benefit against the service measures we consider are most representative of our customer's needs. These measures were directly informed by our customer engagement research and willingness to pay studies. We also subjected them to internal scrutiny in terms of being aligned with how we deliver our performance commitments. Typical service measures include:

- water quality;
- interruptions to supply;
- water pressure;
- flooding;
- environmental impacts; and

[15] TR61 is a water industry wide recognised cost estimation model.

- customer contacts.

In aligning serviceability improvements with customers' willingness to pay for them, the process adheres to the UKWIR Common Framework best practice for capital maintenance planning[16] and the subsequent UKWIR Framework for expenditure decision-making[17] in justifying totex funding requirements. That is, founded on risk-based principles so that capital maintenance is justified on the current and future probability of asset failure and the resultant consequences for customers, the environment and water service providers, including the costs arising.

Fundamentally, for every solution we enter into Solution Manager, we appraise a pre-investment and post-investment position for both Totex costs and service benefits.

- Pre investment position provides an assessment of the risk to service prior to the investment. The pre risk represents the level of service risk that the business will be exposed to if the proactive investment does not go ahead. This pre-position takes into account the fact that should asset failures occur, then the asset will never remain in a failed state and that some remedial action (usually Opex) will be undertaken to restore the asset to service within a reasonable time frame.

- Post investment position provides an assessment of the residual risk to service once the investment has been undertaken.

We outline below in Section 2.5.4 how we quantify both the cost and service performance change delivered by an investment solution to help us identify a least cost portfolio that best meets our customer's needs.

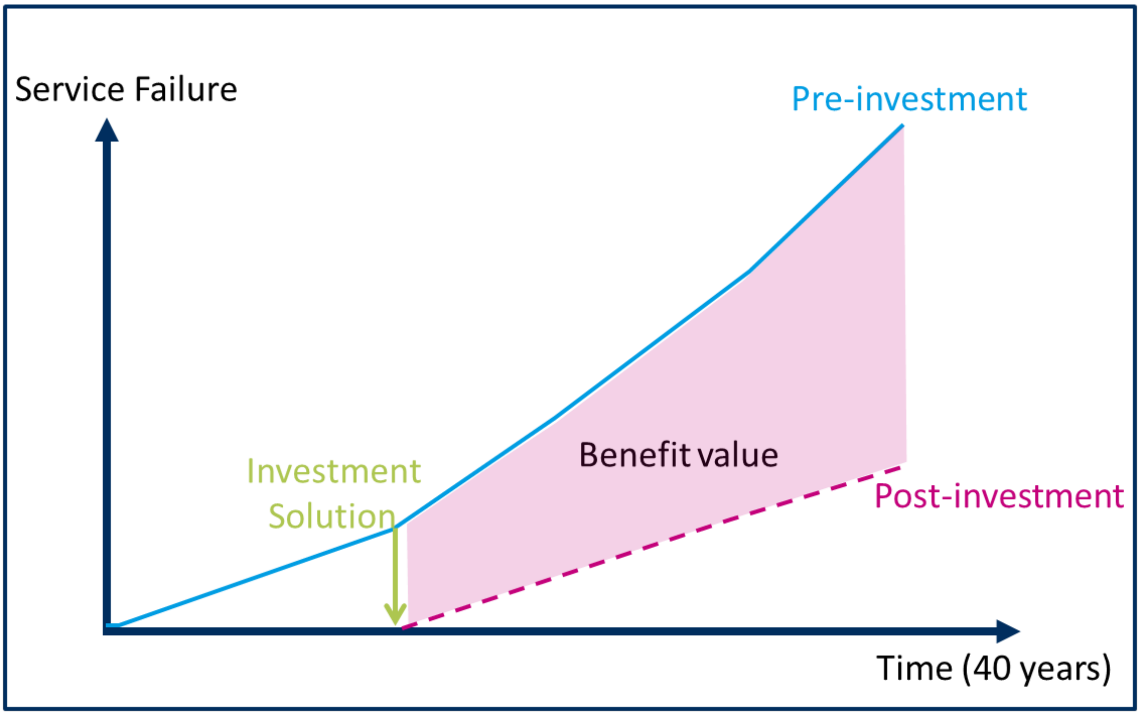
### 2.5.4 Investment Optimisation tool

We developed our Investment Optimisation (IO) tool, also with Hartley McMaster, to carry out cost-benefit analysis of the broad range of solutions captured within our Solution Manager application. Given the data captured around our investment solutions in Solution Manager, the IO Tool functions to provide a common platform to appraise the whole life costs of an investment against the service benefits that investment will provide, in relation to our performance commitments.

The value of the benefit within each solution is the difference between the pre and post-investment position over time, as illustrated in Figure 15 below.

[16] 'Capital Maintenance Planning: A Common Framework' UKWIR, 2002
[17] 'Framework for expenditure decision-making' UKWIR, 2014

Figure 15 Valuing service performance benefit




It does this through the use of a valuation set that ensures that each service measure is valued in monetary terms. This valuation set consists of:

- **willingness to Pay -** the value that customers place on that service improvement e.g. an improved performance in the likelihood of experiencing discolouration or a supply interruption.
- **social / environmental -** the value to society or to the environment of that service improvement e.g. a pollution incident or traffic disruption.
- **private costs of service -** those cost avoided by the business due to the mitigation of service failures e.g. handling customer contacts or issuing boil water notices.

The IO Tool utilises a FICO Xpress optimisation engine to select combinations of investment solutions, attempting to maximise the benefit associated with a chosen investment programme, subject to meeting any cost and performance constraints set.

CBA carried out within the IO Tool produces a Net Present Value (NPV) associated with each scheme, either positive (where the value of the benefits are greater than the whole life costs) or negative (where the value of the benefit isn't sufficient to match the whole life costs), with the IO Tool working to select a combination of investment schemes that produces a plan with the highest net benefit. Prior to implementing constraints, we analysed the production of unconstrained plans to identify not only which investments are purely cost-beneficial and should be undertaken, but also which are deemed to be generating unrealistic benefits or incurring inordinately high negative values. This review provided an initial sense check of the assumptions being made within the CBA, enabling further investigation to subject these assumptions to greater scrutiny and provide governance across the whole process.

With this iterative scenario modelling approach, we were frequently able to involve key stakeholders, in rigorous testing and review sessions to clearly understand the outputs, and ensure the transparency of our decision making. These reviews included extensive sessions scrutinising the inputs and outputs of the process with the independent customer panel, a dedicated sub-group of the panel, and our own Board. In this way, we consider that our final portfolio delivers a good balance between affordability and deliverability.

And to ensure our approach was robust, we applied an appropriate level of governance to the investment optimisation process. We did this by:

- using historical levels of service to help us define our pre-investment decisions;
- documenting our assumptions when estimating service impact, which were reviewed internally and assured externally;
- using our document management system and Solution Manager database to ensure consistency of data;
- engaging with our Board, taking into account their challenges and objectives;
- engaging with the independent customer panel, taking into account its input and challenge; and
- subjecting the approach to external assurance from industry consultants, Jacobs.

We then used our Investment Optimisation (IO) tool to carry out comparisons of different schemes and projects within our overall investment portfolio, valuing every solution both in terms of its whole life costs and its impact against our defined service measures.

Our IO tool works by selecting a combination of investment solutions to maximise the benefit associated with a chosen investment project or scheme. This is subject to meeting the constraints and targets both of our customers' desired service and our business.

This cost-benefit analysis produces a net present value (or 'NPV') for every scheme. Essentially, the NPV is today's value of an amount of money in the future. It is used to calculate the total of all cash flows (inward and outward) linked to a particular project or scheme[18].This is a universally-used financial appraisal method, which enabled us to compare the relative benefit of schemes over a 40-year planning period.

We analysed a number of different scenarios by changing the constraints and targets set within the Investment Optimisation tool. For example, we used a performance constraint to understand the level of investments required to deliver a stretching plan that best meets the needs of our customers.

And we went further, exploring the use of annual constraints and those over the period 2020 to 2025 within our modelling. This was because we looked both at how affordable our proposals were and how we could most effectively phase the efficient delivery of our investment portfolio. This included recognising how the timing of our investment would deliver the flat bill our customers have told us they prefer.

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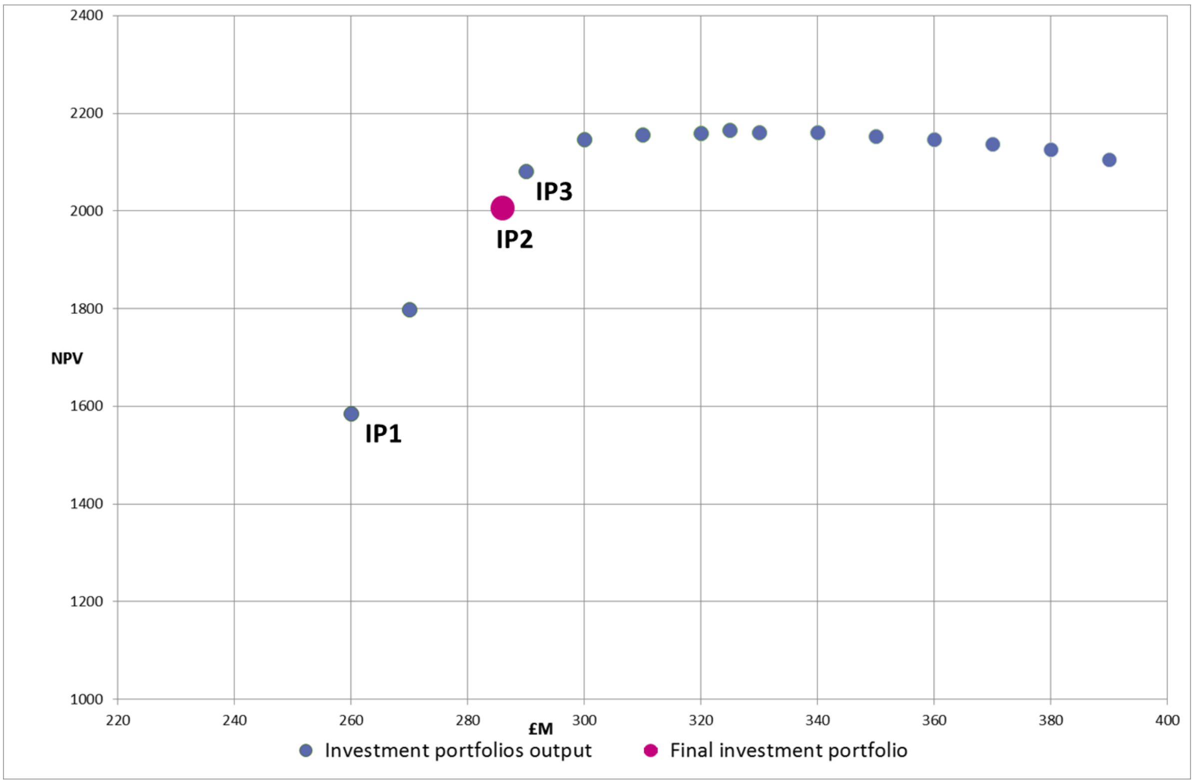
[18] Corporate Finance Institute, https://corporatefinanceinstitute.com/resources/knowledge/valuation/net-present-value-npv/

As a decision support tool, our IO approach allows us to perform many iterations across a number of different modelling scenarios, using cost and performance constraints that must be met in producing a given investment portfolio. We also set dependencies between investment solutions to ensure logical and realistic outputs of the modelling.

We generated portfolios that we could compare between and understand where trade-offs were being made in the selection of investment options. In Figure 16 below, we illustrate the impact of stepped increases in capital expenditure investment and variations in phasing in terms of the overall portfolio NPV.

Figure 16 Generating an optimum portfolio using willingness to pay values




The initial steep profile of the curve illustrates the model being able to select from a wide range of solutions that have been assessed as being highly cost beneficial – that is, Investment Programme 1 (IP1). These investments attract high willingness to pay valuations in terms of their impact against water quality, uninterrupted supply of water to customers and leakage reduction. They include:

- the work to refurbish Barr Beacon, Glascote, St Ives and Cherry Hinton reservoirs;
- the strategic maintenance of our large meter and network control valves;
- nitrate treatment at Ashwood and Cookley-Kinver source pumping stations; and
- increased demand management and leakage reduction.

As the model is run again with increased capital expenditure available, we see it begin to select investment solutions that, while having lower NPVs, still bring additional benefit to the portfolio in terms of a positive impact upon the key service measures that drive us in meeting our performance commitments – that is, Investment Programme 3 (IP3). Example solutions selected here move away from being purely least cost and are more centred on improving our resilience across both our above-ground and underground assets, such as:

- mains duplication in our Winshill zone;
- a new reservoir at Bourn;
- reintroducing water sources at Kingston, Croydon and St Ives; and
- borehole drilling and site refurbishment at Crumpwood.

As the curve begins to descend with capital expenditure above £325m, the model is being forced to bring in those schemes that have a negative NPV – that is, those schemes that are not cost beneficial, thereby impacting adversely on the overall portfolio NPV.

Our preferred investment portfolio is represented by Investment Portfolio 2 (IP2) on the graph. While it is not at the optimum cost beneficial point in the range of investment analysis carried out, following stakeholder review, we considered it to be a good balance between affordability and deliverability whilst achieving the service improvements and resilience that our customers want.

Within this iterative scenario modelling approach we also looked at generated portfolios in context of our cost confidence assessments of each solution. This enabled us to challenge the portfolios around cost certainty and re-engage with the wider business where appropriate. We then involved key stakeholders, who had been integral to all stages of the process up to this point, in rigorous testing and review sessions to clearly understand the outputs, and ensure the transparency of our decision making. These reviews included extensive sessions scrutinising the inputs and outputs of the process with the independent customer panel, a dedicated sub-group of the panel, and our own Board. In this way, we consider that our final portfolio delivers a good balance between affordability and deliverability.

We also looked at the impact of changing the triangulated willingness to pay valuation set on the output portfolio NPV. We are mindful of Ofwat's challenge around the use of willingness to pay at PR14. So we carried out sensitivity analysis to ensure our final optimum investment portfolio is the one that most represents our customers' preferences.

In providing us with a triangulated willingness to pay dataset, we worked with our preferred partner, PJM, to understand a range of sensitivity around the core values. We were able to produce scenarios comparing upper bound, lower bound, package scaled numbers and also a portfolio generated on just private cost beneficial schemes only. The analysis demonstrated that customers value those schemes that ensure secure, reliable supplies and additional resilience. It also demonstrated that higher bound valuations drive the selection of those schemes that improved resilience. We reviewed these choices and included those schemes where they are both deliverable and affordable within our preferred portfolio.

Once we had produced our optimum investment portfolio, we subjected it to further internal challenge and external assurance, to ensure we can deliver it over the period 2020 to 2025. The outputs of our Investment Optimisation tool have enabled us to have informed debate with key stakeholders and develop an investment programme that we are confident will deliver for all our customers now and in the future.

# 3. Our plans for the period 2020-2025 and beyond

This section details our headline investment areas for the period 2020-2025 and beyond – the needs for which have been identified as a result of the approaches we have outlined above. The investments are separated into base maintenance (Section 3.1) and enhancement (Section 3.2).

## 3.1 Base maintenance

### 3.1.1 Non-infrastructure assets

We will invest £85 million net capital expenditure in the base maintenance of our non-infrastructure assets between 2020 and 2025. The main investments driving this spend are summarised in the following sections.

#### 3.1.1.1 Reducing risks to raw water quality

A fundamental part of providing clean, high-quality and reliable water supplies now and in the future is protecting the raw water quality of our sources. The quality of our raw water dictates how effective our treatment processes can be. And compromised raw water quality can result in prolonged outages at our groundwater pumping stations, for instance, if we need to shut a site down until a risk to water quality risk has subsided.

**We will continue to invest in reducing risks to our raw water quality** through a number of means which include:

- continuing our rolling programme of foul drainage inspections and remedial works at our groundwater pumping stations;
- undertaking improvements to our delivery areas at our groundwater sites to ensure the risk of spillages are further reduced;
- making improvements to the headworks on some of our boreholes; and
- relocating some of our septic tanks above ground so we can more easily monitor and manage the risk they pose to raw water quality.

#### 3.1.1.2 Continued borehole maintenance programme

Our boreholes provide the means by which we abstract groundwater. In our South Staffs region, boreholes provide approximately 40% of our customers with water. In our Cambridge region, all of our customers are supplied by groundwater from boreholes. Therefore, any problems with the operation of these boreholes puts at risk our ability to keep our customers' taps flowing. As such, it is fundamental that we maintain these assets throughout 2020-2025 and beyond. To do so requires a continued understanding of the current condition of our boreholes.

We started an inspection programme at PR09 and continued this throughout PR14. **We will continue to invest in this borehole inspection programme, undertaking further surveys of our boreholes**. The surveys involve inspections of the borehole chamber and headworks combined with a camera inspection of the full extent of the borehole, and geophysical logging. Following the surveys, we acquire an interpretative report identifying any defects and areas of concern together with proposals for any remedial works. Indeed, in addition to continuing our rolling inspection programme, **we will undertake remedial works that our inspection programme to date has identified as being required**.

**We will also replace three of our existing boreholes - one in Cambridge and two in our South Staffs region**. Our data indicate deterioration of the boreholes. For example, in the case of the two boreholes in our South Staffs region, the extent of their deterioration over time has resulted in a ca. 20% loss of yield. This 20% loss of yield is significant to our resilience and operational efficiency as the boreholes contribute ca. 70% of the supply to meet average demands in their zone, and importing water from adjacent zones is significantly costly.

In addition to all the above borehole maintenance, we **plan to reintroduce three groundwater sources in our Cambridge region**. We consider there to be both base maintenance and enhancement elements to this investment so we have proportionally allocated the expenditure accordingly. As we consider the larger proportion of the expenditure to be enhancement, further detail on this investment is provided in Section 3.2.2.

#### 3.1.1.3 Continued maintenance of pumping and treatment assets

Our pumping and treatment assets require maintenance day-in day-out to ensure that our sites remain operational and that we can continue to supply our customers with clean, high-quality water now and in the future. Throughout the period 2020-2025 **we will invest in a proactive maintenance programme for our pumping and treatment assets**.

Key themes related to our planned investment in our pumping and treatment assets include:

- Full site refurbishments at a small number of aged and deteriorating sites;
- Replacement of aged dosing equipment;
- Contact tank maintenance;
- Installation of fixed air conditioning units where overheating is a cause of site trips[19];
- Replacement of monitors which are approaching obsolescence and will no longer be supported in the near future;
- Replacement of failing control valves or valves that are life expired; and
- Surge vessel maintenance and automation.

#### 3.1.1.4 Inspection, cleaning and maintenance of existing service reservoirs and towers

Continued maintenance of our service reservoirs and towers is essential to our service. We must maintain these assets in a condition that allows wholesome water to be stored without posing risk to water quality and without risk of structural defects that could make the reservoir unsafe to operate.

Maintaining the assets in this way requires us to have a good understanding of their condition which is best obtained through a rolling inspection and cleaning programme as we have undertaken in previous years. As part of our plans for 2020-2025, **we will continue our rolling cleaning and inspection programme on our service reservoirs and towers**.

[19] This has become an increasing occurrence since we invested in necessary security improvements at our assets during the previous planning period under the Security and Emergency Measures Direction (SEMD).

A continued cleaning and inspection programme is extremely important in helping us minimise the occurrence of unforeseen issues or failures of our storage assets.

**We will also undertake proactive remedial works on specific service reservoirs and towers** where the inspections we have undertaken to date have identified risks requiring mitigation within the timescale of 2020-2025. For example, in our Cambridge region, this includes:

- installing new roof membranes at three sites;
- reinforcing floor and wall joints at six sites; and
- applying protective coatings to floors, walls and internal pipework at six sites.

We clean and inspect our service reservoirs which store water from our surface water sources more regularly than our other storage units. This is because surface water has more naturally occurring organic matter, contains treatment by-products and has a greater risk of trihalomethanes (THMs)[20] than groundwater. THMs are becoming an increasing risk for us as we are finding increasing amounts of organic matter in our raw surface water. Further to our catchment management activities that will help to reduce inputs of organic matter to our surface waters (Chapter 5), **we will invest in a reservoir aeration programme to reduce the risk of THMs forming in our affected service reservoirs**.

**We will also return three service reservoirs to supply by undertaking refurbishment works at two and by decommissioning one reservoir and replacing it with a new (bigger) reservoir**. This latter investment is further detailed in Section 3.2 in the context of enhancement spend but it is emphasised that the maintenance-enhancement split has been proportionally allocated (by storage volume) within our plan (30% maintenance, 70% enhancement).

And, **we will undertake the necessary works to maximise our usable storage at our Glascote Reservoir site** as explained in our Glascote Reservoir Case Study in Section 2.3.6.3.

#### 3.1.1.5 Improving operational efficiency

Improving operational efficiency will improve our service to our customers by reducing the time it takes us to respond to events or issues with our assets. By becoming more efficient we will also reduce our operational costs.

**We will continue to mitigate the effects of generally rising energy prices through our pump efficiency programme (PEP)**. Through our on-going programme, we will undertake pump performance tests which detect when pump performance is less than economically acceptable. This test programme enables us to intervene thereafter to improve efficiency.

[20] Trihalomethanes (THMs) can form as water moves through the water distribution system as a result of chemical interactions between organic matter and chlorine – the chlorine residual we are required to maintain to ensure water is safe to drink when it reaches our customers' taps. There is more organic matter present in surface water than groundwater which is why this issue only affects our service reservoirs that store water from our surface water sources.

**We will also continue to invest in site automation technology.** Our operational staff have praised investments we have made recently to automate site processes and, where possible, enable remote operation of our sites. They have found the technology valuable in improving responsiveness to site failures and minimising the time operatives spend travelling between sites. We will continue to invest in the required technology to deliver further operational efficiencies in this regard.

In addition to site automation and pump efficiency, **our predominantly proactive base maintenance programme enables us to manage our risks in a controlled way which will ensure we continue to run an efficient business**.

### 3.1.1.6 Control systems

Our extensive control system asset base enables us to monitor and control our sites. And whilst we make every effort to future proof our investments, we are finding that equipment obsolescence is an increasing driver for capital investment.

We need to be confident that we can respond to a failure in our control system assets, and therefore, **we will invest in a programme of proactive replacement**, targeting unsupported or incompatible control systems where the potential impact on our service is considered high. We will do this to ensure our customers continue to receive the service they expect and pay for.

Whilst our control system assets are directly related to our service, aiding the operation and control of our Production sites for example, they fall within the management and general assets of our business. Further detail on our M&G assets is provided in the following section.

### 3.1.1.7 Management and General (M&G)

Our M&G assets are the supporting assets which enable us to maintain our day to day business operations. They are diverse and perform a wide range of functions across our business. These assets include our IT and business systems - both hardware and software, equipment, vehicles, buildings and facilities, security and our health and safety assets.

We need to maintain investment in these assets to maintain our business capabilities and operational efficiency, and to enable our people to perform their daily duties proficiently so that we can continue to provide high levels of customer service whilst achieving our customers' expectations. Therefore, **we will continue to invest in our M&G assets.** This investment will ensure our levels of service can be capably maintained whilst delivering the long term strategic outcomes of our business.

The investment in our M&G assets includes:

- maintenance of our IT and business system hardware and software;
- maintenance of our fleet – vans and cars;
- maintenance of electronic security assets at our sites such as access control systems, CCTV, intercoms and alarms and, the installation of new CCTV at our storage assets;
- maintenance of our emergency response assets notably those used to provide alternative supplies;

- maintenance of equipment including health and safety equipment, GPS survey equipment, network operations tools and equipment (including those for leakage) and mobile water quality monitoring equipment; and
- maintenance and updates of our networks and water resources models.

## 3.1.2 Infrastructure assets

We will invest £67 million net capital expenditure in base maintenance of our infrastructure assets between 2020 and 2025. The main investments driving this spend are summarised in the following sections.

### 3.1.2.1 Continued mains renewals

As outlined in Section 2.4.1, we need to renew our mains to manage the long term serviceability of our network to maintain our service to our customers. Replacing mains that are at the end of their useful life also contributes to improved resilience, particularly to variability in the weather - be this very cold winters or very dry summers for example. **We will continue to invest in a mains renewals programme, renewing 321 km of our mains network between 2020-2025 – 273 km in our South Staffs region and 48 km in our Cambridge region**. In Cambridge, this includes some renewals of urban/town centre locations which are costly to renew.

To maximise service benefit, our mains renewal programme will target:

- mains with high leakage;
- mains which burst often;
- mains that when they burst have a large impact to customers such as long duration supply interruptions, road closures, property flooding and damage to third party infrastructure;
- mains that are susceptible to bursts in extreme weather conditions;
- mains that are under capacity causing poor pressures; and
- mains that are over capacity causing potential water quality issues.

As such, we are planning some more expensive renewals schemes in our Cambridge region.

**We will also continue to invest in our mains condition monitoring programme** to ensure we continue to collect valuable information regarding the condition of our infrastructure assets.

In the future we are looking at different technologies and approaches that are available to reduce both the number of customers that are out of water and the duration that they are out of water for when we replace mains (planned supply interruptions). These techniques include using line stop valves, use of other fittings and clamps, inserting new valves under pressure to reduce the number of properties affected, squeeze of existing PE pipes and pre sterilising pipes in order to cut down on outage duration.

We are also reviewing the existing working practices and where necessary updating the procedures and training the staff in order to reduce the time that customers are without water.

### 3.1.2.2 Diversions

We are required to undertake mains diversions when requested by a third party, for example by a developer. This may be for new housing developments or road or rail improvements for example.

Much of this cost is covered by the developer requiring the works to be undertaken, however, we do have to pay a proportion of the costs and this is therefore something we have to factor into our business planning process.

**We have included provision for mains diversions within our plan for 2020-2025**. The most significant scheme we have had to accommodate is to divert mains in preparation for the High Speed railway (HS2) and as part of the HS2 project we are looking at opportunities to improve resilience in the future.

#### 3.1.2.3 Miscellaneous

As well as mains renewals and diversions, there are other activities we will undertake on our infrastructure assets to maintain service to our customers. The investment areas include:

- replacing communication pipes where there is leakage, poor pressures and/ or a risk to water quality;
- maintaining air valves to reduce the risk of catastrophic failure of trunk mains and surface water ingress;
- inspecting and maintaining pipe bridges to reduce the risk of long duration supply interruptions and damage to transport infrastructure;
- maintaining cathodic protection to protect steel mains from corrosion, which reduces the risk of bursts; and
- replacing marker posts, chambers and lids, stop taps.

## 3.2 Enhancement

We have identified a range of investment needs that are enhancements, as they either improve service levels or risk, or relate to growth or statutory obligations. We have classified these enhancement investment needs into five work programmes:

- those that improve **water quality** – either due to a change in raw water quality or a change in water quality standards;
- those that improve **resilience** – through mitigating or minimising the effects of an asset failure;
- those required to meet population **growth – supply side** enhancements including new infrastructure;
- those required to meet population **growth – demand side**, including reducing leakage and helping customers use less water; and
- those required to enhance the **environment** – aligned with our Water Industry National Environment Programme (WINEP) obligations.

Of the needs we have identified, we recognised that we needed to undertake a cost adjustment claim for one significant set of treatment works upgrade projects. The detail of this is provided in Appendix 33 of this business plan and so we have not duplicated the information here. This part of our plan focuses on the other enhancement needs we have, where we did not consider a cost adjustment claim was necessary. We have, however, still ensured that we have assessed these investment needs using appropriate gateways.

The gateways we have used are:

- Why is the investment enhancement?
- Why do we need to carry out the investment?
- What management control do we have over the need or delivery option?
- Why is the investment the best option for customers and how are they protected against under-delivery?
- Are the cost estimates robust and efficient?

Through our five work programmes, we will invest £197 m (£139 m net of contributions) in the enhancement of our assets in the period 2020-2025. The further detail regarding the expenditure under each work programme is provided in the following sections.

### 3.2.1 Water quality

The following needs arise from a deterioration in raw water quality, requiring us to install additional treatment processes and undertake activity in our catchments to mitigate raw water deterioration due to specific local conditions over the long term.

#### 3.2.1.1 Major upgrade of surface water treatment works and strategic mains cleaning programme

Our cost adjustment claim for the upgrade of Hampton Loade and Seedy Mill water treatment works, and our strategic trunk mains cleaning programme, falls into this category. The business case for these schemes is included separately in Appendix 33 of this business plan. The summary of these projects is as follows:

Table 4 Water treatment works and strategic mains cleaning enhancement costs

| Investment area | Schemes | Capital expenditure (£) | Operating expenditure (£) |
|---|---|---|---|
| Treatment upgrade | Hampton Loade<br>(Contributions from Severn Trent Water) | £36.6m<br>(-£10.7m) | £2m (net) |
| | Seedy Mill | £30.5m | £1m |
| Strategic mains cleaning | Strategic trunk mains cleaning programme | £1m | £3m |
| | **Total gross**<br>**Contributions**<br>**Total net** | **£68.1m**<br>**(-£10.7m)**<br>**£57.4m** | **£6m (net)** |

### 3.2.1.2 Additional treatment processes to address raw water deterioration

Due to raw water deterioration, we also need to install additional treatment processes into several of our existing groundwater sites in the South Staffs supply region. These schemes are as follows:

Table 5 New treatment enhancement costs

| Investment area | Schemes | Capital Expenditure (£) | Operating expenditure (£) |
|---|---|---|---|
| New treatment to address raw water deterioration | Ashwood | £3.85m | £0.7m |
| | Cookley-Kinver | £3.85m | £0.7m |
| | Somerford-Slade Heath | £4.7m | £0.7m |
| | **Total net** | **£12.4m** | **£2.1m** |

**Why is the investment enhancement?**

These investments are to address raw water deterioration arising from nitrates and chlorthal in the catchments. Additional treatment processes are required to meet our regulatory compliance standards for these sources and to ensure we can retain operational flexibility in our network, which results in additional capital costs and operating costs being required in AMP7 and beyond.

**Why do we need to carry out the investment?**

A number of groundwater sources in our South Staffs and Cambridge regions have high levels of groundwater nitrates as a result of fertiliser use by farmers over several decades. We have installed a number of ion exchange plants across both regions since the early 1990s - three in our South Staffs region and three in our Cambridge region with a fourth currently being installed in 2018. Pesticides also pose a risk to our raw water quality, and in 2014 we identified the presence of an organic metabolite called chlorthal in some of our groundwater sources within our South Staffs region. This is a degradation product of the banned pesticide chlorthal dimethyl that requires treatment to remove it before water is put into distribution.

These factors mean that there are a number of source stations where water quality improvements are deemed necessary - Ashwood, Cookley-Kinver and Somerford-Slade Heath. Our analysis has indicated that we need to invest in the period 2020-2025 to ensure that we continue to provide our customers with the high-quality water they expect and pay for. A summary of these factors is as follows:

| Site | Investment need factors |
| --- | --- |
| Ashwood | • Ashwood is a strategically important groundwater source in our South Staffs region, supplying about 35,000 properties.<br>• Of the four operational boreholes at the site, two have nitrate and chlorthal concentrations above the PCV and two have concentrations below the PCV. We currently operate a blend between these four boreholes to achieve the PCV.<br>• Nitrate and chlorthal concentrations are continuing to rise and we expect that our blend will be non-compliant by 2024. As concentrations rise and our headroom to the PCV reduces, our operational resilience diminishes as we have less flexibility in how we can operate the site and react to day to day demand needs.<br>• We therefore need to install nitrate removal treatment to enable the source to be used in the future. |
| Cookley-Kinver | • Cookley and Kinver are both strategically important groundwater sources in our South Staffs region, supplying about 10% of the region's demand at peak. Failure of either of these sources significantly impacts upon our supply resilience.<br>• The outputs of the two sites are currently blended to ensure compliance with the nitrate PCV.<br>• Nitrate concentrations are continuing to rise and we expect that by 2025 the existing blend will not be compliant with the PCV. The location of these sources and region it supplies means that there are no alternative blend options.<br>• We therefore need to install nitrate treatment at one of the sources to enable the combined sources to continue to be used in the future. |
| Somerford-Slade Heath | • Somerford and Slade Heath are groundwater sources in our South Staffs region, supplying about 11,000 properties. These two sources are locally critical as they supply customers in a more distant region of our supply network which helps manage local water quality.<br>• The outputs of these two sites are currently blended to achieve the PCV for pesticides.<br>• In 2014 we detected levels of chlorthal in excess of the PCV at Slade Health, which required both sites to be taken out of supply due to the blending arrangement.<br>• We therefore need to install treatment for chlorthal at Slade Heath to |

| | |
|---|---|
| | enable the combined sources to return to supply. |

### What management control do we have over the need or delivery option?

The sources listed above are either at risk of not being able to be utilised, or currently unable to be utilised, as a result of raw water quality issues. Over time, we have sought to mitigate these issues operationally where we could which ensured we were providing best value for money to customers and operating efficiently. However, due to further deterioration in the raw water concentrations of nitrate and chlorthal the risk to supply has become too great to deal with operationally, and we now need to invest in additional treatment processes.

### Why is the investment the best option for customers and how are they protected against under-delivery?

We are currently achieving the required PCVs through blending. Whilst this has been sufficient to continue to provide customers with high quality water to date, the emerging trends in concentrations tell us that this approach is not sustainable in the future.

We will:

- install an ion exchange plant at Ashwood. This will enable us to remove nitrate from the raw water so we can supply customers without having to rely solely on another source of water and we can have increased resilience in our operation of the individual boreholes on site;
- install an ion exchange plant at Cookley or Kinver to remove nitrates from the raw water so we can supply customers without having to rely solely on another source of water; and
- install an ion exchange plant at Slade Heath to remove chlorthal from the raw water so we can return both Somerford and Slade Health into supply and supply customers with high-quality water.

We have identified the above solutions as the best option for our customers following our thorough and detailed optimisation process in which we have considered both the benefits to service that the solutions will deliver and the cost of the investment. We considered alternative solutions, however, only the treatment solutions could meet all of the required objectives. Alternative options we considered were:

- reconfiguring our network so we could blend water from different sources, however we found that our network configuration prohibited this, as it would have required extensive main laying;
- catchment management solutions to improve groundwater quality, however this would not provide the required reduction in concentrations within the required timescales; and
- we also considered the installation of a Granular Activated Carbon (GAC) treatment solution for chlorthal, however, our analysis has indicated that ion exchange is a superior solution for reducing chlorthal concentrations.

We have liaised directly with the Drinking Water Inspectorate (DWI) on the raw water quality issues we face at Ashwood and Cookley-Kinver and received letters of support, in advance of formal notices, for the investment in ion exchange plants at these sites so we can ensure that we continue to comply with the nitrate standard for drinking water quality in the future. Please see the letters of support in Appendix 32.

Our enhancement needs for these sites relate to regulatory compliance standards (PCVs) for nitrate and chlorthal which are fully covered by our performance commitment for 'compliance risk index' (CRI). Additionally, local changes to network configuration and treatment processes can result in customer contact due to the changing taste of the water our customers receive. Our performance in this area will be covered by our performance commitment for 'customer contact about water quality', for which we have a significant and stretching target in AMP7.

**Are the cost estimates robust and efficient?**

Our engineers have worked with Costain in the development of both the scope and costs for these projects.

We consider that through competitive tendering, a strong procurement process and deriving economies from packaging these schemes, we can deliver these schemes significantly more efficiently. Therefore we have already applied an assumed efficiency to the Costain costing proposal. Costain's original costings for the three sites were £13.7m and we have applied an efficiency reduction of £3.1m (23%) to these costs before including in our business plan.

### 3.2.1.3 Lead replacement strategy

We have obligations to ensure that we manage lead effectively and plan to reduce it over time. Our business plan proposes the following scheme:

Table 6 Lead replacement strategy enhancement costs

| Investment area | Schemes | Capital Expenditure (£) | Operating expenditure (£) |
|---|---|---|---|
| Lead replacement strategy | Lead replacement strategy | £3.5m | £0 |
| | **Total net** | **£3.5m** | **£0** |

**Why is the investment enhancement?**

We currently manage lead in our distribution network through a combination of lead pipe replacement and orthophosphate dosing. Almost all of our network in both our South Staffs region and our Cambridge region is chemically dosed. The ongoing operational costs of orthophosphate dosing are part of our base expenditure. However, our activity to remove lead pipes as a result of a long term proactive lead removal strategy is classified as enhancement because it is an activity that has resulted from an increasing recognition over time that lead is potentially hazardous to health and, consequentially, the regulatory standards on lead have been tightening over time.

There have been various communications from the DWI regarding lead in drinking water and it is considered likely that there will be a new lead standard in the near future. Currently the drinking water standard of lead is 10 µg/l but it is anticipated that by 2030 the PCV for lead will be reduced to 5 ug/l. Therefore, we have identified the need to work towards this potential future lead standard now, because replacement of lead across our network is a substantial undertaking. We are aspiring to be substantially lead free by 2050 by implementing a long term strategy of replacement of lead pipes across our South Staffs and Cambridge regions.

### Why do we need to carry out the investment?

From the 1970s onwards the use of lead have been prohibited across Europe and the human health risks have been studied extensively and are generally well understood. Those at particular risk are infants and children because lead can have an adverse impact on mental development. Worldwide it is recommended that human exposure to lead is kept to a minimum and lead is therefore controlled in air, soil, food and water. It is now an accepted fact that there is no 'safe' limit for lead in drinking water and a number of countries are considering a tightening of their drinking water lead standards accordingly.

Water companies have invested heavily in orthophosphate dosing schemes over a number of years which reduces the lead concentration within the water. Although this has resulted in big improvements in lead concentrations, it is not the best solution as it treats the symptom rather than the underlying cause of the problem.

Properties built before circa 1970-1972 are likely to have their drinking water supplied via lead pipes and fittings. As a large number of our properties within our South Staffs and Cambridge regions were built before 1972, we have a number of customers supplied from lead communication pipes (which are owned by us) and lead supply pipes (which belong to the property owners). We have identified that based upon the age of our own assets, there could be up to circa 239,000 properties within our South Staffs and Cambridge regions that may have lead communication pipes and supply pipes. Consequently, such a level of investment to replace all these would be beyond funding capabilities during a single five year planning period – this would incur significant expenditure and in turn, impact significantly on customer bills.

### What management control do we have over the need or delivery option?

We do have choices in timing for our lead strategy, however, the likely extent of legacy lead within our network means that we do need to act now to deliver an affordable strategy over the long term. The DWI's view is that orthophosphate dosing is not sustainable in the long term and the aspiration is to be lead free.

### Why is the investment the best option for customers and how are they protected against under-delivery?

In order to mitigate the risks for our customers at the earliest possible opportunity we are adopting a lead strategy which:

- identifies and prioritises vulnerable customers;
- targets higher risk zones in the context of historic levels of lead recorded;
- replaces lead supplies across our network over a number of AMP periods;
- researches into new alternative technologies, such as lining;
- undertakes a customer engagement and awareness communication programme, to ensure customer awareness of the risks of lead and what we can do to help; and
- optimises current orthophosphate dosing.

Over the period 2020-2025, we intend to replace the lead communication and supply pipes:

- of higher risk customers encompassing primary schools and day nurseries;
- at the same time as replacing small diameter high deteriorated mains (pre 1972);
- when the supply pipe, and or communication pipe, is impacting upon levels of service to customers, such as leakage and low pressure; and
- in water supply zones where water quality samples have shown that a high level of lead is present.
- with close collaboration to our network renewals programmes, leakage reduction programmes and meter installation programmes.

Whilst we do not own the supply pipes at customers' properties, we recognise that any strategy that only replaces a portion of the lead would not fully remove the risk to customers arising from the lead. Therefore our approach goes above and beyond our minimum duties to ensure that we maximise the benefit to our customers of our lead strategy. By aligning lead replacement to our related work programmes we maximise efficiency in delivery.

Our current phosphate dosing programme will continue to manage the risks for all our customers in the interim, however, we will also look at the optimisation of our dosing for the purposes of resilience and sustainability.

As lead is a regulatory compliance parameter, overall compliance with standards is fully covered by our performance commitment for 'compliance risk index' (CRI). Our programme does go beyond the minimum requirements, however, we did not consider it necessary to implement a bespoke performance commitment because the strategy contains a wide range of activity and the cost (£3m) is relatively small in comparison to our total expenditure. We will, however, ensure we make customers aware of our activity each year through the summary annual performance report we publish and our monthly performance reporting dashboard. As part of our activity in our strategy to improve communication on lead, we will be adding additional content to our website and we will take advantage of this to ensure transparency of our activity.

**Are the cost estimates robust and efficient?**

Our overall approach is to prioritise the higher risk groups initially as described above, and then ensure that investment is maintained over successive AMPs. It is envisaged that circa 578 vulnerable properties will be targeted across both regions – 289 by 2025 and an additional 289 by 2030. There is uncertainty in our cost estimates for supply pipe replacement as we do not hold asset data on these so we have made estimates of supply pipe lengths, depths and re-instatements conditions, for example.

We will also plan to trial new technologies such as pipe relining as an alternative to pipe replacement which could offer a more innovative solution and improve efficiency of delivery.

#### 3.2.1.4 Raw water quality resource management

We have obligations under the Water Industry National Environment Programme (WINEP) to deliver environmental and water quality related projects which benefit future sustainability. Our business plan contains the following two schemes related to raw water quality management:

Table 7 Raw water quality management enhancement costs

| Investment area | Schemes | Capital Expenditure (£) | Operating expenditure (£) |
|---|---|---|---|
| Raw water quality resource management | WINEP drinking water protected areas | £2.7m | £0 |
| | Catchment management Blithfield/Severn | £1.4m | £0 |
| | **Total net** | **£4.1m** | **£0** |

### Why is the investment enhancement?

The EA sets out measures to protect and improve the environment in the Water Industry Natural Environment Programme (WINEP). We will prevent a deterioration in the quality of the water sources from which we abstract water, which has longer term benefits in helping to mitigate the extent of water treatment required to produce the high quality water our customers expect from us. For AMP7 we have 18 drinking water protected areas (DrWPA) no deterioration schemes in our WINEP - 14 in South Staffs and four in Cambridge - which are all catchment measures related to rising nitrates at abstraction sources.

WINEP is considered as enhancement spend because it is new activity that has not been historically included within our base expenditure, however, WINEP schemes will have been part of our overall expenditure in the past.

### Why do we need to carry out the investment?

As identified above, for AMP7 we have 18 DrWPA no deterioration schemes in the WINEP - 14 in South Staffs and four in Cambridge, all of which are catchment measures related to rising nitrates at abstraction sources. Following previous investigations during AMP5 and AMP6, these schemes will deliver catchment measures such as changes in land use, where it has been shown that rising nitrates could over time be curbed or reduced to avoid the need for treatment, or the replacement of existing treatment.

Compromised raw water quality can lead to outages at our source stations, for example, if we get spikes in poor raw water quality and need to shut a site down until a risk to raw water quality has subsided. This poses risk to our service and therefore, we need to plan to mitigate this. The risk to raw water quality affects both our groundwater and surface water source stations.

We have identified a particular need to invest in catchment management of our surface water catchments – those of Blithfield Reservoir and the River Severn. This is because the raw water quality of surface water is naturally not as high as that of groundwater. By managing the quality of this raw water as much as possible we are trying to prevent issues arising with our treatment processes further down the line. We see catchment management as a means of addressing the cause of a problem rather than just treating the symptom – in this instance, poor raw water quality. Catchment management is, however, a gradual and long term process that can only go so far, and whilst it should help us in the future, it does not negate the need for investment in improved treatment processes in the shorter term.

### What management control do we have over the need or delivery option?

Our proposed catchment management delivery is a mix of statutory requirements and the continuation of existing programmes, the need for each having been identified from deteriorating raw water quality that could cause a breach of PCVs or the need for end of pipe treatment in the future. In order to mitigate this present and future risk, there is a recognised need for the more sustainable approach at a catchment scale to reduce inputs that lead to the deterioration in raw water quality. The delivery options are established methods based on catchment wide programmes to influence changes in land use and ensure best practice, these programmes of measures are options that we have derived based on industry experience and guidance. There is an element of uncertainty in some of the delivery due to the need to engage with third party stakeholders and implement change on land that is not under our direct control.

### Why is the investment the best option for customers and how are they protected against under-delivery?

We are already undertaking catchment management activities within our Blithfield and River Severn surface water catchments and will continue this in the period 2020-2025 and beyond. This constitutes the best option for our customers because it will help to safeguard raw water quality in the long term. Blithfield (which supplies water to our Seedy Mill treatment works) and the River Severn (which supplies water to our Hampton Loade treatment works) are our largest sources. For this reason, we need to do all we can to ensure these sites remain operational and the treatment that we plan to enhance in the period 2020-2025 and beyond will be as effective as it possibly can be.

These schemes are fully confirmed environmental requirements and therefore do not require a unit cost adjustment mechanism. All of our environmental requirements are guided by the Water industry strategic environmental requirements (WISER) published by Defra the EA and Nnatural England. WISER sets out the environmental obligations and expectations that water companies should include or consider in business plans, some of which are statutory requirements and others guided by environmental legislation. In many cases, these are also included in the WINEP, where specific schemes for delivery can be identified.

### Are the cost estimates robust and efficient?

The cost estimates for our proposed catchment schemes are based on AMP6 trial and implementation of our first catchment scale scheme in the Blithe catchment, which has been fully active for two years and is therefore well established. The PR19 proposals build upon these measures and will be of comparable cost. The AMP6 catchment programme overall has been delivered at less cost than originally expected giving us confidence that we are able to deliver the required programme efficiently and allowing us to undertake more activity than originally planned. The manner in which we deliver and target our catchment schemes is also informed by the previous investigations that we have undertaken so that we focus catchment measures where they will be most effective in improving raw water quality at sources where the need for future treatment or treatment replacement can be avoided, providing long-term efficiency in operating and capital costs.

## 3.2.2 Resilience

Customers have told us that having a secure and reliable supply is a top priority for them and it is for us too. We pride ourselves on having resilient supply networks and we strive to improve our resilience at a range of scales – at the asset level; site level; supply zone level and regional level. This approach has resulted in us having diverse and integrated supply systems that we have developed over time in both our regions. Through our combined bottom up and top down risk assessment process, we have, however, identified a number of ways in which we can improve our resilience further to benefit customers and lower risk.

Our resilience work programme covers a number of schemes, all of which have been identified to ensure that we deliver resilient services to our customers in a cost effective, sustainable way.

### 3.2.2.1 Water production asset resilience

At our water production sites, we have identified the need to improve our resilience in relation to power outages, particularly in our Cambridge region. We have also identified the need to invest in the resilience of our boreholes in our Cambridge region to improve supply security.

Table 8 Water production resilience enhancement

| Investment area | Schemes | Capital expenditure (£) | Operating expenditure (£) |
|---|---|---|---|
| Water production resilience | On site power generation | £0.4m | £0 |
| | New (additional) borehole | £0.6m | £0 |
| | **Total net** | **£1m** | **£0** |

**Why is the investment enhancement?**

The investment needs we have identified are new costs that will deliver an improvement in service to customers in the form of lower risk of supply outages or restrictions in the short and long term.

**Why do we need to carry out the investment?**

Our ability to be resilient in the event of asset failure, either caused by equipment failure or external impacts, is critical to our ability to supply customers with a continuous and reliable supply - one of their top priorities. We continually review the configuration of the assets we operate to ensure that they are operationally resilient, and where there is a business case to do so we look to improve on the assets we have, over time, to raise our level of resilience. At the individual site level, this is rooted in ensuring we have sufficient standby provision to be able to accommodate asset failure or external causes.

In January 2017 the National Risk Assessment (NRA) elevated the risk of total electricity shutdown to the very high category to highly likely with the potential for catastrophic impacts. In light of this, we reviewed our regional capability to maintain supplies during a prolonged power outage (up to one week) scenario across both our South Staffs and Cambridge regions.

We forecast likely demand during a power outage. In the absence of electricity, we predicted demand would approximately halve as a result of the inability of customers to undertake certain household activities such as washing machine and dishwasher use. We based this prediction on the relative proportions of different household activities that our existing data tells us constitutes our customers' water usage.

We predicted our supply capability during a widespread power outage, looking at our existing on site power generation, storage volumes and our ability to move water around the network under such a scenario. Comparing supply and demand, we were able to quantify our capability to maintain supplies and identify where we need to invest to improve our resilience.

Our analysis demonstrated a range of potential impacts on our service. For example, our analysis indicated that we could produce sufficient water to meet the likely demand during a widespread power outage, however, moving it around the network and getting it to some customers' taps would not be possible in some instances. This is mainly due to the absence of power generation at a small number of boosters that are required to transfer water into some of our storage assets and a small number of boosters that directly supply customers.

Although the NRA categorised the risk of total electricity shutdown as highly likely, in the context of our day to day operations such an event is low in likelihood but the impact could be significant. Our analysis has identified the need to mitigate the impacts of such an occurrence and this is one of the ways in which we are addressing the risk to our service of low likelihood but high impact events.

Whilst undertaking this analysis, we also took the opportunity to review our resilience at a more local scale, and identify where there may be a need to improve our resilience and responsiveness to less severe, but more likely interruptions to power supplies, as a result of, for example:

- brownouts - a drop in the voltage of an electricity supply. So whilst electricity may not be lost altogether, it has the potential to impact our site operations;
- thunderstorms - we often experience sites shutting down when lightning occurs as a result of brownouts or very short duration loss of mains electricity that tend to accompany these storms; and
- road traffic accidents - we recently lost three of our groundwater source stations in our Cambridge region for a few hours as a result of road traffic accident which destroyed a nearby electricity pylon.

We have also identified that investment is required to improve borehole resilience in our Cambridge region. Three of our largest sites are single borehole sources, which together provide around 30% of our total supply volume in Cambridge region. During a period of average demand the temporary loss of one of these sites as a result of asset failure could be mitigated. However, during a peak demand period the loss of one of these sites would significantly risk our ability to meet our demand. Site outages as a result of borehole issues also tend to be more prolonged than other asset failures. It is also for this reason that we have identified the need to reduce the risk to service by investing in on site resilience.

### What management control do we have over the need or delivery option?

The investment required to mitigate the risk of power outages at our production sites is to reduce the impact of external factors affecting our service and the need for this investment is therefore beyond our control. In just the past few months we have seen multiple power outages due to the weather (thunderstorms) and as noted above, we had an instance of more prolonged local power outage being caused by a nearby road traffic accident.

We cannot influence the cause of these risks, nor can we manage the rate at which mains electricity supplies are restored by third parties. Instead, we have recognised the need to improve our ability to mitigate the impacts of power outage on our service. And, we are mindful that should a widespread regional or national, low likelihood-high impact power outage occur, we should be striving to be self-sufficient.

With regards to improving the resilience of our boreholes, we can manage the risk of failure of our existing assets, and we do so through our base maintenance programme. However, owing to licence restrictions and the location of all our existing infrastructure, we have limited control over where we can site additional boreholes. We also recognise the pressing need to improve our resilience in light of the fast rate of growth that is occurring in our Cambridge region.

### Why is the investment the best option for customers and how are they protected against under-delivery?

Our customers have told us that they expect us to provide a resilient service. Whilst many of our customers may not directly observe an improved service as a result of our investment in resilience, such investment means that they should not experience a reduced level of service when things do go wrong – it is our way of ensuring that our customers will continue to receive the service they expect and pay for under all circumstances.

We currently manage the risk of power outage through our existing on-site power generation capability (generators at a number of our production sites) and through an emergency power contingency plan with an external provider. There is a service level agreement in place with this contract, however, as noted above, we recognise the need to be self-sufficient - particularly if there was to be a widespread power outage during which there would be unprecedented demand on the common resources provided by third parties.

Even in more likely day to day circumstances, we are increasingly recognising that we do not want to be dependent on a third party – we were recently let down in this regard and we do not want to continue carrying this level of risk to our service. It is for these reasons that investing in our own on site power generation capability is the best investment option for our customers.

We have identified:

- sites where we need to invest in on site generators to maintain sufficient water production;
- sites where we need to install an uninterruptable power supply to manage brownouts and maintain the communications between key assets, for example, between booster stations and associated storage reservoirs;
- the need to invest in a small stock of mobile generators that we can deploy when we need to, without having to rely on external resources; and
- the need to invest in electrical works to enable generators to be hooked up quickly, without the need for complex re-wiring so that we can respond quickly to an event.

The above investments will provide us with the resilience we require to maintain our service in the event of power failures. The investments identified are proportional to the associated level of risk to our service. Some sites require a permanent generator on site, most commonly our source stations, so that we can still abstract water, treat it and put it into distribution. At other sites, however, for example a booster station supplying a service reservoir or tower, or only a small number of properties, an improved hook up point where we can quickly deploy one of our own mobile generators is considered to provide the best, most cost-beneficial solution.

To improve our borehole resilience, we intend to drill a new borehole at one of our existing highest output groundwater source stations. This is the best option for our customers because it will make us more resistant to potential failures that would otherwise result in, potentially prolonged unplanned outage. It will enable us to still abstract water and therefore continue to supply our customers. This will be particularly advantageous during peak demand periods which generally carry a higher level of risk to service.

The intended investment in an additional borehole enables us to improve our resilience whilst making use of our existing infrastructure - so by adding to it, we are delivering additional resilience in a more cost effective way than we would if we were trying to establish a new site altogether. Similarly, as we do not intend to increase the amount of water we abstract, delivery will be further eased as we will not be subject to any licence changes.

We have optimised our investments and selected the most cost-beneficial solutions. This process has ensured that the above investments are the best option for our customers - both in terms of the service they receive and the price they pay for this service.

We have a wide range of performance commitments which cover reliability of supply, quality and asset health all with stretching targets over AMP7 and beyond. These enhancement needs are fully covered by these performance commitments.

**Are the cost estimates robust and efficient?**

The costs for these schemes have been developed using a bottom up quantity surveying approach. We have strongly challenged the scopes of the upgrades required, and ensured that we have fully reflected any efficiencies that we are projecting from our framework contracts, which would deliver these schemes, over AMP7.

#### 3.2.2.2 Reintroduction of Cambridge groundwater sources

Our Cambridge region is a high growth region, and in our final water resources management plan we identified that we need to reintroduce three sources into supply to meet our overall supply demand balance. We have not categorised this as growth enhancement because these sources are existing assets, but, we do need to undertake investment to enable them to operate and meet tighter quality standards since the sites were last used.

Table 9 Reintroduction of Cambridge groundwater sources

| Investment area | Schemes | Capital expenditure (£) | Operating expenditure (£) |
|---|---|---|---|
| Reintroduction of Cambridge groundwater sources | Reintroduction of Croydon, Kingston and St Ives groundwater sources in Cambridge region | £2.3m | £0 |
| | **Total net** | **£2.3m** | **£0** |

### Why is the investment enhancement?

The reintroduction of these sources is driven by a combination of both growth, water quality and resilience. Primarily it is growth that is driving the reintroduction of the site, however, as these are existing assets that have not been used in recent years, they are part of the existing infrastructure of our supply network, and hence their reintroduction helps meet our supply demand balance overall and cannot be attributed to any specific area of growth or development. Furthermore, the actual investment we need to undertake to make these sites operational is a mixture of base maintenance and new treatment process to meet stricter quality standards than when these sites were last used. We have proportionally allocated between base expenditure and enhancement for these schemes to properly account for the base maintenance component of the refurbishment.

### Why do we need to carry out the investment?

Since the three groundwater source stations Croydon, Kingston and St Ives were removed from supply (Croydon and Kingston in 2012 and St Ives in 1999), we have been operating with reduced supply resilience.

The three groundwater sources Croydon, Kingston and St Ives were initially removed from supply due to water quality issues. The Greensands Aquifer source of Croydon and Kingston posed particular issues for iron, manganese and ammonia, whilst the risk of microbial contamination at St Ives (river terrace gravel source) could not be economically treated at the time. We were able to mitigate the loss of these sites operationally and maintain sufficient supply demand balance. This meant we did not need to immediately invest in new treatment processes immediately, keeping bills lower for customers.

However, the level of growth being experienced in Cambridge now means we need to reintroduce these sources, and our plans were detailed in our Cambridge Water Resources Management Plan. An additional 4.6 Ml/d of deployable output will be provided helping to meet our supply demand balance in the region.

### What management control do we have over the need or delivery option?

As identified above, these schemes are required to meet our supply demand balance in light of growth in the region, and to ensure we meet regulatory compliance standards for water quality when the sites are into supply.

### Why is the investment the best option for customers and how are they protected against under-delivery?

We are currently managing the absence of our Croydon, Kingston and St Ives groundwater sources by increasing the transfer of water from our Cambridge supply zone into the two respective zones that these sites are located within. We are doing this via two transfer boosters in particular which draw water from our Cambridge zone and pump it into the neighbouring Croydon and Bourn supply zones.

Whilst operating our network in this way has enabled us to maintain a level of service to our customers to date, we have been operating at a reduced level of resilience. A reliable water supply is one of our customers' top priorities and as growth within the Croydon and Bourn zones continues at a rapid rate, the combination of reduced resilience and increased demand mean that the risk to our service associated with these operations will reach an unacceptable level.

We will reduce this increasing risk by reintroducing Croydon, Kingston and St Ives groundwater sources to supply. Our investment optimisation process identified these supply options as the most cost-beneficial solutions to addressing the supply/demand balance.

The three sources are located to the west of our Cambridge supply zone where future growth is forecast to be greatest. As noted above, supplies to the west of Cambridge are currently heavily supported by the transfer of water from our Cambridge zone. So, reintroducing these sources will increase our Production capacity within the zones the water is needed will relieve the pressure on our Cambridge zone and make us more resilient. Also, the fact that these sites are still within our existing licence agreements, that they are on land that is already owned by us, and, that we have historic knowledge of these sites, all contribute to their reintroduction being the most cost-effective solution.

We do, however, need to overcome the historic raw water quality issues that we had at these sites. We will do this by:

- mitigating the risk to raw water quality (cleaning existing boreholes, drilling new boreholes, and installing new improved headworks); and
- investing in modern treatment methods (notably pressure filters and breakpoint chlorination at Croydon and Kingston, and ultraviolet (UV) treatment at St Ives).

Our package of performance commitments fully covers this expenditure as it links to overall reliability of supply and water quality compliance performance commitments.

### Are the cost estimates robust and efficient?

Our engineers have worked with Costain to develop costs for these projects. Costain's original costings for the three sites were £9.9m (including both the enhancement and base cost allocation), however, we significantly challenged ourselves on the scope and made significant adjustments based on our experience of delivery of these types of schemes on existing sites where we already have some infrastructure. We have included £3m for delivery of these schemes in total, £2.27m being allocated to enhancement and £0.9m to base expenditure.

### 3.2.2.3 Network asset resilience

We have identified investments to improve our network resilience which cover the key asset types of mains, valves and water transfers.

Table 10 Network resilience enhancement

| Investment area | Schemes | Capital expenditure (£) | Operating expenditure (£) |
|---|---|---|---|
| Network resilience | Mains and valves | £2.5m | £0 |
| | Transfers (Perry Barr) | £0.6m | £0 |
| | **Total net** | **£3.1m** | **£0** |

**Why is the investment enhancement?**

The investment needs we have identified are new costs that will deliver an improvement in service to customers by reducing the risk of, and frequency or duration of, supply interruptions when we have unexpected network events as a result of asset failure or external influences.

**Why do we need to carry out the investment?**

Over time we have continuously strived to develop diverse and resilient supply networks in our South Staffs and Cambridge regions. We continually look for improvements however and our modelling, risk elicitation and ever increasing experience have identified areas where we can do more to improve our network resilience. For example we still have a number of single feed areas across our networks where further investment in resilience would improve our service. We have looked at our networks and considered where our biggest risks lie in terms of continuing to supply our customers in the event of an asset failure. In doing this, we have identified where we could improve our service levels by investing in our infrastructure assets to move water around our network in a different way should an issue arise.

**What management control do we have over the need or delivery option?**

We need to continually invest in network resilience because we recognise that, whilst we already invest substantially in our network to maintain stable asset health over time, for example through our mains renewals programme, we cannot prevent failures (bursts) occurring in our mains network altogether. To ensure customers receive the service they expect even in adverse conditions, we need to continually review how our network operates and make improvements that mitigate the impact that failures can have on customers. We do have control over the timing of these investments, and we consider all of our proposed investments with affordability and value for money for customers in mind. The package we have put forward represents the right balance of investment, risk and cost.

**Why is the investment the best option for customers and how are they protected against under-delivery?**

We have identified a number of investments across both our South Staffs and Cambridge regions to mitigate the impact of failures in our pipe network. And similarly to our approach to determining the best investment solution for each of our on site power generation needs, we have identified solutions in which the investment is proportional to the associated level of risk to our service to ensure the cost effectiveness of all our schemes. We will:

- lay 'dual' mains where appropriate to improve local resilience within the network;
- install more valves so that we can better isolate certain parts of our network without affecting as many customers
- install a booster to transfer water from Severn Trent into the South Staffs region at the Perry Barr location.

Laying additional mains allows us prevent supply interruptions for customers by providing an alternative route of supply in the event of an asset failure. Installing additional valves would give us more flexibility to move water around our network and allow us to isolate, certain parts of our network more easily and therefore speed up the rate at which we can respond to an asset failure.

We have an existing export from our South Staffs region to Severn Trent's Perry Barr service reservoir. We have identified an opportunity to improve resilience in our area by installing a booster pump which will utilise this transfer main to import water back into South Staffs region. We are currently in discussions with Severn Trent to confirm operational and contractual arrangements. This solution delivers improved resilience in the area at least cost for customers.

The cost benefit appraisal we have undertaken using our investment optimisation process has ensured that the most cost effective solutions are included within our plan which will, in turn, ensure that our plan includes the best options for our customers.

We have a wide range of performance commitments which cover reliability of supply, quality and asset health all with stretching targets over AMP7 and beyond. These enhancement needs are fully covered by these performance commitments.

**Are the cost estimates robust and efficient?**

The costs for these schemes have been developed using a bottom up quantity surveying approach. We have strongly challenged the scopes of the upgrades required, and ensured that we have fully reflected any efficiencies that we are projecting from our framework contracts, which would deliver these schemes, over AMP7.

## 3.2.3 Growth – supply side enhancements

We have a range of needs to meet population growth in our supply regions. The majority of costs in this category relate to new infrastructure to enable us to deliver water to new customers, and we also include costs of developing our future plans and improving pressure to existing customers.

### 3.2.3.1 Infrastructure to service new customers

New property developments require infrastructure to be built to service them. Our needs in this area are as follows:

Table 11 Infrastructure to service new customers

| Investment area | Schemes | Capital expenditure (£) | Operating expenditure (£) |
|---|---|---|---|
| Infrastructure to service new customers | New Bourn service reservoir<br>Contributions (Infrastructure charge) | £2.5m<br>(-£2.5m) | £0 |
| | New development mains and CPs<br>Contributions (Infrastructure charge) | £72.5m<br>(-£45m) | £0 |
| | **Total gross**<br>**Contributions**<br>**Total net** | **£75m**<br>**(-£47.5m)**<br>**£27.5m** | **£0** |

### Why is the investment enhancement?

Infrastructure to service new customers is classified as enhancement because it is not part of our historical costs. Our costs for new developments are derived from a robust growth forecast aligned with our water resources management plan, and are fully detailed in Table APP28 of the business plan table set. As we have statutory obligations to supply new customers, we have focussed this part of the narrative on our decisions regarding Bourn reservoir.

### Why do we need to carry out the investment?

In order to supply new customers, we either install new infrastructure ourselves or it is installed by developers and self lay providers. This new infrastructure includes supply mains, local distribution mains, connections and water meters. On our strategic network, growth can require construction of new assets in order to accommodate the increase in demand from customers.

### What management control do we have over the need or delivery option?

We are required to service new customers in our regions of supply as part of our statutory duties. Where this involves non-direct infrastructure, as with our requirement to construct a new service reservoir at Bourn, we undertake robust analysis of our local supply arrangements, storage and network capacities in order to determine the best option.

### Why is the investment the best option for customers and how are they protected against under-delivery?

We have statutory obligations to supply new customers, and so we have focussed this part of the narrative on our decisions regarding Bourn reservoir.

Bourn reservoir is a strategically important site consisting of two service reservoirs of total capacity 6.8 Ml within the Cambridge supply network. Reservoir 2 (2.3 Ml) is not currently in supply because in 2012 we identified corrosion to the circumferential pre-stressing, which makes the structure unsafe.

We will replace it with a new bigger reservoir to better service the growth within the local area. As part of the driver for this investment is maintenance and part growth, we have proportionally allocated the costs for this investment between base maintenance and enhancement. The total cost of this investment will be £3.5m, with £2.45m being attributable to the increase in capacity of the reservoir. We have included this cost within the network reinforcement costs recovered through the infrastructure charge.

We will commence construction of the new 8 Ml reservoir at this site in 2020. We need the new reservoir in supply by summer 2022 to meet projected growth in demand resulting from new developments in the West of Cambridge. Our analysis indicates that the 8 Ml reservoir will provide us with 24 hours storage under average demands for the next 20 years and will enable us to sustain average day peak week demands before storage reaches critically low levels.

As this investment relates to growth and is included within our network reinforcement costs and infrastructure charge, a bespoke performance commitment is unnecessary. Our overall supply resilience is fully covered by our performance commitment package.

**Are the cost estimates robust and efficient?**

We have worked with Stonbury to generate a robust cost estimate for the reservoir rebuild. Our cost estimates for new developments mains and connections are provided in detail in Ofwat's App28 business plan table.

#### 3.2.3.2 Dealing with low pressure for customers

To ensure we continue to improve our levels of service to our customers we replace communication pipes when it has been identified that the required pressure and flow rate is not being achieved at either the boundary to the property or at the property itself.

Table 12 Dealing with low pressure for customers

| Investment area | Schemes | Capital expenditure (£) | Operating expenditure (£) |
|---|---|---|---|
| Dealing with low pressure for customers | Communication pipe renewals | £0.5m | £0 |
| | **Total** | **£0.5m** | **£0** |

**Why is the investment enhancement?**

When older houses were constructed they often had their water supply connections shared between multiple properties. Also, older connections were smaller than the modern equivalent because there were less water using appliances in the home. When a customer experiences low pressure as a result of these issues, we upgrade their connection to modern standards to solve the problem, enhancing the customer's service over their original level.

### Why do we need to carry out the investment?

We have a statutory obligation to ensure customers receive a minimum level of flow and pressure. When we find that a communication pipe needs to be replaced we undertake that work immediately to ensure the customer receives the best possible service and fast resolution of their issue.

### What management control do we have over the need or delivery option?

As above, this expenditure reacts to issues with customers' communication pipes and when we find an issue we ensure we act in the customers' interest as quickly as possible to resolve it to their satisfaction.

### Why is the investment the best option for customers and how are they protected against under-delivery?

When an individual customer has an issue it is important that we respond to improve service to the level the customer expects. Our projection for communication pipe replacement is based on our historic rate and costs derived from historic typical costs. The number of communication pipes we replace under these criteria is relatively small and as such the costs are also small relative to our total costs. We do not consider a bespoke performance commitment to be necessary for this level of activity.

### Are the cost estimates robust and efficient?

We have based our projection on our historic costs, as we undertake these communication pipe replacements regularly.

## 3.2.4 Growth – demand side enhancements

We detail below our investment needs relating to demand side enhancements to help manage our supply demand balance and service customers who want to move to metered supplies.

### 3.2.4.1 Managing demand

With growth in demand we undertake a range of activity to help ensure that water is not wasted, either from our network or by customers. In AMP7, we will be delivering a substantial leakage reduction programme and complimenting this with a range of water efficiency activity to help customers use water wisely. Our metering programme also supports this objective.

Table 13 Managing demand

| Investment area | Schemes | Capital expenditure (£) | Operating expenditure (£) |
|---|---|---|---|
| Managing demand | Leakage reduction | £6.9m | £3.4m |
| | Consumption monitoring | £0.16m | £0 |
| | Helping customers use water wisely | £2.76m | £1m |
| Metering | Meter optant programme | £12.7m | £0 |
| | **Total** | **£22.5m** | **£4.4m** |

#### Why is the investment enhancement?

As our population, and therefore demand for water, grows over time, we undertake a range of activity to try and ensure that we can continue to supply customers over the long term. These are new costs which will deliver a step change in service from AMP6, particularly on leakage.

#### Why do we need to carry out the investment?

We need to continue to invest in demand side enhancements to ensure we can meet our supply demand balance over the long term, and therefore ensure that we can continue to provide a reliable supply of water to our customers against challenges such as population growth and water scarcity.

On metering, most customers agree that having a water meter is the fairest way to charge because people pay for how much water they use. Metering also helps us to manage our demand by giving us better data on consumption patterns.

#### What management control do we have over the need or delivery option?

The investments we have identified are required to meet our stretching targets on leakage and water efficiency, and to meet our increased meter optant forecasts that will result from our planned increase in marketing activity.

### Why is the investment the best option for customers and how are they protected against under-delivery?

Reducing leakage on our network of pipes, protecting the natural environment and educating customers about the need to use water wisely are three of the things our customers have told us matter most to them. So, we have identified these investment needs to help reduce the demand for water across our regions. These investments are aligned with our water resources management plan, and meet our supply demand balance over the planning period.

Our customers have told us that they want us to reduce leakage so we have set ourselves the ambitious targets of reducing leakage by 25% in our South Staffs region and 15% in our Cambridge region. To do this, we will invest £6.25m in leakage reduction as well as continuing with our other investments, as part of base expenditure such as mains renewals, that also contribute to us delivering our leakage targets. How we intend to reduce our leakage is summarised in 'Our Environment' (Chapter 5) and in further detail in our South Staffs and Cambridge region water resource management plans.

We have challenging performance commitments for leakage for each region to protect customers against under delivery.

Our customers have also told us that water efficiency is important to them. They want us to educate all of our customers – both existing and new – about the importance of using water wisely, and, they have told us that they want us to protect the natural environment. Ensuring that we use water efficiently is one of the ways we intend to reduce our impact on the natural environment. We will invest in consumption monitoring in our Cambridge region to improve our data quality, and continue to promote water efficiency both with our customers directly and with developers, ensuring that they build water efficient homes with help from our water efficiency incentive. We consider this to be especially important in light of the growth that is forecast in our regions.

We have put in place challenging performance commitments for water efficiency, for each region, and additional performance commitments covering our house building incentive and education, to ensure that customers are fully protected and our wide range of activity in this area is reflected in our reporting.

Finally, we need to make provision for those customers who want to switch to a metered supply, but also metering is a way we can encourage customers to use less water to help meet our supply demand balance. In our South Staffs region, 37% of customers currently have a meter; the figure in our Cambridge region, one of the driest parts of the country, is much higher at 72%. While our engagement suggests that customers see metering as important, there is little support across either region for making meters compulsory for all those who currently do not have one, so we are not going to do this.

We will be doing more to encourage customers to have a meter fitted. This includes providing better information to customers – particularly those on low incomes – about the benefits of choosing a water meter and we will also offer additional advice on how to use water wisely, how to determine if there is a leak on their supply pipe and how this benefits the environment.

We expect our increased activity will increase metering levels by 2025 to around 50% in our South Staffs region and 80% in our Cambridge region.

We have not implemented a separate performance commitment for our metering programme as the primary benefit for water demand will materialise in our residential water consumption measure which we are financially incentivising. As part of our summary annual report we produce each year, for customers, we will report on the metering activity we have undertaken and the benefits that this has realised.

Our plans for demand side enhancements have been considered in conjunction with the supply side enhancements we also need to help meet our supply demand balance, and both of these components feed into our water resource management plan. The process by which these options were selected is detailed in our water resources management plan taking account of:

- Customer views;
- Cost;
- Resilience;
- Environmental impact; and
- Deliverability.

### Are the cost estimates robust and efficient?

We have generated cost estimates from detailed scoping and business as usual data, as we already incur similar costs regularly however this expenditure represents a step change in the level of activity we undertake.

## 3.2.5 Environment

Our environmental needs below are confirmed needs under the Water Industry National Environment Programme (WINEP). As part of our duties we must ensure that the water we take from the natural environment is abstracted in a sustainable way that does not lead to a deterioration of that environment. It also means that we contribute to an overall improvement of the environment where appropriate.

### 3.2.5.1 Water industry national environment programme enhancement expenditure

Our environmental programme is comprised of four main components: ecological improvements, invasive non-native species, water framework directive and schemes required to meet eels regulations at our river intake works.

Table 14 Water industry national environment programme

| Investment area | Schemes | Capital expenditure (£) | Operating expenditure (£) |
|---|---|---|---|
| Water industry national environment programme | Ecological improvements | £0.3m | £0 |
| | Invasive non-native species (INNS) | £0.25m | £0 |
| | Water Framework Directive (WFD) schemes | £0.55m | £0 |
| | Eels regulations (measures at intakes) | £2.95m | £0 |
| | **Total** | **£4.05m** | **£0** |

#### Why is the investment enhancement?

Environmental improvements are new costs that we incur to make improvements to the environment that we interact with as part of our operations. The majority of our environmental obligations are driven by external requirements.

#### Why do we need to carry out the investment?

As highlighted above, the majority of our environmental obligations are driven by external requirements and are part of our statutory duties to protect and enhance the environment. These duties arise from existing legislation, such as the NERC act, the WFD, Fisheries and Eels, and for the most part are included in the WINEP tables as schemes for investigation or implementation. The guiding principles within WISER and recommendations from regulators support non statutory obligations such as the continuation of catchment schemes and the catchment approach to protect raw water quality, where we are continuing with our existing AMP catchment schemes.

#### What management control do we have over the need or delivery option?

We need to comply with our legal obligations under the water industry national environment programme, and our wider duties for sustainable operations and protection of the environment. We have had extensive discussions with the EA over our requirements and looked at many options for how we can deliver the need.

All of the delivery options identified through the WINEP have been preceded by an investigations stage which has been signed off and agreed with the EA. In this process, we have been able to improve the definition and requirements of the schemes included for PR19. Where PR19 schemes are investigations, we will agree the scope of these in advance with the EA.

### Why is the investment the best option for customers and how are they protected against under-delivery?

The work programmes that this investment covers will:

- ensure the continued protection designated sites, such as Sites of Special Scientific Interest (SSSIs)[21], across both regions;
- contribute to our biodiversity obligations laid down in the Natural Environment and Rural Communities Act 2006 on land we own or in the water catchments in which we operate;
- prevent deterioration of the environment from where we take and store our water so that we meet the environmental objectives of the European Union's Water Framework Directive;
- prevent the spread of Invasive Non-Native Species (INNS), which are any non-native animal or plant that has the ability to spread causing damage to the environment, economy, our health or the way we live;
- ensure the water we take from the environment does not impact on fish and eels to comply with the Eels (England and Wales) Regulations 2009 and the Fisheries Act;
- ensure our underground water sources are not affected by contamination from the land; and
- prevent a deterioration in the quality of the water sources from where we take drinking water. This means we can reduce the levels of treatment required to produce the high-quality drinking water our customers expect.
- Improve biodiversity on 690 hectares of land by improving our own land and making grants available to other local stakeholders.
- We will help to improve up to 1,000 km of rivers in both regions.

All have been predicted by investigations into the need and are supported by WINEP drivers and WINEP schemes.

### Are the cost estimates robust and efficient?

The cost estimates that we have used for our environmental schemes have been produced on the basis of the best available information. For catchment management schemes we have used the AMP6 scheme costs as the basis for additional programmes of measures, similarly for WFD and NERC WINEP drivers we have made estimates based on previous work, or used industry knowledge where applicable. AMP6 WINEP delivery costs are taken from framework consultants and procured on a competitive basis. Prior investigations have included cost benefit work to ensure that we have targeted and specified our proposed schemes appropriately.

# 4. Benefits to customers of our approach

The table below summarises the main investments included within our plan which will enable us to meet our service targets for 2020-2025.

Table 15 Our service performance commitments and the investments that will contribute to their delivery (base maintenance in green, enhancement in purple, investments which we have proportionally allocated are in blue)

| Headline investments | Delivering upgraded water treatment works | Reducing the number of customer contacts about the taste, smell and appearance of our water | Always meeting water quality standards | Making sure water always comes through customers' taps | Reducing the number of water production failures | Finding and fixing visible leaks more quickly | Reducing the number of burst mains | Avoiding severe water supply restrictions | Regulatory driven | Operational cost saving driven |
|---|---|---|---|---|---|---|---|---|---|---|
| Full site refurbishments | | | ✓ | ✓ | ✓ | | | | | |
| Borehole maintenance programme | | | ✓ | ✓ | ✓ | | | | | |
| Pumping and treatment asset maintenance | | | ✓ | ✓ | ✓ | | | | | |
| Service reservoir and tower maintenance | | ✓ | ✓ | ✓ | ✓ | | | | | |
| Reservoir aeration to reduce trihalomethanes | | ✓ | ✓ | | | | | | | |
| Pump efficiency programme | | | | | | | | | | ✓ |

| Headline investments | Delivering upgraded water treatment works | Reducing the number of customer contacts about the taste, smell and appearance of our water | Always meeting water quality standards | Making sure water always comes through customers' taps | Reducing the number of water production failures | Finding and fixing visible leaks more quickly | Reducing the number of burst mains | Avoiding severe water supply restrictions | Regulatory driven | Operational cost saving driven |
|---|---|---|---|---|---|---|---|---|---|---|
| Control systems and site automation maintenance | | | ✓ | ✓ | ✓ | | | | | ✓ |
| Mains renewals | | | ✓ | ✓ | | | ✓ | | | |
| Mains diversions | | | | | | | | | ✓ | |
| Replacing communication pipes, maintaining air valves, maintaining pipe bridges, cathodic protection | | ✓ | | ✓ | | ✓ | ✓ | | ✓ | |
| Management and general | | | | ✓ | | | | | | ✓ |
| Hampton Loade and Seedy Mill treatment works upgrades | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | | |

| Headline investments | Delivering upgraded water treatment works | Reducing the number of customer contacts about the taste, smell and appearance of our water | Always meeting water quality standards | Making sure water always comes through customers' taps | Reducing the number of water production failures | Finding and fixing visible leaks more quickly | Reducing the number of burst mains | Avoiding severe water supply restrictions | Regulatory driven | Operational cost saving driven |
|---|---|---|---|---|---|---|---|---|---|---|
| Raw water quality resource management - WINEP DWPAs and catchment management | | | ✓ | ✓ | ✓ | | | ✓ | | |
| New treatment | | | ✓ | ✓ | | | | ✓ | | |
| Lead strategy | | | ✓ | | | | | | ✓ | |
| Eel screens and passes | | | ✓ | | | | | | ✓ | |
| Water production resilience - power generation and second boreholes | | | | ✓ | ✓ | | | | | |
| Network resilience - mains, valves, transfers | | | | ✓ | | | ✓ | | | ✓ |
| Supply side schemes - reintroduction of | | ✓ | | ✓ | | | | ✓ | | |

| Headline investments | Delivering upgraded water treatment works | Reducing the number of customer contacts about the taste, smell and appearance of our water | Always meeting water quality standards | Making sure water always comes through customers' taps | Reducing the number of water production failures | Finding and fixing visible leaks more quickly | Reducing the number of burst mains | Avoiding severe water supply restrictions | Regulatory driven | Operational cost saving driven |
|---|---|---|---|---|---|---|---|---|---|---|
| groundwater sources | | | | | | | | | | |
| New developments - network reinforcement | | | | ✓ | | | | | ✓ | |
| New developments - new service reservoir | | | | ✓ | | | | ✓ | | |
| Demand side enhancements - leakage reduction, water efficiency and consumption monitoring | | | | ✓ | | ✓ | | ✓ | | |
| WINEP - ecological improvements, INNS and WFD | | | | | | | | | ✓ | |
| Metering - meter optants | | | | | | ✓ | | | ✓ | |
| CP renewals DG2 | | | | ✓ | | | | | ✓ | |

# Appendix A29.1

## WRMP 2019 - Deciding on future options

South Staffs Water

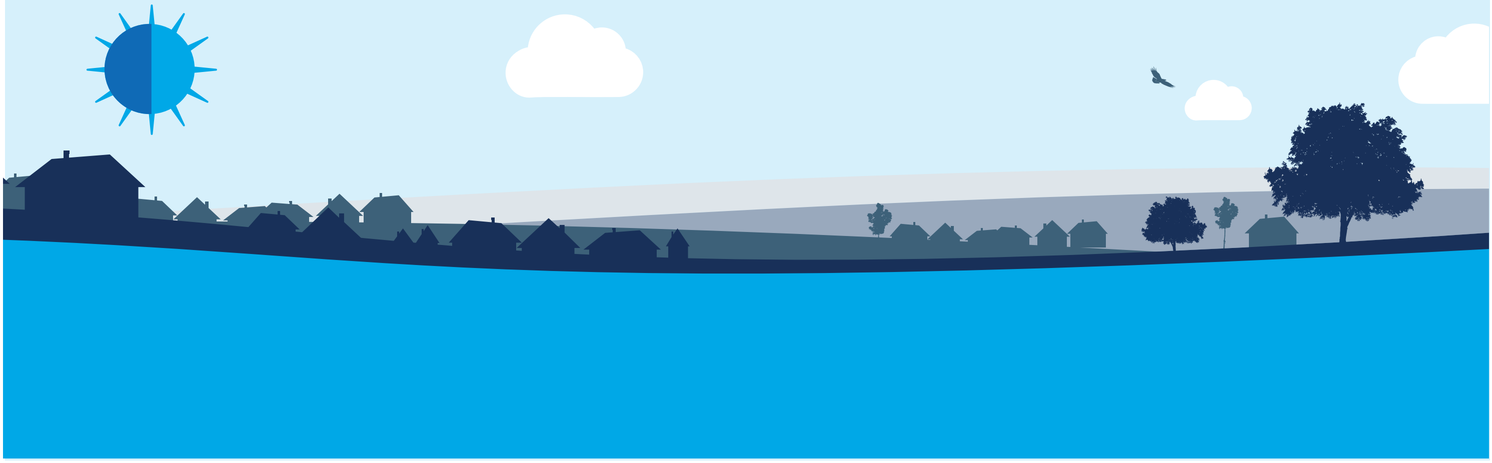
incorporating

CAMBRIDGE WATER COMPANY

# Cambridge Water

## Draft Water Resources Management Plan 2019

# Section 10:
# Deciding on future options



# 10. Deciding on future options

**Overview of options development and selection**

We have followed the eight stage approach outlined in 'WRMP 2019 Methods – decision making process guidance' (UKWIR, 2016) for the identification of options and selection of our proposed programme of work.

We have carried out a process of defining the challenge we are facing and quantifying the complexity and scale of it. This has helped us define the approach to decision-making which is appropriate for us and our circumstances.

We have developed a multi-criteria decision-support tool to help model the future and make robust decisions about our proposed programme alongside a least cost approach.

We have developed an unconstrained list of options, including:

- demand-side options;
- supply-side options;
- production options;
- third party options; and
- resilience options.

These have been screened and evaluated to define our list of feasible options. An SEA has been carried out on all feasible options to help inform the proposed programme.

All options have been modelled in our MCA tool under a range of scenarios to test our plan.

We have developed our proposed programme taking account of:

- customer views;
- cost;
- resilience;
- environmental impact; and
- deliverability.

## 10.1 Overview

We have followed the eight-stage approach outlined in 'WRMP 2019 Methods – decision making process guidance' (UKWIR, 2016) for the identification of options and selection of our proposed programme of work.

1. Collate and review planning information.
2. Identify unconstrained options.
3. Problem characterisation and evaluate strategic needs/complexity.
4. Decide modelling method.

5. Identify and define data inputs.
6. Undertake decisions making modelling/options appraisal.
7. Stress testing and sensitivity analysis.
8. Final planning forecast and comparison to EBSD benchmark.

Traditionally options would only be developed where a supply/demand balance deficit has been identified or is likely and an intervention is required to breach the gap. Problem characterisation for Cambridge Water identified that because of significant growth and the likely impact of reduced DO from our existing groundwater portfolio, there is an opportunity to review our existing operations across all sources to identify the most appropriate mix of supply and demand options going forwards. This approach allows us to take an integrated view of key questions for decision-making regarding water resource assets.

- How do we ensure we meet our future demand scenarios?
- Can we improve our levels of operational and extreme drought resilience?
- How do we ensure the decisions meet current and future needs?
- How do we ensure our plans reflect our customers' priorities and preferences?
- How do we ensure that our assets are fit for purpose?

A full appraisal of capex, life cycle costs and opex (totex) for all options (existing resources and potential new resources as well as demand management options) ensures we can produce a least cost solution. The inclusion of other un-monetised attributes also allows us to optimise on other objectives and understand the value of differences. This multi-criteria approach and the DMF is described in detail in section 10.3.

Therefore, a full range of demand management options and supply options including all existing sources have been developed for modelling in the DMF and this allows the opportunity to re-evaluate the mix of resources for the future and ensure our assets are able to meet future demand scenarios.

## 10.2 Problem characterisation

The problem characterisation assessment is a tool for assessing our vulnerability to various strategic issues, risks and uncertainties. This assessment enables the development of appropriate, proportional responses with regards to decision making. We followed the approach set out in the latest guidance 'WRMP 2019 Methods – decision making process guidance'; this provided a robust and consistent approach that we applied to both our regions of operation (South Staffs Water and Cambridge Water).

There are two key areas to the problem characterisation assessment.

- How big is the problem? This assesses the scale of the strategic needs and the requirement for either new resources or demand management activities.
- How difficult is it to solve? This assesses the complexity of the challenge.

A detailed internal stakeholder workshop was held in both regions, facilitated independently by Arup and HR Wallingford. The appraisal of both problem and complexity concluded that compared with WRMP14 we face new risks to our overall supply/demand balance. The problem characterisation was developed collaboratively and is presented below. A full report detailing the problem characterisation is included in **appendix O**.

**Figure 16: Problem characterisation assessment**

| | | Strategic Needs Score ("How big is the problem") | | | |
|---|---|---|---|---|---|
| | | 0-1 (None) | 2-3 (Small) | 4-5 (Medium) | 6 (Large) |
| **Complexity Factors Score ("How difficult is it to solve")** | Low (<7) | PR14 | | | |
| | Medium (7-11) | | | PR19 - CAM | |
| | High (11+) | | | | |

Our WRZ is in the amber area of medium strategic needs (scale of the problem) and complexity scores. Based on the information presented in our WRMP14 our WRZ would previously have been in the green area of lower risk.

The key drivers behind the changes to the level of risk are as follows.

- A wider appreciation of drought resilience, which means that we may be vulnerable to droughts that are different to those experienced historically.
- Concerns because of regulatory pressures on abstraction licences, which are leading to sustainability reductions and restrictions on available groundwater resources.
- Long-term regional growth is being encouraged by Government but with large uncertainty over the amount and timing.
- There are limited supply-side options available to us within our area of supply – intercompany bulk imports or significant resource development would be required to replace supplies, and these carry additional uncertainty in timing, costs and availability.

The significance of the WRMP problem characterisation is that it drives a DMF based on a more complex extended modelling approach.

## 10.3 Modelling method and data inputs

We have in the past followed the economics of balancing supply and demand (EBSD) approach, which is a well-established framework and traditionally focused on monetisation and developing least cost portfolios to meet supply and demand challenges. However, for the more challenging complex issues identified through the problem characterisation a more sophisticated approach to analysis is required.

Working with Arup and Hartley McMaster, our incumbent provider for asset management optimisation, we reviewed appropriate methods for combining both a WRMP challenge together with a more traditional asset management problem; therefore, providing a platform that enabled us to appraise our whole supply capability challenge. Together we worked through the UKWIR guidance to develop our existing optimisation software, which follows EBSD for portfolio selection, and extended it to allow investment option performance against other objectives to be assessed and incorporated into the portfolio selection process using multi-criteria analysis (MCA) techniques.

MCA is listed as a ‘Current (Baseline) Approach’ in the guidance document with this approach being followed by some water companies for previous plans. However, it is recommended that it is reasonable for a water company to take a progressive, yet pragmatic approach to WRMP 2019 based on the experience from WRMP 2014. We assessed in the problem characterisation that our area would have been classified as green at WRMP 2014 and therefore a move to MCA for this draft WRMP is a progressive move. We consider that through our application of MCA across a range of supply and demand scenarios, this approach goes beyond the ‘Current (Baseline) Approach’ and represents an Extended Approach.

The model can appraise both supply, including the requirements to maintain existing assets, and demand-side options and requires monetised information regarding construction, lifecycle and operating costs. Yield information for each of the planning scenarios is also captured, as well as any demand-side reductions/benefits.

The decision making within the model appraises two key criteria first – water quality and quantity; these are treated as ‘gateways’ in the model. These gateways are linked back to our customer priorities and hygiene factors and triangulate well with all other PR19 engagement to date, together with our ongoing day-to-day customer insight work.

A report detailing the modelling approach is included in **appendix P** and a summary of key aspects is included in the following sections.

#### 10.3.1.1 Quantity

For each year of the planning period the DMF requires the demand problem to be set for each WRZ. This is the volume of water required for the zone, including allowances for:

- headroom;
- climate change; and
- population growth.

In line with water resource management planning guidelines, and in order to understand the normal operating scenario, the annual demand in the framework is set as a three-tier problem.

- Dry year annual average (DYAA).
- Dry year critical period (DYCP).
- Normal year annual average (NYAA).

In any year of the planning period the combination of options selected must be able to deliver the volume required for each of these scenarios as a minimum. The model is free to provide a volume greater than that required and subsequently partially utilise some sources. All volumes are megalitres per day (Ml/d).

In order to understand the impact of different population growth and climate change projections it is envisaged that a series of different future demand projections are generated that reflect different futures. This is further discussed in section 10.7.

#### 10.3.1.2 Quality

The intention to include water quality in the framework is predicated on the assumption that we need to demonstrate that investments related to a particular source will deliver the required water quality both now and into the future against a range of possible future challenges, therefore meeting customer expectations.

There are choices to be made and trade-offs to consider in terms of the degree of sophistication, future proofing and flexibility for future adaption depending on the pace and scale of emerging challenges. There is likely to be more than one acceptable solution to the various quality issues, and thus a degree of potential for different optimised portfolios.

We considered several measures currently.

- Regulatory (mean zonal compliance).
- Customer opinion (acceptability).
- DWI reported events/incidents.

If quality is to be taken into account a mechanism needs to be found to assess the relative beneficial impact on quality over time of each option considered.

Two options for assessing quality benefit were considered.

1. Measurement of the number of failures that each option reduces compared to a 'do nothing' baseline (failure based).
2. The degree of quality improvement or protection that each option provides against a set of assumed challenges (risk based).

Option 1 was discounted because of the difficulty and limited accuracy of generating sensible do nothing baselines and the highly subjective assessment of failure reduction for each project in isolation from other improvement activity over such an extended period of time. Option 2 has been developed as basis of the approach to assessing the water quality impact of different investment options.

Water quality is impacted by both external and internal factors and investment decisions need to take account of known and likely changes to both. External factors such as raw water quality arriving at abstraction points, pollution, climate change impacts on water quality, peak summer temperatures and third party contamination can all be assessed in terms of risks, historic information and assumptions made on current and future challenges.

Assessments of water quality cover a wide range of parameters and it is not the intention of this framework to provide a detailed analysis of treatment performance; its purpose is to allow comparison between different investment options. Working with our internal water quality experts, in conjunction Arup, a series of high-level water quality metrics have been identified against which the performance of investment options can be assessed. These are as follows.

- Microbiology – E.coli, Coliforms, Clostridia, Cryptosporidia.
- Pesticides – nitrates, metaldehyde.
- Disinfection by –products - THM potential.
- Aesthetic/discolouration potential – iron, manganese, aluminium.

For each source of water, a target water quality grade is entered for each water quality metric for each year of the planning period. This enables the model to reflect changing water quality and treatment targets over time.

Each investment option entered into the model must specify its performance capability with respect to each water quality metric. This is discussed later in the report.

#### 10.3.1.3 Multi-criteria

All options are also scored against other un-monetised objectives, including:

- operational resilience – each option was scored on how the delivered solution would improve reliability, flexibility and the diversity of our supply capability;

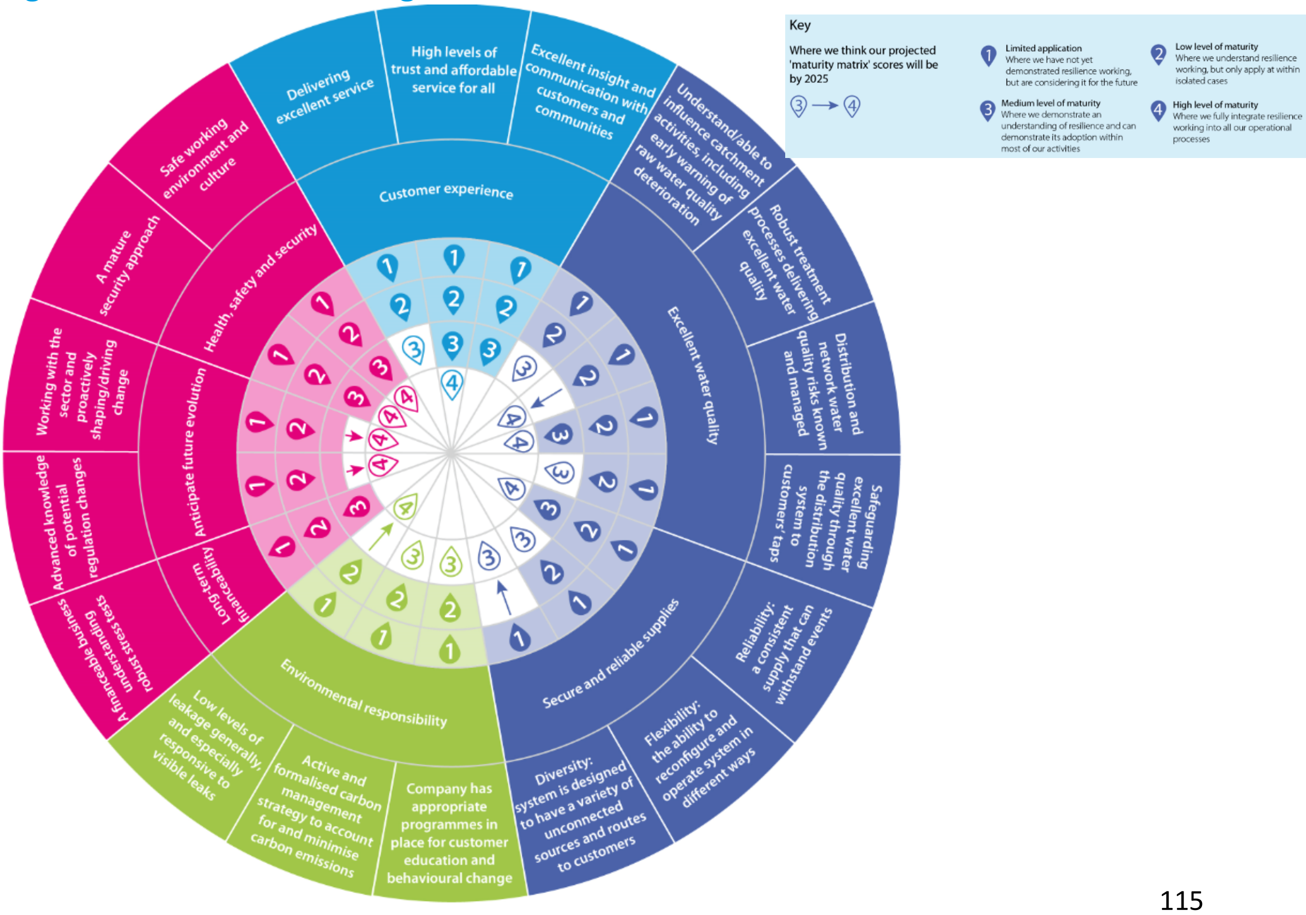
- deliverability – each option was scored to assess the operational certainty of the solution, if any third party consents were required;
- environmental sustainability – this was a basket measure and all options were scored on levels of carbon and impact on biodiversity, scale and severity (both during construction and implementation);
- social sustainability – this was a measure of disruption on local communities; and
- customer preference – this was gained from our customer engagement programme.

### 10.3.1.4 Resilience

We have been reviewing our approach to defining, quantifying and presenting resilience. To support this, we have developed a tool described as a 'resilience lens' with a number of key business objectives and a selection of desired states.

Elements from this business resilience tool can be associated with outputs from the DMF and in several different criteria when used in the assessment of investment options (figure 17). A single investment option on its own will have limited influence on the lens. However, if the cumulative impact of multiple options is considered, then an overall resilience performance for a portfolio can be calculated and compared against other portfolios. The choice of investment options is not able to influence performance against the entire resilience lens but will impact elements of the resilience lens as indicated in figure 17.

**Figure 17: Resilience lens segments**



### 10.3.1.5 Operational resilience

A major component of our resilience, that the choice of the long-term plan investment options can impact on, is operational resilience. A number of elements of operational resilience were considered for inclusion in the DMF. The selected categories are listed below.

- The extent to which an option impacts the **reliability of supply** to customers at the right volume and quality.
- The extent to which an option impacts the **flexibility of supply** options across the WRZ.
- The extent to which an option impacts the **diversity of supply** options available in the WRZ.

Each of the feasible options were scored from one to four, with the lowest score assigned to options that have a low impact on resilience and the highest score to those that have the largest impact on resilience. The factors considered in the scoring are shown in figure 18.

**Figure 18: Operational resilience**

| | Reliability | Flexibility | Diversity of supply |
|---|---|---|---|
| **Principle** | **The degree of reliability of critical assets - levels of unplanned outage** | **The degree of flexibility to reconfigure system to respond to events** | **The degree of diversity of supplies available; level of dependency on sources.** |
| **Factors** | Levels of drought susceptibility; range of yield Level of competition for the resource | Physical location of the resource within the network, ability to help support areas of single source | Extent to which the WRZ deployable output is dependent on this option |
| | Treatment vulnerability; level of complexity, difficulty of treatment, extent of dual streaming, extent of bankside storage. Experience of outage on existing sites | Ability to help the network recover, particularly with respect to North South and South North transfers | Extent to which the local network or area of supply is dependent on this option. |
| | Impact on discolouration events | Ability to provide extra capacity from normal (peak demand) | |
| **Score** | *Enter Option Score (0 to 5)* | *Enter Option Score (0 to 5)* | *Enter Option Score (0 to 5)* |

All these attributes provide the framework for the MCA. Incorporating these aspects into the optimisation provides us with a robust DMF. Optimising across the full range of objectives together with stress testing key drivers, such as demand scenarios, yields and critical cost elements has enabled us to demonstrate that a robust, no regrets decision has been made.

### 10.3.1.6 Deliverability

Deliverability describes the complexity of an option in terms of execution. More complex solutions may provide a step change improvement but the benefits are less certain. A less complex solution may be a quick win and simple to implement but may not provide longevity of solution. For new technology there is also a risk that it will not work as well as expected, or that it costs more than anticipated. It provides a pragmatic means to measure the ease of an option in terms of development, implementation and operation to deliver a required outcome.

Within the DMF deliverability is defined as follows.

- **Third party approvals** – the degree of difficulty involved in obtaining permission to carry out the option and the likelihood that the option will be approved. This includes environmental and social impacts and effort associated with mitigating unacceptable impacts. The costs of this are included in the totex figure. A scheme which is located near or within an area of social or environmental significance will incur significantly more complex and intensive third party approvals and requirements. We also considered infrastructure such as the power and gas network from both a capacity and availability perspective.
- **Benefits proven** – the degree of confidence that the scheme will deliver anticipated benefits. This is demonstrated through the strength of the evidence base of solution benefits being demonstrated previously at scale in the water sector, and context relevant to the scheme proposed (that is, track record in material benefits). For example, a well-established treatment technology may have a strong evidence based demonstrating benefits, but if it has never been applied at similar scale to that proposed by us this option is less well proven than one which has a strong evidence base at the relevant scale. For example, large-scale water efficiency may not have been proven.
- **Operations proven** – the degree of confidence that we will be able to operate, carry out or deliver the scheme without issue. This is based on both the technology maturity and how well acquainted we are with the site – for example, introduction of an existing mothballed site would be more deliverable than the introduction of a new resource.
- **Contractual supply chain risk** – level of risk associated with suppliers and supply chain needs for scheme. This revolves around the number of players in the supply chain with whom we do not already have existing or trusted relationships. Each new relationship represents an additional element of risk within the scheme as issues are more likely to arise within new relationships where expectations are not as well established and understood as in long-standing supply chain relationships.

The scoring matrix is shown in in figure 19.

## Figure 1: Deliverability scoring

**Deliverability**

| | Third Party Approvals | Benefits Proven | Operations Proven | Contractual Supply Chain Risk |
|---|---|---|---|---|
| 5 | Scheme does not trigger any third party approval. | Anticipated results proven at scale in the UK. High degree of confidence. | Technology and resource already used by South Staffs. Proven track record in with South Staffs. | Existing supply chain with good relationships well established. Simple contractual arrangements. Low risk. |
| 4 | Scheme triggers simple third party approval. South Staffs are well versed in the process. Scheme will almost certainly be approved. | Anticipated results proven in theory or outside the UK. High degree of confidence. | Technology or resource known to South Staffs but not currently used or use being significantly increased.. | Existing supply chain with some new players and some existing players. Contractual complexity relatively simple. |
| 3 | Scheme triggers moderately complex third party approval. South Staffs know the process. Some uncertainty around likelihood of approval. | Strong evidence demonstrates that the scheme will deliver anticipated results. Good degree of confidence. | Technology or resource new to South Staffs but well known to other water companies. . | Both new and existing players in supply chain for scheme. Moderate contractual complexity, moderate degree of risk. |
| 2 | Scheme triggers complex third party approval process. South Staffs unfamiliar with process. Some uncertainty around likelihood of approval. | Evidence demonstrates that the scheme will deliver anticipated results. Moderate degree of confidence. | Technology not currently implemented in the UK or new resource to South Staffs with some data availabilty , not currently used by others. | Most players in the supply chain are new to South Staffs but all have very strong track records. Contractual complexity greater than usual for South Staffs |
| 1 | Scheme requires complex third party approval, not previously undertaken by South Staffs. Much uncertainty around likelihood of approval success. It is as likely that the application will be rejected as approved. | Evidence suggests that the scheme will deliver anticipated results. May require additional investment to get these benefits. Moderate degree of confidence. | Technologies not implemented anywhere else in the world or totally new resources with no data availability. . | Most players in the scheme supply chain are new to South Staffs. High degree of contractual complexity and risk. |

| | Magnitude Factor |
|---|---|
| 1 | Less than 10 Ml/d |
| 2 | 10 Ml/d - 40 Ml/d |
| 3 | 40Ml/d - 100 Ml/d |
| 4 | More than 100 Ml/d |

**Total Deliverability Score =** Sum of scores x Magnitude

### 10.3.1.7 Environmental sustainability

Environmental sustainability is an important part of our existing decision making and operations, with a specific ODI allocated to ‘Operations which are environmentally sustainable’. Within this outcome there are several different ODIs, including:

- leakage (financial incentive to meet set performance levels);
- water efficiency (PCC);
- biodiversity (non-financial reputational measure); and
- operational carbon (non-financial reputational measure).

Within the DMF, environmental sustainability has been measured through the following elements.

- Lifecycle carbon.
- Biodiversity.
- Sustainable abstraction.

A summary of how these indicators in the framework, including inputs and background to their development, is described below.

### Lifecycle carbon

Carbon emissions are ordinarily measured as ‘embodied’ or ‘operational’. Embodied carbon is the sum of emissions of greenhouse gases from the manufacture, transport and construction of materials, together with end of life emissions. Operational carbon is the emissions of greenhouse gases during the operational or in-use phase of a building or asset.

## Figure 20: Carbon scoring

**Carbon Emissions**

| | | | |
|---|---|---|---|
| Energy Consumption | | kWh/year | |
| Output | | ML/year | |
| KWh/ML | =Energy / Output | KWh/ML | |
| CO2e factor - energy | 0.50036 | kgCo2e/KWh | *(UKWIR workbook 15/16 value)* |
| Operations Carbon for Option | '= KWh/ML x kgCO2e/KWh | kgCO2e/ML | |
| Comparison Score | | | |
| Carbon Score | =comparison score x output | | |

| *Score* | *Comparison of option carbon with corporate measure* |
|---|---|
| 5 | *<0.1% of total corporate emissions* |
| 4 | *>0.1% - <0.3% of total corporate emissions* |
| 3 | *>0.3% - <0.5% of total corporate emissions* |
| 2 | *>0.5 - <1% of total corporate emissions* |
| 1 | *>1% of total corporate emissions* |
| ***SST Region emissions 2015/16 = 42,796,197 Kg CO2 on 120,964Ml*** | |

The average energy consumption per year in full operation is calculated. This is then divided by the expected output from the option to quantify KWh per Ml. This is multiplied by the emissions factor calculated in the current UKWIR workbook.

The emissions result is then compared with the corporate total figure (currently 0.48Tonnes$CO_2$e/Ml) and a score assigned. The final carbon score is calculated by multiplying the assigned comparative score by the volumetric output of the option.

### Biodiversity

Biodiversity represents the variety and population of animals and plants and the effectiveness of the natural systems that support them. Measuring changes in biodiversity in a business's decision making demonstrates stewardship and social responsibility in this area.

In 2010, the UK was a signatory to the Convention of Biological Targets, where a set of 20 global targets were defined dedicated to biodiversity goals (known as the 'Aichi Targets'). It has taken more than five years to define a biodiversity indicator to inform the decision-making process for a business.

As biodiversity is a devolved responsibility in the UK, it is difficult to pinpoint specific quantifiable measures that are comparable. There are also many different indicators to choose from rendering any tool cumbersome for the user. Since Aichi, the Joint Nature Conversation Committee (JNCC) has defined an indicator for biodiversity specifically for decision making as the "number of publicly accessible records [within the National Biodiversity Network Gateway] at 1$km^2$ resolution or better".

Therefore, on a global, national and regional scale, biodiversity can be used in decision making based on land area impacted (hectares) and a qualitative means to represent change over time for any indicator relevant to the decision. The indicator developed by the JNCC does not say if the solution reaches a specific target or if the solution is 'good or bad' for biodiversity. It does, however, define if a solution has a detrimental or improving effect on biodiversity, or no change. The JNCC also included time in this qualitative method – short term representing change over five years or less and long term as changes over more than ten years. The European Environment Agency and Defra both subscribe to this method in their KPI expectations.

Our current ODI for this indicator quantifies the ‘number of hectares under active environmental management’. While this is an easily understandable and comparable measure, it does not define the extent of the success of the management being carried out from a particular approach or method. The DMF takes both our current measure as a scaling factor and the JNCC indicative impact scale and provides a simple way for the tool’s user to define biodiversity as appropriate to the solution in question.

As with the JNCC approach, it will not specify targets to be met or if a solution is good or bad, but it does enable the decision to be informed regarding likely positive and negative impacts to an area of space affected by the implementation of a solution.

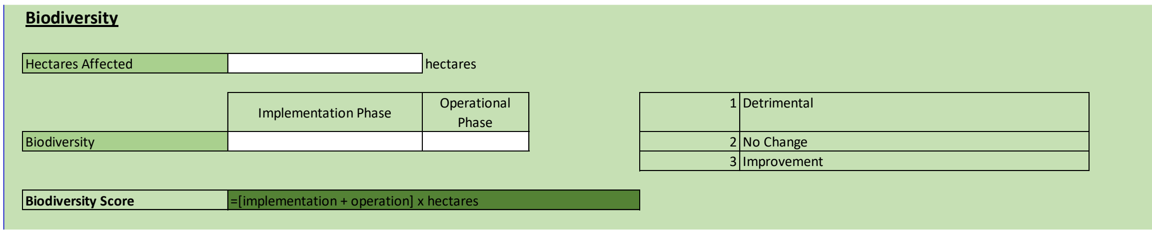
The biodiversity scoring method is shown in figure 21.

Hectares affected is based on understanding of the biodiversity in the area and how the solution may impact it.

To replicate the JNCC definition described above:

- ‘implementation’ period equates to five years or less from the start of build/implementation to point of hand over; and
- ‘operation’ represents the long-term effect on the biodiversity after the solution is implemented and is operating as business as usual.

## Figure 21: Biodiversity scoring




This impact scores are defined as follows, compared to prior to implementation.

- **Detrimental** – for the biodiversity measures important to the area affected, a detrimental impact is anticipated.
- **No change** – there will be no impact or change to the existing biodiversity of the area considered.
- **Improvement** – a positive impact is anticipated from the solution in the area considered.

The scores are then scaled by area affected for option comparison.

## Sustainable abstraction

Regulators and the industry at large agree that water abstraction must be sustainable and does not damage the environment. Sustainable abstraction can incorporate:

- leakage;
- water efficiency;
- metering; and
- consumer behaviour.

As these are covered in other indicators and work streams, this sub-indicator allows the user to score sustainable abstraction based on designation against the affected catchment area and the difference estimated from solution implementation.

Solution development will be done with the appreciation of the water cycle in geographical and volume terms to ensure that demand is met in the right location across the network. This is associated with the quantity measure but also that the quantity is in the right place. The current Restoring Sustainable Abstraction (RSA) programme is likely to lead to licence changes and designation changes that are not currently known, which can make this a difficult measure to pinpoint over a longer time horizon planning period.

If a region is designated as over-abstracted by the Environment Agency, then abstraction licences are likely to be reduced or removed. Some licences are also time limited.

The Environment Agency provides catchment abstraction management strategies for a specified catchment area. These are informed on a water availability status for the region. Our South Staffs region is considered a medium water stress area; our Cambridge region is a high water stress area (that is, it is over abstracted). The framework needs to be account for the regional differences and any potential future changes that may be enforced.

Abstraction licences impacts need to be considered using the following information.

1. Size of catchment area available and the volume affected within this area.
2. Environment Agency designation of abstraction from the catchment that is deemed sustainable.
3. The abstraction licence available to us, even if it not fully utilised.

The DMF assesses what the change in abstraction would be against the licensed volume as a result of a solution's implementation.

The framework therefore uses volume abstracted (Ml/d) and a qualitative score based on the Environment Agency's current water resource availability status designation as a scaling factor (in order of increasing benefit):

- 1 – over abstracted;
- 2 – no water available (no new licences);
- 3 – water available, no deterioration or impact on WFD; and
- 4 – reduction in abstraction – for example, demand management.

The sustainable abstraction scoring method is shown in figure 22. The water sensitivity score is based on the Environment Agency's definitions for the area in question.

Impact scoring is arranged to show any reduction in abstraction to have a more favourable (higher) score, and a lower score for where abstraction is taking place in areas that highly water stressed.

### Figure 22: Sustainable abstraction scoring

**Sustainable Abstraction**

| | |
|---|---|
| Volume of abstraction impacted (Ml/d) | 80 |
| Water Sensitivity Score | 3 |
| Sustainable Abstraction Score | = Volume x Water sensitivity |

| | |
|---|---|
| 1 | Over Abstracted |
| 2 | No water available |
| 3 | Water Available, no deterioration or impact on WFD |
| 4 | Reduction in abstraction (e.g. demand management) |

The sustainability abstraction score is then derived by a simple multiplication of score and output (Ml/d).

#### 10.3.1.8 Combined score

The final indicator score is a sum of the three inputs described above. It is important to note that this indicator covers a number of different and complex elements in sustainability. The scoring is to be used for comparison purposes only. A low score does not necessarily imply a solution is detrimental to the environment, but that it has less positive benefit compared with other solutions considered.

#### 10.3.1.9 Customer preferences

The embedding of customers' preferences within the technical decision making process is a critical element of investment planning; in order to allow decisions to be guided by this a simple indicator has been utilised as shown in figure 19. This applies a score to each option based on how well it is aligned with customer preferences. This is informed by the customer engagement workshops.

## 10.4 Options development

Demand management options have been developed with the assistance of consultants Artesia. Details of the process of developing options and the pro formas for all feasible options are included in **appendix Q**.

Demand management options include:

- leakage reduction – including innovative options that enhance the efficacy of leak detection;
- water efficiency – options that stretch the boundaries of traditional water efficiency measures; and
- metering – more free meter options, change of occupier metering and compulsory metering with different types of meter.

As noted in section 3.1.1 we are not classified as water stressed using the Environment Agency water stress classification methodology (last updated in 2012) and therefore do not have powers to impose compulsory metering. We have carried out a partial re-evaluation ourselves to test the classification and consider our status would remain as not seriously water stressed.

Despite this we have explored the potential for compulsory metering as an option to understand whether it would prove to be the most cost-effective way to balance supply and demand going forward.

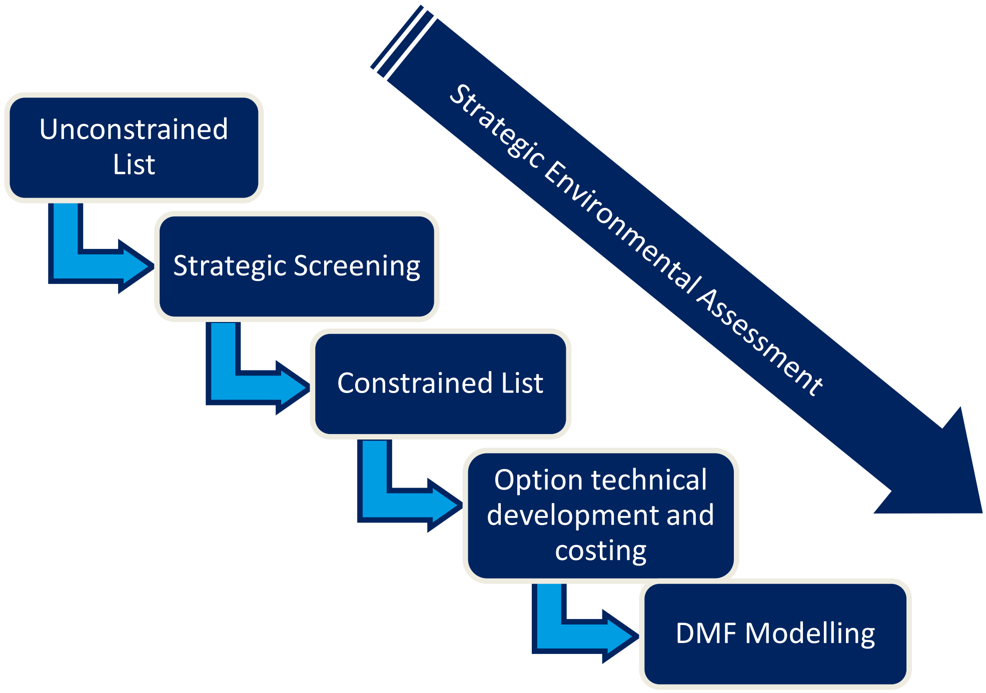
Supply options have been developed with the assistance of consultants Atkins, using a multi-stakeholder approach, both internally and externally. Details of the process of developing options and the pro formas for all feasible options are included in **appendix R**. In accordance with Defra instructions and the Security and Emergency Measures Directive Advice Notes and Guidance we have not made this detailed appendix available to the public. This report is only available to the Environment Agency.

Supply options include:

- investment in existing groundwater sources – making boreholes resilient new treatment processes based on deterioration of groundwater quality and other enhancements;
- new groundwater sources – remediation of mothballed sources, and trade or acquisition of sources from third parties;
- new surface water sources; and
- trades with third parties – neighbouring water companies and other licence holders.

Options development has followed a twin-track process from unconstrained through to constrained during which SEA has been carried out alongside options development.

## Figure 23: Options development process




Stages of options development included:

- identification of unconstrained options through brainstorming events, including both internal expertise together with leading industry consultants;
- detailed engagement with the Environment Agency in developing both demand management options and resources options identification;
- initial screening using criteria such as technical and/or environmental feasibility – show stoppers;
- further review of screening following more detailed scheme description;
- Environment Agency views sought on resources options at various stages; and
- SEA scoping occurring concurrently.

The numbers of options considered throughout the process are shown in the following table.

### Table 29: WRMP options considered

| Option type | Number of unconstrained options | Number of streamlined options | Number of feasible options in DMF | Comments |
|---|---|---|---|---|
| Maintenance of existing groundwater | 42 | 32 | 32 | Options relate to capital maintenance of existing sources including replacement boreholes and new treatment requirements to maintain existing DO. |
| New groundwater | 114 | 39 | 4 | Options include additional boreholes at existing groundwater sources to provide greater peak output, reinstatement of sites currently unused because of treatment requirements and new locations providing additional resource. |
| New surface water | | | 16 | Options to develop new surface water sources and new associated treatment plants. |
| Third party water and trades | | | 16 | Identified from approaches to and discussions with other water companies and the Environment Agency. |
| Leakage reduction | 190 | 40 | 5 bundles plus one separate option | Leakage options were bundled to provide packages of works to deliver different volumes of leakage reduction. |
| Metering and water efficiency | | | 5 bundles plus two separate options | Metering options were bundled together with some water efficiency options to provide packages of works to deliver different volumes of saving. Some metering options were also kept as separate options. |
| Total | 346 | 111 | 86 | |

Outline scheme design and costs were developed for each of the options included on the feasible list for modelling in the DMF. The criteria used to evaluate each option in the DMF modelling are described in the sections above. The following sections describe the screening of unconstrained options to the feasible list.

## 10.5 Feasible options included in DMF

### 10.5.1 Maintenance of existing groundwater sources

Options relating to the existing groundwater sources contributing to baseline DO are included in the DMF. These options are based on requirements for maintaining the DO.

Capital maintenance requirements over the next 40 years have been identified to ensure that decisions regarding new options are considered alongside options to maintain existing sources and that continuation of output from existing sources is not viewed as being at no cost

When considering capital maintenance schemes potential impacts on DO as a result of WFD ‘no deterioration’ have been factored into the expected yield. All expected AMP6 sustainability changes have been included and those sites at risk of causing deterioration if abstraction increases above the recent actual abstraction over the period 2005 to 2015 have been capped at recent actual. Therefore, the options included can all be regarded as environmentally feasible.

All groundwater sources currently in use are included in baseline DO and are included in the model as capital maintenance options.

Excluded from the baseline DO are sources that are not in operation, but may be licensed. These have been reviewed in the options screening process to determine inclusion or otherwise in the constrained list. Specific examples include:

- LBPW – a licensed source which is not currently operational This was screened out as it is low volume and the volume is included elsewhere on an aggregate licence developed into a more feasible option. There would also be a WFD limit on the available yield which screened this out on an environmental basis; and
- CRPW, SIPW, and KIPW2 – licensed sources which are not currently operational. These are options in our current drought plan and are therefore feasible. Options to reintroduce these sources are included in the ‘new groundwater sources’ options. The WFD limit on the available yield of these sources is less and therefore the options have a viable licensed yield available.

### 10.5.2 New sources

The unconstrained list of options was screened using the following criteria to derive the constrained list of options.

### Table 30: Criteria used to screen supply options

| Criteria | Considerations |
|---|---|
| **Location of scheme benefits** | |
| Scale | Option DO is proportional to the estimated supply-demand deficit. |
| Location | Option is within, or can serve, the area of estimated supply/demand deficit. |
| Future proofing | Ability to mitigate against future DO losses because of external events – climate change, licence reduction, etc. |
| **Statutory/regulatory/legal constraints** | |
| Planning and environmental | Likely to be acceptable in terms of planning and statutory environmental constraints. |
| WFD | Scheme does not cause deterioration of a WFD water body. |
| HRA | Scheme does not impact on Natura 2000 site. |
| **Meet customer/stakeholder needs** | |
| Customer | Scheme complies with customer experience targets and does not cause detriment to service standards. Avoidance of customer discrimination. |
| Internal stakeholder | Complements South Staffs Water's business plan, strategy and is in line with corporate objectives. |
| External stakeholder | Likely to be acceptable to third party group including local stakeholder groups. |
| **Option robustness** | |
| Flexibility | Option can be scaled and flexed operationally to meet supply/demand needs. |
| Favourable | Option is more favourable of all options identified for this water source. |
| Viability | Option is technically feasible. |
| Known technologies | Option is achievable without significant R&D/trials. |
| Licensing | Abstraction licence is likely to be secured. |

The technical note in **appendix S** describes the screening process in more detail.

**Appendix T** contains a report detailing the approach to costing new sources of water.

#### 10.5.2.1 New groundwater sources

Options to reinstate sites currently unused because of treatment requirements have been included in the DMF. New locations providing additional resource have also been considered.

**Table 31: New groundwater sources options**

| New groundwater sources | | | | |
|---|---|---|---|---|
| Option | NYAA Yield Ml/d | DYAA Yield Ml/d | CP Yield Ml/d | Major investment requirements |
| Recommission SIPW | 1.6 | 1.6 | 4.5 | Existing licence, mothballed source. River gravels/shallow aquifer. Extensive rebuild required. |
| Recommission CRPW2 | 1.4 | 1.4 | 2.5 | Existing licence, mothballed source. Treatment review required (filters). |
| Recommission KIPW2 | 1 | 1 | 1.2 | Existing licence, mothballed source. Treatment review required (filters). |
| Combined Ouse Gravel Sources | 2 | 2 | 5 | Existing licences combined, mothballed sources. River gravels/shallow aquifer. Extensive rebuild required At location to be determined, requiring Environment Agency agreement to relocate abstraction point. |

When considering all schemes the potential impacts on DO as a result of WFD ‘no deterioration’ have been factored into the expected yield. All agreed AMP6 sustainability changes have been included in baseline DO, and a reduction to this has been applied for WFD no deterioration risk. In agreement with the Environment Agency, deployable outputs have been capped at the recent actual abstraction for the period 2005 to 2015 to ensure there is no deterioration risk while investigations are carried out in AMP7.

#### 10.5.2.2 New surface water sources

There are limited available surface water resources within or close to our area of supply. The chalk rivers typical of the area are unsuitable for large PWS abstractions and already have existing environmental impacts. The only viable surface water source in the region is the River Ouse. Options have been explored at two key locations – the Ely Ouse and Great Ouse in the main reaches of the river where flows could be available, at high flows. We have also developed options that take a transfer from the Ely Ouse Essex Transfer scheme, a strategic north to south transfer which uses the same source. These are categorised as trades/transfers.

### Table 32: New surface water sources options

| New surface water sources | | | | |
|---|---|---|---|---|
| **Option** | **NYAA yield Ml/d** | **DYAA yield Ml/d** | **CP yield Ml/d** | **Major investment requirements** |
| Upper Stour Reservoir | 40 | 40 | 40 | New intake and treatment works, associated infrastructure, new reservoir and transfer pipelines, raw and potable |
| Abstraction from Ely Ouse with reservoir | 24 | 24 | 24 | New intake and treatment works, associated infrastructure, new reservoir and transfer pipelines, raw and potable |
| Abstraction from Ely Ouse, with reservoir – ten-year delay to coincide with settlement development North of Waterbeach | 25 | 25 | 25 | New intake and treatment works, associated infrastructure, new reservoir and transfer pipelines, raw and potable |
| Abstraction from Ely Ouse, with reservoir – no delay, pipeline connection to further South into grid | 25 | 25 | 25 | New intake and treatment works, associated infrastructure, new reservoir and transfer pipelines, raw and potable |
| Abstraction from Ely Ouse, with reservoir – including wider environmental benefits | 20 | 20 | 20 | New intake and treatment works, associated infrastructure, new reservoir and transfer pipelines, raw and potable. Landscaping access and habitat creation |
| Abstraction from Ely Ouse, with reservoir – supported by Anglian Water transfer | 40 | 40 | 40 | New intake and treatment works, associated infrastructure, new reservoir and transfer pipelines, raw and potable |
| Abstraction from Ely Ouse, with reservoir – supported by Anglian Water transfer and wider environmental benefits | 40 | 40 | 40 | New intake and treatment works, associated infrastructure, new reservoir and transfer pipelines, raw and potable. Landscaping access and habitat creation |

| New surface water sources | | | | |
|---|---|---|---|---|
| **Option** | **NYAA yield Ml/d** | **DYAA yield Ml/d** | **CP yield Ml/d** | **Major investment requirements** |
| New raised reservoir on Great Ouse | 40 | 40 | 40 | New intake and treatment works, associated infrastructure, new reservoir and transfer pipelines, raw and potable |
| New raised reservoir on Great Ouse – sub-option with smaller DO output | 24 | 24 | 24 | New intake and treatment works, associated infrastructure, new reservoir and transfer pipelines, raw and potable |
| New raised reservoir on Great Ouse – with wider environmental benefits | 30 | 30 | 30 | New intake and treatment works, associated infrastructure, new reservoir and transfer pipelines, raw and potable. Landscaping access and habitat creation |
| New raised reservoir on Great Ouse – sub-option with smaller DO output and wider environmental benefits | 18 | 18 | 40 | New intake and treatment works, associated infrastructure, new reservoir and transfer pipelines, raw and potable. Landscaping access and habitat creation |
| String of high flow winter reservoirs – one site | 10 | 10 | 10 | New intake and treatment works, associated infrastructure, new reservoir and transfer pipelines, raw and potable |
| Two high flow winter reservoirs – two sites | 20 | 20 | 20 | New intake and treatment works, associated infrastructure, new reservoirs and transfer pipelines, raw and potable |
| Three high flow winter reservoirs – three sites | 30 | 30 | 30 | New intake and treatment works, associated infrastructure, new reservoirs and transfer pipelines, raw and potable |
| Four high flow winter reservoirs – four sites | 40 | 40 | 40 | New intake and treatment works, associated infrastructure, new reservoirs and transfer pipelines, raw and potable |

| New surface water sources | | | | |
|---|---|---|---|---|
| Option | NYAA yield Ml/d | DYAA yield Ml/d | CP yield Ml/d | Major investment requirements |
| String of high flow winter reservoirs – four sites, sub-option with smaller overall DO | 24 | 24 | 40 | New intake and treatment works, associated infrastructure, new reservoirs and transfer pipelines, raw and potable |

These surface water options on the Ouse are equivalent to, or have been included as part of the WRE project (see section 4.3.6.1). Other water companies in the region also have options which make use of water from the Ouse and there are already a number of licensed abstractions. An Ouse working group with members from Anglian, Cambridge, Essex and Suffolk and the Environment Agency has been formed to understand all the potential options associated with the Ouse. This group has liaised to determine what the available yields would be from the Ouse.

### 10.5.2.3 New trades/third party inputs

We have explored the opportunity for third parties to provide water to us. This includes:

- treated water transfers;
- raw water transfers; and
- licence trades.

The feasible options which were included in the DMF are as follows.

**Table 33: New trades/third party inputs options**

| Trades | | | | |
|---|---|---|---|---|
| Option | NYAA yeld Ml/d | DYAA yield Ml/d | CP yield Ml/d | Major investment requirements |
| Affinity transfer via LOPW connection | 8 | 8 | 8 | Requires a WRE option to enable Affinity surplus from existing North ring main |
| AWS transfer from Ruthamford South – location 1 | 8 | 8 | 8 | Similar WRE option. Potable treated water – Graffham SW origin to West of CAM area in A428 corridor |
| AWS transfer from Ruthamford South – location 2 | 8 | 8 | 8 | As above, input South of A428 corridor |

| Trades | | | | |
|---|---|---|---|---|
| Option | NYAA yeld Ml/d | DYAA yield Ml/d | CP yield Ml/d | Major investment requirements |
| AWS Ruthamford North to CAM | 5 | 5 | 5 | Similar WRE option. (larger yield)<br>Potable water – SW/GW into North of CAM area. Could be purchase of GW source as alternative. |
| AWS transfer from Ely to Waterbeach – ten-year delayed start | 10 | 10 | 10 | Potable transfer, supported by WRE options, East of CAM supply area. Delay to coincide with growth in location |
| AWS transfer from Ely to Waterbeach – immediate start | 40 | 40 | 40 | As above, no delay |
| AWS transfer from Haverhill to Shudy Camps | 10 | 10 | 10 | Potable transfer, supported by WRE options, SE of CAM supply area |
| AWS transfer from Haverhill to Rivey/Linton | 20 | 20 | 20 | Potable transfer, supported by WRE options, SE of CAM supply area |
| AWS transfer from Haverhill to Balsham | 10 | 10 | 10 | Potable transfer, supported by WRE options, SE of CAM supply area |
| | 5 | 5 | 5 | |
| Transfer/ Trade off with Ely Ouse Essex transfer – with new main from Kennett PS to Waterbeach | 10 | 10 | 10 | WRE option.<br>Raw trade from EOETS, treated at either end. East of area, depending on treatment location |
| Ely Ouse Essex Transfer reversal from Abberton | 40 | 40 | 40 | Reversal of EOETS from Abberton reservoir. Otherwise similar to above. Would be supported by WRE options |
| Ely Ouse Essex Transfer reversal from Abberton – sub-option with smaller DO | 24 | 24 | 24 | As above, smaller DO |

| Trades | | | | |
|---|---|---|---|---|
| Option | NYAA yeld Ml/d | DYAA yield Ml/d | CP yield Ml/d | Major investment requirements |
| Ely Ouse Essex Transfer with new res (shared with AWS) | 40 | 40 | 40 | WRE option.<br>Shared resource with AWS, CAM supplied via EOETS or new main (raw SW) with treatment to east of area. |
| Ely Ouse Essex Transfer with new res (shared with AWS) – sub-option with smaller DO | 24 | 24 | 24 | As above smaller DO |
| Thetford (CAM)/Beck Row (AWS) sources swap | 4.9 | 4.9 | 10.7 | Acquisition of AWS GW sources with close proximity to existing main. Supported by WRE options for AWS |
| Thetford (CAM)/Barnham Cross (AWS) sources swap | 4.9 | 4.9 | 10.7 | |
| Licence trade at Barrington with new borehole, combined with CW54 – so added treatment and network connection at CRPW2/HEPW | 0.24 | 0.24 | 1.2 | Third party disused BH adoption |
| Treated water reservoir (new service reservoir) in ‘A428 corridor’ | 2 | 2 | 8 | Additional storage only – requires trade from AWS or other resource. AWS trade into west of area or new resource development |

Discussions have been held with adjacent companies Anglian Water and Affinity Water to consider the opportunities for bulk water trades. The WRE regional water resources strategy group also considers a variety of transfer options, and large resources options from all companies are included in the regional modelling. Some transfer options may be dependent on a larger resource being developed by one of the other companies to increase available resource to facilitate the trade, and these issues are considered by WRE.

### 10.5.3 Demand management

The unconstrained list of options was screened using the following criteria to derive the constrained list of options.

### Table 34: Demand management options screening

| Criteria | Considerations |
|---|---|
| Yield uncertainty | What is the risk/uncertainty of the option delivering its estimated water saving? |
| Lead time | What is the time required to deliver the water savings? |
| Flexibility | Has the adaptability of an option be reflected? |
| Security of supply | How robust is the overall scheme? |
| Environmental impact | Will the option result in environmental impacts? |
| Sustainability | What is the impact of the option on wider sustainability? |
| Promotability | Will customers support the option? |
| Suitability | How well the option meets the assumed planning problem? |
| Technical difficulty | How difficult the option is to deliver? |

After the screening exercise there remained around 35 options of which some represented only very small savings. Bundles of options which delivered different volumes of saving were then created. Bundles were created for leakage activities, and water efficiency and metering were bundled together. Some metering options were also kept as separate options.

Savings for all options are based on annual averages. For metering there may be some additional peak benefits but there is limited evidence to support this and therefore this has not been included.

Metering options were based on AMR meters, unless otherwise stated as AMI smart meters. Options are based on programmes of five years' duration unless otherwise stated.

Leakage reduction bundles 1.0 to 1.4 (phase 1) were tested in early runs of the DMF to test the baseline leakage reduction to be committed to. Leakage reduction bundles 1.5 to 1.8 (phase 2) and the live network option replaced the earlier leakage bundles in later runs to test how much more leakage could be reduced economically.

The make-up of the leakage and metering bundles is shown in the following tables. Full details of all the demand management options are included in **appendix Q**.

## Figure 24: Phase 1 leakage reduction options

| Bundles | Sub-option code | Sub-option name | Yield profile: Year first delivery | Yield profile: Year maximum yield | Yield profile: Maximum yield |
|---|---|---|---|---|---|
| Leakage Bundle 1.0 | 129 | Pressure Management | 1 | 1 | 1.64 |
| Leakage Bundle 1.0 | 073a | ALC Ph.1 | 1 | 2 | 0.87 |
| Leakage Bundle 1.1 | 059_60 | Improve allowances | 2 | 3 | 0.16 |
| Leakage Bundle 1.1 | 073b | ALC Ph.2 | 3 | 5 | 0.78 |
| Leakage Bundle 1.2 | 088 | DMA sub-metering | 1 | 2 | 0.81 |
| Leakage Bundle 1.2 | 073c | ALC Ph.3 | 6 | 10 | 1.30 |
| Leakage Bundle 1.3 | 057 | TMSR monitoring | 1 | 5 | 0.30 |
| Leakage Bundle 1.3 | 073d | ALC Ph.4 | 11 | 15 | 1.10 |
| Leakage Bundle 1.4 | 180a | LDAR Ph. 1 | 1 | 10 | 0.25 |
| Leakage Bundle 1.4 | 180b | LDAR Ph. 2 | 1 | 10 | 0.22 |

| | | | |
|---|---|---|---|
| Cam Leakage Bundle 1.0 | 1 | 2 | 2.5 |
| Cam Leakage Bundle 1.1 | 1 | 5 | 3.4 |
| Cam Leakage Bundle 1.2 | 1 | 10 | 5.6 |
| Cam Leakage Bundle 1.3 | 1 | 15 | 7.0 |
| Cam Leakage Bundle 1.4 | 1 | 15 | 7.4 |

| sub-option code | sub-option name | Yield profile: year first delivery | Yield profile: Year maximum yield | max yield |
|---|---|---|---|---|
| 500 | Live Network | 1 | 3 | 0.78 |

## Figure 25: Phase 2 leakage reduction options

| Bundles | Sub-option code | Sub-option name | Yield profile: Year first delivery | Yield profile: Year maximum yield | Yield profile: Maximum yield |
|---|---|---|---|---|---|
| CAM Leakage Bundle 1.5, CAM Leakage Bundle 1.6, CAM Leakage Bundle 1.7, CAM Leakage Bundle 1.8 | 059_60 | Improve allowances | 2 | 3 | 0.18 |
| CAM Leakage Bundle 1.5, CAM Leakage Bundle 1.6, CAM Leakage Bundle 1.7, CAM Leakage Bundle 1.8 | 073b | ALC Ph.2 | 3 | 5 | 0.78 |
| CAM Leakage Bundle 1.5, CAM Leakage Bundle 1.6, CAM Leakage Bundle 1.7, CAM Leakage Bundle 1.8 | 088 | DMA sub-metering | 1 | 2 | 0.81 |
| CAM Leakage Bundle 1.6, CAM Leakage Bundle 1.7, CAM Leakage Bundle 1.8 | 073c | ALC Ph.3 | 6 | 10 | 1.30 |
| CAM Leakage Bundle 1.6, CAM Leakage Bundle 1.7, CAM Leakage Bundle 1.8 | 057 | TMSR monitoring | 1 | 5 | 0.30 |
| CAM Leakage Bundle 1.7, CAM Leakage Bundle 1.8 | 073d | ALC Ph.4 | 11 | 15 | 1.10 |
| CAM Leakage Bundle 1.8 | 180a | LDAR Ph. 1 | 1 | 10 | 0.25 |

| Bundle | Year first delivery | Year maximum yield | Maximum yield |
|---|---|---|---|
| CAM Leakage Bundle 1.5 | 1 | 5 | 1.77 |
| CAM Leakage Bundle 1.6 | 1 | 10 | 3.37 |
| CAM Leakage Bundle 1.7 | 1 | 15 | 4.47 |
| CAM Leakage Bundle 1.8 | 1 | 15 | 4.72 |

## Figure 26: Water efficiency and metering options

| Option Code | Option | modified | year first delivery | Year maximum yield | year stop delivery | yield profile | Max Yield (Ml/d) | 2079/2080 Yield |
|---|---|---|---|---|---|---|---|---|
| 021 | Household WEFF programme company led plumber install (2 runs) | Y | 1 | 10 | 14 | | 0.2 | |
| 200.00 | Partnership with retailers for more efficient white goods (2 runs) | Y | 1 | 10 | 14 | | 0.2 | |
| 157a | Dual flush toilets social housing | N | 1 | 5 | 14 | | 0.1 | |
| 307 | Variable infrastructure charge | N | 1 | 10 | 14 | | 0.3 | |
| 023a | Non HH water efficiency programme - company led site visit with installation | N | 1 | 5 | 14 | | 0.2 | |
| 207A | Compulsory Metering AMR | N | 1 | 25 | none | | 1.7 | |
| | CAM - WEM 1.0 | | 1 | 10 | none | | 2.5 | 1.7 |
| 021 | Household WEFF programme company led plumber install (2 runs) | Y | 1 | 10 | 14 | | 0.2 | |
| 200.00 | Partnership with retailers for more efficient white goods (2 runs) | Y | 1 | 10 | 14 | | 0.2 | |
| 157a | Dual flush toilets social housing | N | 1 | 5 | 14 | | 0.1 | |
| 307 | Variable infrastructure charge | N | 1 | 10 | 14 | | 0.3 | |
| 023a | Non HH water efficiency programme - company led site visit with installation | N | 1 | 5 | 14 | | 0.2 | |
| 206A | 206 FMO AMR | N | 1 | 25 | none | | 0.2 | |
| | CAM - WEM 1.1 | | 1 | 10 | none | | 1.0 | 0.2 |
| 021 | Household WEFF programme company led plumber install (2 runs) | Y | 1 | 10 | 14 | | 0.2 | |
| 200.00 | Partnership with retailers for more efficient white goods (2 runs) | Y | 1 | 10 | 14 | | 0.2 | |
| 157a | Dual flush toilets social housing | N | 1 | 5 | 14 | | 0.1 | |
| 307 | Variable infrastructure charge | N | 1 | 10 | 14 | | 0.3 | |
| 023a | Non HH water efficiency programme - company led site visit with installation | N | 1 | 5 | 14 | | 0.2 | |
| 111A | 111 Change of Occupier AMR | N | 1 | 25 | none | | 0.4 | |
| | CAM - WEM 1.2 | | 1 | 10 | none | | 1.3 | 0.4 |
| 021 | Household WEFF programme company led plumber install (2 runs) | Y | 1 | 10 | 14 | | 0.2 | |
| 200.00 | Partnership with retailers for more efficient white goods (2 runs) | Y | 1 | 10 | 14 | | 0.2 | |
| 157a | Dual flush toilets social housing | N | 1 | 5 | 14 | | 0.1 | |
| 023a | Non HH water efficiency programme - company led site visit with installation | N | 1 | 10 | 14 | | 0.2 | |
| 207S | Compulsory Metering AMI | N | 1 | 25 | none | | 2.3 | |
| | CAM - WEM 1.3 | | 1 | 10 | none | | 2.8 | 2.3 |
| 021 | Household WEFF programme company led plumber install (2 runs) | Y | 1 | 10 | 14 | | 0.2 | |
| 200.00 | Partnership with retailers for more efficient white goods (2 runs) | Y | 1 | 10 | 14 | | 0.2 | |
| 157a | Dual flush toilets social housing | N | 1 | 5 | 14 | | 0.1 | |
| 307 | Variable infrastructure charge | N | 1 | 10 | 14 | | 0.3 | |
| 023a | Non HH water efficiency programme - company led site visit with installation | N | 1 | 5 | 14 | | 0.2 | |
| | CAM - WEM 1.4 | | 1 | 10 | 14 | | 0.9 | |
| | | | | | | | | |
| 207S | Compulsory Metering AMI | N | 1 | 25 | none | | 2.3 | 2.3 |
| 207A | Compulsory Metering AMR | N | 1 | 25 | none | | 1.7 | 1.7 |

**CAM Final Committed WEM**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | CAM - WEM 1.5 | Y | 1 | 5 | none | | 0.6 | 0.6 |
| 206A - Committed | 206 FMO AMR | N | 1 | 25 | none | | 0.3 | 0.3 |

### 10.5.4 Resilience options

A number of options have been considered specifically for resilience purposes only. These include:

- enhancing our existing groundwater portfolio, by drilling additional boreholes, therefore reducing the impact of asset outage; and
- upsizing some delivery mains to ensure we can transport our maximum license value from our existing groundwater assets.

These options have been appraised within the DMF in the same way as all the other supply- and demand-side options, and all options have been scored for how they affect operational resilience. Where included in the preferred portfolio customer support can be demonstrated.

## 10.6 Customer support for options

Our approach to customer engagement and the findings from that work are described in detail in section 5.

In general terms, customers are more in favour of all aspects of demand management including:

- leakage reduction;
- Metering; and
- education to help change behaviours.

Customers have not expressed a desire to improve levels of service and reduce the frequency of temporary use bans.

## 10.7 Modelling results

In order to successfully demonstrate that the preferred portfolio is effective and robust in meeting a range of future uncertainties, a series of scenarios were appraised within the model.

These scenarios mainly focused on stress testing the demands or available yields within the options; however, we also looked to understand the certainty in deliverability of an option and how the model would behave if some feasible options were excluded from the analysis (for example, the live network option). In addition to this, we have optimised across a range of the other objectives included within the MCA to understand how bringing in portfolios with a greater level of resilience, or more focused on customer preferences would change the base portfolio.

Through the scoring of some of the objectives within the MCA approach, such as resilience and deliverability we were able to generate the following scenarios.

- Scenario 1: Reduced DO as a result of a more extreme view of the impact of WINEP (additional 11Ml/d reduction on DYAA DO).
- Scenario 2: Reduced DO and demand because of drought.
- Scenario 3: A higher rate of growth than currently predicted.
- Scenario 4: Exclusion of options where there was some particular uncertainty:
  - live network – because of uncertainty of volumes delivered.

We then overlaid the outputs of our specific WRMP customer engagement work to ensure that our customer preferences around the supply and demand options were reflected within our preferred portfolio, enabling us to demonstrate a level of customer interaction and co-creation.

The outputs of the DMF for each of these scenarios were then considered in the context of the distribution network to ensure that we maintained or improved on our customer priorities and hygiene factors such as continuous supplies and excellent water quality.

#### 10.7.1.1 Base – least cost run

Our least cost programme was derived from a combination of two modelling runs of the DMF.

- The first run had no reductions to DO for WINEP and was the baseline demand forecast. This identified the most cost-effective leakage reduction.
- The second run included the leakage reduction identified in stage 1 applied to the demand forecast and also included reductions in DO applied to our groundwater sources to reflect the most likely impact from WINEP.

#### Results

- Groundwater – 97Ml/d DO for DYAA (maintain all sites except RIPW and HEPW).
- Leakage – 2Ml/d reduction over AMP7.
- Compulsory metering – from year 24.
- Live network – earliest introduced in year 15 (1.4Ml/d).
- Trades – Affinity via LOPW (year 55).

#### 10.7.1.2 Sensitivity testing

We then considered scenarios to test the least cost programme. The identified leakage reduction was applied to the demand forecast line for these runs so a 2Ml/d leakage reduction was an embedded option in all cases.

### Scenario 1 – more extreme WINEP

We looked to apply a more severe application of the potential impact of WINEP. To enable the model to return a feasible result we had to reduce the construction period of those feasible solutions that could be delivered in time for a 2020 start date.

#### Results

- Groundwater – 93Ml/d DO on DYAA (maintain all sites).
- Leakage – 2Ml/d reduction (included by reducing demand).
- Live network – year 16 (1.4Ml/d).
- Compulsory metering – year 26.
- New Groundwater – recommission CRPW2 (1.4Ml/d).
- Trades – Affinity via LOPW (year 55).

### Scenario 2 – Drought

We then considered scenarios to test the least cost programme. The identified leakage reduction was applied to the demand forecast line for these runs so a 2Ml/d leakage reduction was an embedded option in all cases.

In this scenario, the available groundwater yield was set at the DO modelled for the worst drought impacts at those sources where yields could be reduced in drought. The demand applied for dry year average, and the peak scenario is the constrained demand after any drought management measures have been employed.

#### Results

- Groundwater – 85Ml/d DO on DYAA (maintain all sites).
- Leakage – 2Ml/d reduction (included by reducing demand).
- Live network – year 4 (1.4Ml/d).
- Compulsory metering – year 18.
- Additional leakage – year 7 rising to 3.4Ml/d by year. 15.
- New groundwater – recommission CRPW2 (1.4Ml/d).
- Trades – Affinity via LOPW (year 55).

In this portfolio, as a result of available licences already being reduced for no deterioration, more increases in demand management are required, reflecting the need for drought management options as per our drought plan.

### Scenario 3 – Higher rate of growth than predicted

Because of the scale of growth we are experiencing in the Cambridge area, and the levels of growth forecast to continue, we have run a scenario with a higher demand forecast based on an increase in properties above that included in our baseline demand forecasts. The need to consider a higher growth scenario is further supported by development proposals such as the Milton Keynes–Oxford–Cambridge corridor. The impact of this on the future development of Cambridge is not clear at this stage but it is prudent to take the view that growth will be greater.

The feasible portfolios which were generated were in line with the extreme WINEP scenario, utilising more of the available groundwater.

#### Scenario 4 – Excluding uncertain options

There is some uncertainty over the scale of leakage reduction which the live network option could deliver. Since this was selected in most portfolios within the 25-year planning period we tested to see what the alternative option would be if this were excluded from the modelling.

The feasible portfolios were similar to those selected for the extreme WINEP scenario, utilising more of the available groundwater.

### 10.7.1.3 Resilience

We also looked to understand the benefit of maximising the levels of resilience we could achieve by potentially doing something different within our asset portfolio.

We had included a number of feasible options that delivered the same DO, but offered more in terms of operational resilience. Coupled with this we also included network options to enhance our transfer capabilities, improving our operational flexibility.

We ran a series of scenarios targeting increased operational resilience. There was a clear trade-off between cost and resilience. We also tested the outputs of these scenarios with our network experts to ensure that the optimised portfolios were both feasible, in terms of network constraints, and also delivered local operational resilience.

### 10.7.1.4 The preferred portfolio

The outputs presented in the table below show the journey from the base least cost scenario through to a hybrid portfolio that we consider demonstrates a robust flexible approach to ensuring the balance of supply and demand into the future. The preferred portfolio has been shaped by what our customers have told us is important. In essence this promotes demand-side opportunities and balances resilience benefits against cost for supply-side options.

## Table 35: Our preferred portfolio

| | Portfolio results | | | | | | |
|---|---|---|---|---|---|---|---|
| | Baseline | WINEP applied (leakage reduction applied) | Drought (leakage reduction and WINEP applied) | Extreme application of WINEP (leakage reduction applied)* | Increased operational resilience (with WINEP and leakage reduction) | Reflecting customer preferences (with WINEP and leakage reduction) | Preferred |
| Existing groundwater | All existing groundwater – excluding RIPW and LIPW | All existing groundwater – excluding RIPW and LIPW | All existing groundwater (further reduce yield) | All existing groundwater | All existing groundwater | All existing groundwater | All existing groundwater |
| Leakage | 2Ml/d reduction<br>live network – yr14 1.4Ml/d | 2Ml/d reduction<br>live network – yr14 1.4Ml/d | 2Ml/d reduction<br>live network – yr4 1.4Ml/d | 2Ml/d reduction<br>live network – yr16 1.4Ml/d | 2Ml/d reduction<br>live network – yr1 1.4Ml/d | 2Ml/d reduction<br>live network – yr14 1.4Ml/d | 2Ml/d reduction<br>Explore live network |
| Demand management | Compulsory Metering yr24 – rising to 2.3Ml/d by yr51 | Compulsory Metering yr24 – rising to 2.3Ml/d by yr51 | Compulsory Metering yr18 – rising to 2.3Ml/d by yr45 | Compulsory Metering yr26 – rising to 2.3Ml/d by yr53 | Compulsory Metering yr26 – rising to 2.3Ml/d by yr53 | Increase meter optants<br>Increase water efficiency | Increase meter optants<br>Increase water efficiency |
| New groundwater | Nothing selected | Nothing selected | Reintroduce CRPW2 | Reintroduce CRPW2, | Reintroduce CRPW2, KIPW2 and SIPW | Nothing selected | Reintroduce CRPW2, KIPW2 and SIPW |
| New surface works | Nothing selected | Nothing selected | Nothing selected | Nothing selected | Nothing selected | Nothing selected | Nothing selected |

| Portfolio results | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Baseline | WINEP applied (leakage reduction applied) | Drought (leakage reduction and WINEP applied) | Extreme application of WINEP (leakage reduction applied)* | Increased operational resilience (with WINEP and leakage reduction) | Reflecting customer preferences (with WINEP and leakage reduction) | Preferred |
| Trades | Affinity – LOPW yr 55 | Affinity – LOPW yr 55 | Affinity – LOPW yr 55 | Affinity – LOPW yr 55 | Affinity – LOPW constructs sooner, but not utilised | Affinity – LOPW yr 55 | Affinity – LOPW yr 55 |

*Same portfolio was selected for increased growth.

South Staffs Water

incorporating

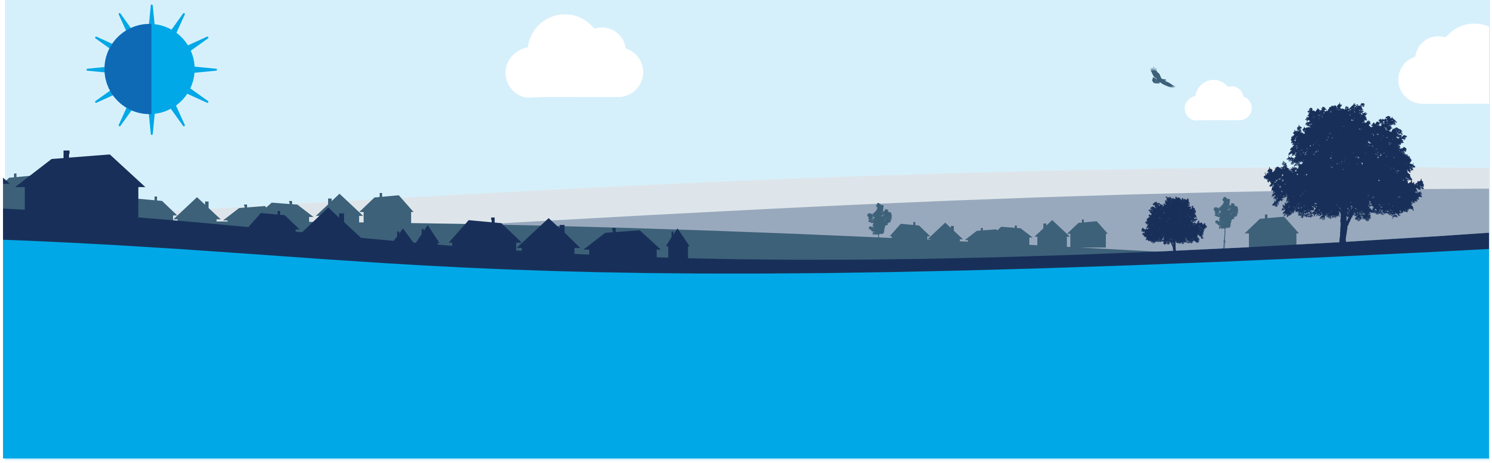
CAMBRIDGE WATER COMPANY

# South Staffs Water

## Draft Water Resources Management Plan 2019

Section 10:

# Deciding on future options



# 10. Deciding on future options

**Overview of options development and selection**

We have followed the eight-stage approach outlined in 'WRMP 2019 Methods – decision making process guidance' (UKWIR, 2016) for the identification of options and selection of our proposed programme of work.

We have carried out a process of defining the challenge we are facing and quantifying the complexity and scale of it. This has helped us define the approach to decision-making which is appropriate for us and our circumstances.

We have developed a multi-criteria decision-support tool to help model the future and make robust decisions about our proposed programme.

We have developed an unconstrained list of options, including:

- demand-side options;
- supply-side options;
- production options;
- third party options; and
- resilience options.

These have been screened and evaluated to define our list of feasible options. An SEA has been carried out on all feasible options to help inform the proposed programme.

All options have been modelled in our MCA tool under a range of scenarios to test our plan.

We have developed our proposed programme taking account of customer views, cost, resilience, environmental impact and deliverability.

## 10.1 Overview

We have followed the eight-stage approach outlined in 'WRMP 2019 Methods – decision making process guidance' (UKWIR, 2016) for the identification of options and selection of our proposed programme of work.

1. Collate and review planning information.
2. Identify unconstrained options.
3. Problem characterisation and evaluate strategic needs/complexity.
4. Decide modelling method.
5. Identify and define data inputs.
6. Undertake decisions making modelling/options appraisal.
7. Stress testing and sensitivity analysis.
8. Final planning forecast and comparison to EBSD benchmark.

Traditionally, options would only be developed where a supply/demand balance deficit has been identified or is likely and an intervention is required to breach the gap. Problem characterisation for South Staffs Water identified that because of the need to invest in our two major treatment works to ensure long-term serviceability of resources there is an opportunity to review our existing operations across all sources to identify the most appropriate mix of supply and demand options going forwards irrespective of any supply/demand deficit. This approach allows us to take an integrated view of key questions for decision-making regarding water resource assets.

- How do we ensure that our assets are fit for purpose?
- How do we ensure we meet our future demand scenarios?
- Can we improve our levels of operational and extreme drought resilience?
- How do we ensure the decisions meet current and future needs?
- How do we ensure our plans reflect our customers' priorities and preferences?

A full appraisal of capex, life cycle costs and opex (totex) for all options (existing resources and potential new resources as well as demand management options) ensures we can produce a least cost solution. The inclusion of other un-monetised attributes also allows us to optimise on other objectives and understand the value of differences. This multi-criteria approach and the decision-making framework (DMF) is described in detail later in this section.

Therefore, a full range of demand management options and supply options including all existing sources have been developed for modelling in the DMF and this allows the opportunity to re-evaluate the mix of resources for the future and ensure our assets are able to meet future demand scenarios.

## 10.2 Problem characterisation

The problem characterisation assessment is a tool for assessing our vulnerability to various strategic issues, risks and uncertainties. This assessment enables the development of appropriate, proportional responses with regards to decision-making. We followed the approach set out in the latest guidance 'WRMP 2019 Methods – Decision Making Process'; this provided a robust and consistent approach that we applied to both our regions of operation.

There are two key areas to the problem characterisation assessment.

- How big is the problem? This assesses the scale of the strategic needs and the requirement for either new resources or demand management activities.
- How difficult is it to solve? This assesses the complexity of the challenge.

A detailed internal stakeholder workshop was held in both regions, facilitated independently by Arup and HR Wallingford. The appraisal of both scale of problem and complexity, concluded that compared with WRMP14, we face new risks to our overall supply/demand balance. The problem characterisation was developed collaboratively and is presented below. A full report detailing the problem characterisation is included in **appendix R**.

**Figure 17: Problem characterisation assessment**

| | | Strategic Needs Score ("How big is the problem") | | | |
|---|---|---|---|---|---|
| | | 0-1 (None) | 2-3 (Small) | 4-5 (Medium) | 6 (Large) |
| **Complexity Factors Score ("How difficult is it to solve")** | Low (<7) | PR14 | | | |
| | Medium (7-11) | | | PR19 - SST | |
| | High (11+) | | | | |

Our WRZ is in the amber area of medium strategic needs (scale of the problem) and complexity scores (how difficult problem is). Based on the information presented in our WRMP14 our WRZ would previously have been in the green area of lower risk.

The key drivers behind the changes to the level of risk are:

- a wider appreciation of drought resilience, which means that we may be vulnerable to droughts that are different to those experienced historically;
- wider resilience issues affecting our WRZ; there is a potential decline in the volume, quality and reliability of available water resource without the renewal of long-term treatment work assets; and
- high-level concerns because of regulatory pressures on abstraction licenses which are leading to license claw back and sustainability reductions.

The significance of the WRMP problem characterisation is that it drives a need for more sophisticated decision making, based on a more complex extended modelling approach.

## 10.3 Modelling method and data inputs

We have in the past followed the economics of balancing supply and demand (EBSD) approach, which is a well-established framework and traditionally focused on monetisation and developing least cost portfolios to meeting supply and demand challenges. However, for the more challenging complex issues identified through the problem characterisation a more sophisticated approach to analysis is required.

Working with Arup and Hartley McMaster, our incumbent provider for asset management optimisation, we reviewed appropriate methods for combining both a WRMP challenge together with a more traditional asset management problem. The aim was to provide a platform that enabled us to appraise our whole supply capability challenge. Together we worked through the UKWIR guidance to develop our existing optimisation software, which follows EBSD for portfolio selection, and extended it to allow investment option performance against other objectives to be assessed and incorporated into the portfolio selection process using multi-criteria analysis (MCA) techniques.

Because of the need for potentially significant expenditure in our two strategic surface water treatment works, we looked to extend our analysis beyond the WRMP and include aspects of asset management. This enables us to appraise our whole supply capability and ensure that we make a robust and flexible decision, for now and in the future.

MCA is listed as a 'Current (Baseline) Approach' in the guidance document, with this approach being followed by some water companies for previous plans. However, it is recommended that it is reasonable for a water company to take a progressive, yet pragmatic approach to WRMP 2019 based on the experience from WRMP 2014. We assessed in the problem characterisation that our area would have been classified as green at WRMP 2014 and therefore a move to MCA for this draft WRMP is a progressive move. We consider that through our application of MCA across a range of supply and demand scenarios, this approach goes beyond the 'Current (Baseline) Approach' and represents an 'Extended Approach'.

The model can appraise both supply, including the requirements to maintain existing assets, and demand-side options, and requires monetised information regarding construction, lifecycle and operating costs. Yield information for each of the planning scenarios is also captured, as well as any demand-side reductions/benefits.

The decision making within the model appraises two key criteria first; these are treated as 'gateways' in the model (quantity and quality). These gateways are linked back to our customer priorities and hygiene factors and triangulate well with all other PR19 engagement to date, together with our ongoing day-to-day customer insight work.

A report detailing the modelling approach is included in **appendix S** and a summary of key aspects is included in the following sections.

#### 10.3.1.1 Quantity

For each year of the planning period the DMF requires the demand problem to be set for each WRZ. This is the volume of water required for the zone, including allowances for:

- headroom;
- climate change; and
- population growth.

In line with water resource management planning guidelines, and in order to understand the normal operating scenario, the annual demand in the framework is set as a three-tier problem.

- Dry year annual average (DYAA).
- Dry year critical period (DYCP).
- Normal year annual average (NYAA).

In any year of the planning period the combination of options selected must be able to deliver the volume required for each of these scenarios as a minimum. The model is free to provide a volume greater than that required and subsequently partially utilise some sources. All volumes are megalitres per day (Ml/d).

In order to understand the impact of different population growth and climate change projections it is envisaged that a series of different future demand projections are generated that reflect different futures. This is further discussed in section 10.7.

#### 10.3.1.2 Quality

The intention to include water quality in the framework is predicated on the assumption that we need to demonstrate that investments related to a particular source will deliver the required water quality both now and into the future against a range of possible future challenges, therefore meeting customer expectations.

There are choices to be made and trade-offs to consider in terms of the degree of sophistication, future proofing and flexibility for future adaption depending on the pace and scale of emerging challenges. There is likely to be more than one acceptable solution to the various quality issues, and thus a degree of potential for different optimised portfolios.

We considered several measures currently.

- Regulatory (mean zonal compliance).
- Customer opinion (acceptability).
- DWI reported events/incidents.

If quality is to be taken into account a mechanism needs to be found to assess the relative beneficial impact on quality over time of each option considered.

Two options for assessing quality benefit were considered.

1. Measurement of the number of failures that each option reduces compared to a 'do nothing' baseline (failure based).
2. The degree of quality improvement or protection that each option provides against a set of assumed challenges (risk based).

Option 1 was discounted because of the difficulty and limited accuracy of generating sensible do nothing baselines and the highly subjective assessment of failure reduction for each project in isolation from other improvement activity over such an extended period of time. Option 2 has been developed as the basis of the approach to assessing the water quality impact of different investment options.

Water quality is impacted by both external and internal factors and investment decisions need to take account of known and likely changes to both. External factors such as raw water quality arriving at abstraction points, pollution, climate change impacts on water quality, peak summer temperatures and third party contamination can all be assessed in terms of risks, historic information and assumptions made on current and future challenges.

Assessments of water quality cover a wide range of parameters and it is not the intention of this framework to provide a detailed analysis of treatment performance; its purpose is to allow comparison between different investment options. Working with our internal water quality experts, in conjunction with Arup, a series of high-level water quality metrics have been identified against which the performance of investment options can be assessed. These are as follows.

- Microbiology – E.coli, Coliforms, Clostridia, Cryptosporidia.
- Pesticides – nitrates, metaldehyde.
- Disinfection by-products – THM potential.
- Aesthetic/discolouration potential – iron, manganese, aluminium.

For each source of water, a target water quality grade is entered for each water quality metric for each year of the planning period. This enables the model to reflect changing water quality and treatment targets over time.

Each investment option entered into the model must specify its performance capability with respect to each water quality metric. This is discussed later in the report.

#### 10.3.1.3 Multi-criteria

All options are also scored against other un-monetised objectives, including:

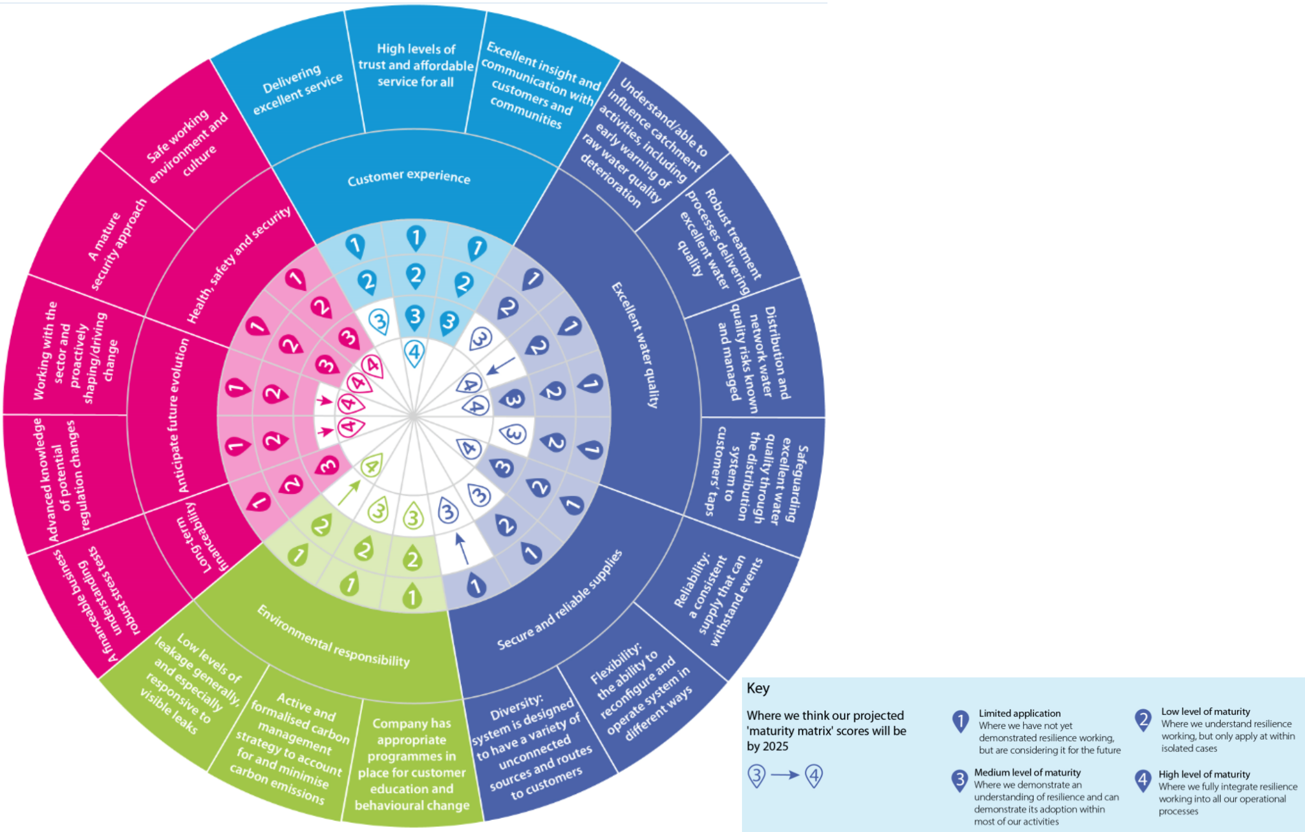
- operational resilience – each option was scored on how the delivered solution would improve reliability, flexibility and the diversity of our supply capability;
- deliverability – each option was scored to assess the operational certainty of the solution, if any third party consents were required;
- environmental sustainability – this was a basket measure and all options were scored on levels of carbon and impact on biodiversity, scale and severity (both during construction and implementation);
- social sustainability – this a measure of disruption on local communities; and
- customer preference – this was gained from our customer engagement programme.

#### 10.3.1.4 Resilience

We have been reviewing our approach to defining, quantifying and presenting resilience. To support this, we have developed a tool described as a ‘resilience lens’ with a number of key business objectives and a selection of desired states.

Elements from this business resilience tool can be associated with outputs from the DMF and in several different criteria when used in the assessment of investment options (figure 18). A single investment option on its own will have limited influence on the lens. However, if the cumulative impact of multiple options is considered, then an overall resilience performance for a portfolio can be calculated and compared against other portfolios. The choice of investment options is not able to influence performance against the entire resilience lens but will impact elements of the resilience lens as indicated in figure 18.

## Figure 18: Resilience lens segments




### 10.3.1.5 Operational resilience

A major component of our resilience, that the choice of the long-term plan investment options can impact on, is operational resilience. A number of elements of operational resilience were considered for inclusion in the DMF. The selected categories are listed below.

- The extent to which an option impacts the **reliability of supply** to customers at the right volume and quality.
- The extent to which an option impacts the **flexibility of supply** options across the WRZ.
- The extent to which an option impacts the **diversity of supply** options available in the WRZ.

Each of the feasible options were scored from one to four, with the lowest score assigned to options that have a low impact on resilience and the highest score to those that have the largest impact on resilience. The factors considered in the scoring are shown in figure 19.

## Figure 19: Operational resilience

| | Reliability | Flexibility | Diversity of supply |
|---|---|---|---|
| **Principle** | **The degree of reliability of critical assets - levels of unplanned outage** | **The degree of flexibility to reconfigure system to respond to events** | **The degree of diversity of supplies available; level of dependency on sources.** |
| **Factors** | Levels of drought susceptibility; range of yield Level of competition for the resource | Physical location of the resource within the network, ability to help support areas of single source | Extent to which the WRZ deployable output is dependent on this option |
| | Treatment vulnerability; level of complexity, difficulty of treatment, extent of dual streaming, extent of bankside storage. Experience of outage on existing sites | Ability to help the network recover, particularly with respect to North South and South North transfers | Extent to which the local network or area of supply is dependent on this option. |
| | Impact on discolouration events | Ability to provide extra capacity from normal (peak demand) | |
| **Score** | *Enter Option Score (0 to 5)* | *Enter Option Score (0 to 5)* | *Enter Option Score (0 to 5)* |

All these attributes provide the framework for the MCA. Incorporating these aspects into the optimisation provides us with a robust DMF. Optimising across the full range of objectives together with stress testing key drivers, such as demand scenarios, yields and critical cost elements has enabled us to demonstrate that a robust, no regrets decision has been made.

### 10.3.1.6 Deliverability

Deliverability describes the complexity of an option in terms of execution. More complex solutions may provide a step change improvement but the benefits are less certain. A less complex solution may be a quick win and simple to implement but may not provide longevity of solution. For new technology there is also a risk that it will not work as well as expected, or that it costs more than anticipated. It provides a pragmatic means to measure the ease of an option in terms of development, implementation and operation to deliver a required outcome.

Within the DMF deliverability is defined as follows.

- **Third party approvals** – the degree of difficulty involved in obtaining permission to carry out the option and the likelihood that the options will be approved. This includes environmental and social impacts and effort associated with mitigating unacceptable impacts, the costs of this are included in the totex figure. A scheme which is located near or within an area of social or environmental significance will incur significantly more complex and intensive third party approvals and requirements. We also considered infrastructure such as the power and gas network from both a capacity and availability perspective.
- **Benefits proven** – the degree of confidence that the scheme will deliver anticipated benefits. This is demonstrated through the strength of the evidence base of solution benefits being demonstrated previously at scale in the water sector, and context relevant to the scheme proposed (that is, track record in material benefits). For example, a well-established

treatment technology may have a strong evidence based demonstrating benefits, but if it has never been applied at similar scale to that proposed by us this option is less well proven than one which has a strong evidence base at the relevant scale. For example, large-scale water efficiency may not have been proven.

- **Operations proven** – the degree of confidence that we will be able to operate, carry out or deliver the scheme without issue. This is based on both the technology maturity and how well acquainted we are with the site – for example, introduction of an existing mothballed site would be more deliverable than the introduction of a new resource.
- **Contractual supply chain risk** – level of risk associated with suppliers and supply chain needs for scheme. This revolves around the number of players in the supply chain with whom we do not already have existing or trusted relationships. Each new relationship represents an additional element of risk within the scheme as issues are more likely to arise within new relationships where expectations are not as well established and understood as in long-standing supply chain relationships.

The scoring matrix is shown in figure 20.

### Figure 20: Deliverability scoring

**Deliverability**

| | Third Party Approvals | Benefits Proven | Operations Proven | Contractual Supply Chain Risk |
|---|---|---|---|---|
| 5 | Scheme does not trigger any third party approval. | Anticipated results proven at scale in the UK. High degree of confidence. | Technology and resource already used by South Staffs. Proven track record in with South Staffs. | Existing supply chain with good relationships well established. Simple contractual arrangements. Low risk. |
| 4 | Scheme triggers simple third party approval. South Staffs are well versed in the process. Scheme will almost certainly be approved. | Anticipated results proven in theory or outside the UK. High degree of confidence. | Technology or resource known to South Staffs but not currently used or use being significantly increased.. | Existing supply chain with some new players and some existing players. Contractual complexity relatively simple. |
| 3 | Scheme triggers moderately complex third party approval. South Staffs know the process. Some uncertainty around likelihood of approval. | Strong evidence demonstrates that the scheme will deliver anticipated results. Good degree of confidence. | Technology or resource new to South Staffs but well known to other water companies. . | Both new and existing players in supply chain for scheme. Moderate contractual complexity, moderate degree of risk. |
| 2 | Scheme triggers complex third party approval process. South Staffs unfamiliar with process. Some uncertainty around likelihood of approval. | Evidence demonstrates that the scheme will deliver anticipated results. Moderate degree of confidence. | Technology not currently implemented in the UK or new resource to South Staffs with some data availability , not currently used by others. | Most players in the supply chain are new to South Staffs but all have very strong track records. Contractual complexity greater than usual for South Staffs |
| 1 | Scheme requires complex third party approval, not previously undertaken by South Staffs. Much uncertainty around likelihood of approval success. It is as likely that the application will be rejected as approved. | Evidence suggests that the scheme will deliver anticipated results. May require additional investment to get these benefits. Moderate degree of confidence. | Technologies not implemented anywhere else in the world or totally new resources with no data availability. . | Most players in the scheme supply chain are new to South Staffs. High degree of contractual complexity and risk. |

| Magnitude Factor | |
|---|---|
| 1 | Less than 10 Ml/d |
| 2 | 10 Ml/d - 40 Ml/d |
| 3 | 40Ml/d - 100 Ml/d |
| 4 | More than 100 Ml/d |

**Total Deliverability Score =** Sum of scores x Magnitude

### 10.3.1.7 Environmental sustainability

Environmental sustainability is an important part of our existing decision making and operations, with a specific ODI allocated to 'Operations which are environmentally sustainable'. Within this outcome there are several different ODIs, including:

- leakage (financial incentive to meet set performance levels);
- water efficiency (PCC);
- biodiversity (non-financial reputational measure); and

- operational carbon (non-financial reputational measure).

Within the DMF, environmental sustainability has been measured through the following elements.

- Lifecycle carbon.
- Biodiversity.
- Sustainable abstraction.

A summary of how these indicators in the framework including inputs and background to their development is described below.

## Lifecycle carbon

Carbon emissions are ordinarily measured as ‘embodied’ or ‘operational’. Embodied carbon is the sum of emissions of greenhouse gases from the manufacture, transport and construction of materials, together with end of life emissions. Operational carbon is the emissions of greenhouse gases during the operational or in-use phase of a building or asset.

## Figure 21: Carbon scoring

**Carbon Emissions**

| | | | |
|---|---|---|---|
| Energy Consumption | | kWh/year | |
| Output | | ML/year | |
| KWh/ML | =Energy / Output | KWh/ML | |
| CO2e factor - energy | 0.50036 | kgCo2e/KWh | *(UKWIR workbook 15/16 value)* |
| Operations Carbon for Option | '= KWh/ML x kgCO2e/KWh | kgCO2e/ML | |
| Comparison Score | | | |
| Carbon Score | =comparison score x output | | |

| *Score* | *Comparison of option carbon with corporate measure* |
|---|---|
| *5* | *<0.1% of total corporate emissions* |
| *4* | *>0.1% - <0.3% of total corporate emissions* |
| *3* | *>0.3% - <0.5% of total corporate emissions* |
| *2* | *>0.5 - <1% of total corporate emissions* |
| *1* | *>1% of total corporate emissions* |
| ***SST Region emissions 2015/16 = 42,796,197 Kg CO2 on 120,964Ml*** | |

The average energy consumption per year in full operation is calculated. This is then divided by the expected output from the option to quantify KWh per Ml. This is multiplied by the emissions factor calculated in the current UKWIR workbook.

The emissions result is then compared with the corporate total figure (currently 0.48Tonnes$CO_2$e/Ml) and a score assigned. The final carbon score is calculated by multiplying the assigned comparative score by the volumetric output of the option.

## Biodiversity

Biodiversity represents the variety and population of animals and plants and the effectiveness of the natural systems that support them. Measuring changes in biodiversity in a business’s decision making demonstrates stewardship and social responsibility in this area.

In 2010, the UK was a signatory to the Convention of Biological Targets, where a set of 20 global targets were defined dedicated to biodiversity goals (known as the 'Aichi Targets'). It has taken more than five years to define a biodiversity indicator to inform the decision-making process for a business.

As biodiversity is a devolved responsibility in the UK, it is difficult to pinpoint specific quantifiable measures that are comparable. There are also many different indicators to choose from rendering any tool cumbersome for the user. Since Aichi, the Joint Nature Conversation Committee (JNCC) has defined an indicator for biodiversity specifically for decision making as the "number of publicly accessible records [within the National Biodiversity Network Gateway] at 1km$^2$ resolution or better".

Therefore, on a global, national and regional scale, biodiversity can be used in decision making based on land area impacted (hectares) and a qualitative means to represent change over time for any indicator relevant to the decision. The indicator developed by the JNCC does not say if the solution reaches a specific target or if the solution is 'good or bad' for biodiversity. It does, however, define if a solution has a detrimental or improving effect on biodiversity, or no change. The JNCC also included time in this qualitative method – short term representing change over five years or less and long term as changes over more than ten years. The European Environment Agency and Defra both subscribe to this method in their KPI expectations.

Our current ODI for this indicator quantifies the "number of hectares under active environmental management". While this is an easily understandable and comparable measure, it does not define the extent of the success of the management being carried out from a particular approach or method. The DMF takes both our current measure as a scaling factor and the JNCC indicative impact scale and provides a simple way for the tool's user to define biodiversity as appropriate to the solution in question.

As with the JNCC approach, it will not specify targets to be met or if a solution is good or bad, but it does enable the decision to be informed regarding likely positive and negative impacts to an area of space affected by the implementation of a solution.

The biodiversity scoring method is shown in figure 22.

Hectares affected is based on understanding of the biodiversity in the area and how the solution may impact it.

To replicate the JNCC definition described above:

- 'implementation' period equates to five years or less from the start of build/implementation to point of hand over; and
- 'operation' represents the long-term effect on the biodiversity after the solution is implemented and is operating as business as usual.

## Figure 22: Biodiversity scoring

**Biodiversity**

| | | | | |
|---|---|---|---|---|
| Hectares Affected | | hectares | | |
| | Implementation Phase | Operational Phase | 1 | Detrimental |
| Biodiversity | | | 2 | No Change |
| | | | 3 | Improvement |
| **Biodiversity Score** | =[implementation + operation] x hectares | | | |

This impact scores are defined as follows, compared to prior to implementation.

- **Detrimental** – for the biodiversity measures important to the area affected, a detrimental impact is anticipated.
- **No change** – there will be no impact or change to the existing biodiversity of the area considered.
- **Improvement** – a positive impact is anticipated from the solution in the area considered.

The scores are then scaled by area affected for option comparison.

### Sustainable abstraction

Regulators and the industry at large agree that water abstraction must be sustainable and does not damage the environment. Sustainable abstraction can incorporate:

- leakage;
- water efficiency;
- metering; and
- consumer behaviour.

As these are covered in other indicators and work streams, this sub indicator allows the user to score sustainable abstraction based on designation against the affected catchment area and the difference estimated from solution implementation.

Solution development will be done with the appreciation of water cycle in geographical and volume terms to ensure that demand is met in the right location across the network. This is associated with the quantity measure but also that the quantity is in the right place. The current Restoring Sustainable Abstraction (RSA) programme is likely to lead to licence changes and designation changes that are not currently known, which can make this a difficult measure to pinpoint over a longer time horizon planning period.

If a region is designated as over-abstracted by the Environment Agency, then abstraction licences are likely to be reduced or removed. Some licences are also time limited.

The Environment Agency provides catchment abstraction management strategies for a specified catchment area. These are informed on a water availability status for the region. Our South Staffs region is considered a medium water stress area; our Cambridge region is a high water stress area (that is, it is over abstracted). The framework needs to be account for the regional differences and any potential future changes that may be enforced.

Abstraction licences impacts need to be considered using the following information.

1. Size of catchment area available and the volume affected within this area.
2. Environment Agency designation of abstraction from the catchment that is deemed sustainable.
3. The abstraction licence available to us, even if it not fully utilised.

The DMF assesses what the change in abstraction would be against the licensed volume as a result of a solution's implementation.

The framework therefore uses volume abstracted (Ml/d) and a qualitative score based on the Environment Agency's current water resource availability status designation as a scaling factor (in order of increasing benefit):

- 1 – over abstracted;
- 2 – no water available (no new licences);
- 3 – water available, 'no deterioration' or impact on WFD; and
- 4 – Reduction in abstraction – for example, demand management.

The sustainable abstraction scoring method is shown in figure 23. The water sensitivity score is based on the Environment Agency's definitions for the area in question.

Impact scoring is arranged to show any reduction in abstraction to have a more favourable (higher) score, and a lower score for where abstraction is taking place in areas that highly water stressed.

### Figure 23: Sustainable abstraction scoring

**Sustainable Abstraction**

| | |
|---|---|
| Volume of abstraction impacted (Ml/d) | 80 |
| Water Sensitivity Score | 3 |
| Sustainable Abstraction Score | = Volume x Water sensitivity |

| | |
|---|---|
| 1 | Over Abstracted |
| 2 | No water available |
| 3 | Water Available, no deterioration or impact on WFD |
| 4 | Reduction in abstraction (e.g. demand management) |

The sustainability abstraction score is then derived by a simple multiplication of score and output (Ml/d).

#### 10.3.1.8 Combined score

The final indicator score is a sum of the three inputs described above. It is important to note that this indicator covers a number of different and complex elements in sustainability. The scoring is to be used for comparison purposes only. A low score does not necessarily imply a solution is detrimental to the environment, but that it has less positive benefit compared with other solutions considered.

#### 10.3.1.9 Customer preferences

The embedding of customers' preferences within the technical decision making process is a critical element of investment planning; in order to allow decisions to be guided by this a simple indicator has been utilised as shown in figure 23. This applies a score to each option based on how well it is aligned with customer preferences. This is informed by the customer engagement workshops.

## 10.4 Options development

Demand management options have been developed with the assistance of consultants Artesia. Details of the process of developing options and the pro formas for all feasible options are included in **appendix T**.

Demand management options include:

- leakage reduction – including innovative options that enhance the efficacy of leak detection;
- water efficiency – options that stretch the boundaries of traditional water efficiency measures;
- metering – more free meter options, change of occupier metering and compulsory metering with different types of meter.

Supply options have been developed with the assistance of consultants Atkins. Details of the process of developing options and the pro formas for all feasible options are included in **appendix U**. In accordance with Defra instructions and the Security and Emergency Measures Directive Advice Notes and Guidance we have not made this detailed appendix available to the public. This report is only available to the Environment Agency.

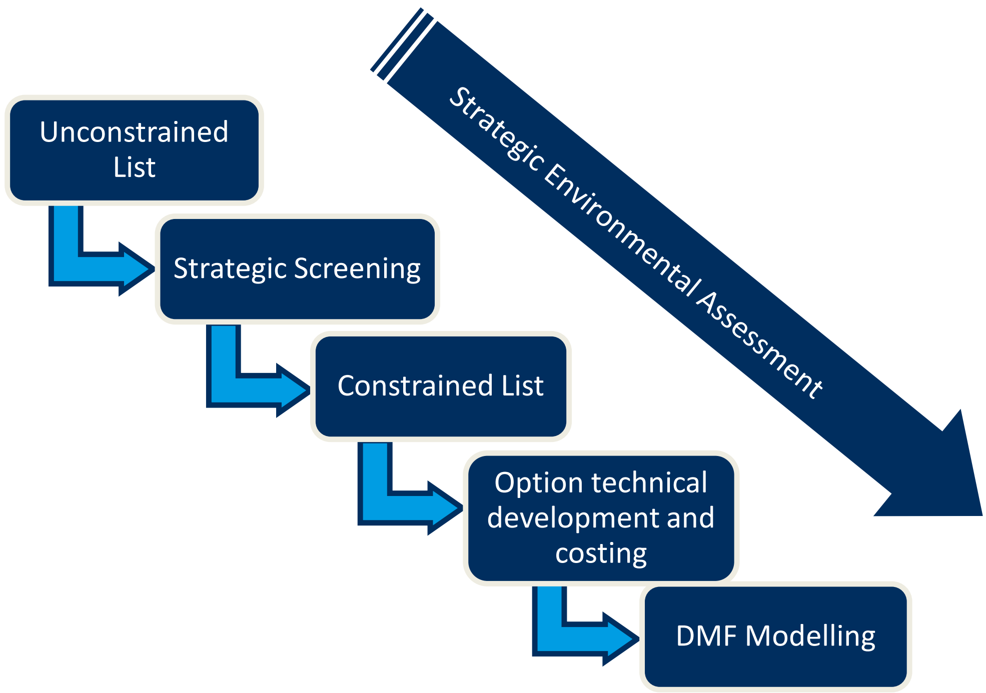
Supply options include:

- investment in existing groundwater sources – replacement boreholes based on asset condition, new treatment processes based on deterioration of groundwater quality;
- new groundwater sources – some new peak capacity at existing sources and some new abstractions in virgin locations;
- new surface water sources;

- trades with third parties – neighbouring water companies, Canals and Rivers Trust, Coal Authority; and
- replacement treatment works at various capacities.

Options development has followed a dual streamed process from unconstrained through to constrained where SEA has been carried out alongside options development.

**Figure 24: Options development process**




Stages of options development included:

- identification of unconstrained options through brainstorming events including both internal expertise together with leading industry consultants;
- Environment Agency involved in both demand management options and resources options identification;
- Initial screening using criteria such as feasibility, etc;
- Further review of screening following more detailed scheme description;
- Environment Agency views sought on resources options; and
- SEA scoping occurring concurrently.

The numbers of options considered throughout the process are shown in the following table.

## Table 32: WRMP options considered

| Option type | Number of unconstrained options | Number of streamlined options | Number of feasible options in DMF | Comments |
|---|---|---|---|---|
| Maintenance of existing groundwater | 27 | 27 | 27 sources with multiple options | Options relate to capital maintenance of existing sources including replacement boreholes and new treatment requirements to maintain existing DO |
| Maintenance of existing surface water – including production losses | 112 | 24 | 2 sources with 45 options – with variations in size, location and delivery | Options relate to maximum capacity of works and treatment processes and number of works treating the two existing source waters, together with alternative phasings for constructions |
| New groundwater | 98 | 23 | 10 | Options include additional boreholes at existing groundwater sources to provide greater peak output, reinstatement of sites currently unused because of treatment requirements and new locations providing additional resource |
| New surface water | | | 5 | Options to increase surface water abstraction at existing locations for treatment at existing treatment works are included as well as options for new surface water intakes and new associated treatment plants |
| Third party water and trades | | | 3 | Identified from approaches to and discussions with other water companies, Canals and Rivers Trust, Coal Authority and the Environment Agency |
| Leakage reduction | 190 | 40 | 5 bundles plus one separate option | Leakage options were bundled to provide packages of works to deliver different volumes of leakage reduction |
| Metering | | | 5 bundles | Metering options were bundled |

| Option type | Number of unconstrained options | Number of streamlined options | Number of feasible options in DMF | Comments |
|---|---|---|---|---|
| Water efficiency | | | plus two separate options | together with some water efficiency options to provide packages of works to deliver different volumes of saving. Some metering options were also kept as separate options |
| Total | 427 | 114 | 105 | |

Outline scheme design and costs were developed for each of the options included on the feasible list for modelling in the DMF. The criteria used to evaluate each option in the DMF modelling are described in section 10.3. The following sections describe the screening of unconstrained options to the feasible list.

## 10.5 Feasible options included in DMF

### 10.5.1 Maintenance of existing groundwater sources

Options relating to the existing groundwater sources contributing to baseline DO are included in the DMF. These options are based on requirements for maintaining the DO. For some sources there are multiple options identifying where new treatment may be needed in the future. By having treatment as a separate option this enables the DMF model to appraise whether to select the treatment option to continue with that source or whether to select an alternative lower cost option from the point where treatment is required. In most cases where treatment is required if it is selected then other capital maintenance costs must also be included.

Capital maintenance requirements over the next 40 years have been identified to ensure that decisions regarding new options are considered alongside options to maintain existing sources and that continuation of output from existing sources is not viewed as being ‘free’.

When considering capital maintenance schemes potential impacts on DO as a result of WFD ‘no deterioration’ have been factored into the expected yield. All expected AMP6 sustainability changes have been included and those sites at risk of causing deterioration if abstraction increases above the recent actual abstraction over the period 2000 to 2015 have been capped at recent actual.

All groundwater sources included in baseline DO are included in the model as capital maintenance options.

HAPW and HUPW are licensed sources which are not currently operational and are not included in baseline DO. There are no options to reintroduce them.

SSPW, SAPW, SHPW and SOPW are also not currently operational and not included in baseline DO. Options to reintroduce these sources are included in the 'new groundwater sources' options.

### 10.5.2 Maintenance of existing surface water treatment works

There were multiple options considered regarding the future treatment capacity at our River Severn Works and our Central Works. The range of options included replacement with current capacity, smaller works and larger works and options to split the works into smaller components and carry out treatment at multiple locations to enhance levels of resilience. For all these options the baseline NYAA and DYAA DO remained the same as currently assessed in our DO modelling.

### 10.5.3 New sources

The unconstrained list of options was screened using the following criteria to derive the constrained list of options.

**Table 33: Criteria used to screen supply options**

| Criteria | Considerations |
|---|---|
| **Location of scheme benefits** | |
| Scale | Option DO is proportional to the estimated supply/demand deficit. |
| Location | Option is within, or can serve, the area of estimated supply/demand deficit. |
| Future proofing | Ability to mitigate against future DO losses as a result of external events – climate change, licence reduction, etc. |
| **Statutory/regulatory/legal constraints** | |
| Planning and environmental | Likely to be acceptable in terms of planning and statutory environmental constraints. |
| WFD | Scheme does not cause deterioration of a WFD water body. |
| HRA | Scheme does not impact on Natura 2000 site. |
| **Meet customer/stakeholder needs** | |
| Customer | Scheme complies with customer experience targets and does not cause detriment to service standards. Avoidance of customer discrimination. |
| Internal stakeholder | Complements our business plan and strategy, and is in line with corporate objectives. |

| Criteria | Considerations |
| --- | --- |
| External stakeholder | Likely to be acceptable to third party group including local stakeholder groups. |
| **Option robustness** | |
| Flexibility | Option can be scaled and flexed operationally to meet supply/demand needs. |
| Favourable | Option is more favourable of all options identified for this water source. |
| Viability | Option is technically feasible. |
| Known technologies | Option is achievable without significant R&D/trials. |
| Licensing | Abstraction licence is likely to be secured. |

The technical note in **appendix V** describes the screening process in more detail.

**Appendix W** contains a report detailing the approach to costing new sources of water.

#### 10.5.3.1 New groundwater sources

Options to provide additional groundwater at existing groundwater sources have been included alongside reinstatement of sites currently unused because of treatment requirements. New locations providing additional resource have also been considered.

**Table 34: New groundwater sources options**

| New groundwater sources | | | | |
| --- | --- | --- | --- | --- |
| **Option** | **NYAA yield Ml/d** | **DYAA yield Ml/d** | **CP yield Ml/d** | **Major investment requirements** |
| KIPW1 | 0 | 0 | 9 | New borehole for peak output and improved blend main |
| HIPW | 0 | 0 | 5 | New borehole for peak output and improved blend main<br>Or<br>New borehole for peak output plus nitrate treatment |
| SSPW | 4.9 | 4.9 | 4.9 | New boreholes, abandonment of well and nitrate treatment |

| New groundwater sources | | | | |
|---|---|---|---|---|
| **Option** | **NYAA yield Ml/d** | **DYAA yield Ml/d** | **CP yield Ml/d** | **Major investment requirements** |
| Warton Unit | 2 | 2 | 2.5 | New borehole in Warton groundwater unit and new treatment works |
| SAPW (linked with augmentation water from Chase Water) | 4.9 | 4.9 | 4.9 | Reinstate SAPW borehole |
| SOPW | 1.5 | 1.5 | 1.5 | Headworks, remediation of boreholes, treatment for SOPW boreholes |
| SOPW/SHPW | 6.4 | 6.4 | 7 | Redrill boreholes at SHPW, treatment for SHPW and SOPW |
| Coven | 1.9 | 1.9 | 2.8 | New groundwater source in Coven unit south of SOPW |

The selection of some of these options (KIPW1inver and HIPW) is dependent on the selection of associated capital maintenance schemes to secure the current output from existing groundwater sources.

When considering these schemes potential impacts on DO as a result of WFD ‘no deterioration’ have been factored into the expected yield. All expected AMP6 sustainability changes have been included and those sites at risk of causing deterioration if abstraction increases above the recent actual abstraction over the period 2000 to 2015 have been capped at recent actual.

The Environment Agency’s view of options which abstract water only for peak periods is not clear at this stage. The intention of peak DO schemes is to provide additional water at times of peak demand, usually in the summer and for a maximum of 6-12 weeks each year. The storage capacity of the sandstone aquifer in this region is such that it is likely that short-term peak abstraction will have no additional impact on the environment providing the long-term abstraction does not increase above recent actual where a risk of deterioration has been identified. In order to account for this uncertainty around acceptability of these peak options it was decided to test alternative solutions if options providing peak DO were selected in the modelling as part of the preferred options portfolio.

#### 10.5.3.2 New surface water sources

These options include both additional raw water input to be treated at our existing Central Works or our River Severn Works and new sources with their own associated treatment.

**Table 35: New surface water sources options**

| New surface water sources | | | | |
|---|---|---|---|---|
| **Option** | **NYAA yield Ml/d** | **DYAA yield Ml/d** | **CP yield Ml/d** | **Major investment requirements** |
| Raw water from the River Trent to support Blithfield levels | 3 | 3 | 0 | For treatment at Central Works |
| Increase the storage in Blithfield by raising the dam by 1m | 5 | 8.5 | 0 | For treatment at Central Works |
| Increase the storage in Blithfield by raising the dam by 2m | 10 | 18 | 0 | For treatment at Central Works |
| River Trent 40 | 40 | 20 | 40 | 40Ml/d intake on River Trent with treatment works and six-month bankside storage. Possible location between Rugeley and Yoxall |
| River Trent 70 | 70 | 49 | 70 | 70Ml/d intake on River Trent with treatment works and six-month bankside storage. Possible location between Alrewas and Burton |

We have been part of the River Trent Working Group liaising with other water companies and third parties regarding current use of and future options for use of the River Trent resource. It is evident that a number of water companies have options for using the River Trent and that there is insufficient flow at times of need for all of these options to proceed. The allocation of the River Trent resource will be subject to Environment Agency agreement over greatest justification of need. On this basis it is possible that other water companies with fewer alternative options would be successful in securing rights to abstract water from the River Trent in preference to us. In order to account for this uncertainty around River Trent options it was decided to test alternative solutions if these options were selected in the modelling as part of the preferred options portfolio.

#### 10.5.3.3 New trades/third party inputs

We have explored the opportunity for third parties to provide water to us. This includes treated water transfers and raw water transfers. There were a number of options explored with the Coal Authority and Canals and Rivers Trust which were screened out because of design feasibility or uncertainty of yield. The feasible options which were included in the DMF are as follows.

**Table 36: New trades/third party inputs options**

| Option | Trades | | | Major investment requirements |
|---|---|---|---|---|
| | NYAA yield Ml/d | DYAA yield Ml/d | CP yield Ml/d | |
| Severn Trent Water – reversal of Perry Barr trade | 20 | 20 | 20 | Treated water bulk supply |
| UU – water into the River Severn | 30 | 30 | 0 | Release of raw water from UU to River Severn for treatment at River Severn Works |
| CRT – Chase Water (2Ml/d) in conjunction with an option to reinstate an existing source at SAPW (5Ml/d) | 2 | 2 | 2 | Release of compensation flow from Chase Water to augment Crane Brook would offset need to use PWS water for this purpose |
| CRT – from canals to Blithfield | 0 | 5 | 0 | Raw water option to transfer water from the canal network to support Blithfield levels |
| Shropshire Groundwater Scheme (SGS) | 20<br>50<br>80 | 20<br>50<br>80 | 0<br>0<br>0 | Three raw water options relating to commissioning phases 6, 7 and 8 of Shropshire Groundwater Scheme. |

Severn Trent Water has confirmed that the 20Ml/d trade via Perry Barr is available. The option has been modelled using assumed costs which have not been subject to commercial negotiation and would likely be subject to change.

The Environment Agency view on the viability of the options based on SGS is uncertain at the time of preparing the draft WRMP. The Environment Agency is due to carry out a review of the scheme and the viability of commissioning future phases. It is not clear whether this review will be completed in time for conclusions to be included within the final WRMP and whether this would exclude the options from the feasible list. Until this is confirmed the options remain on the feasible list. In order to account for this uncertainty around SGS options it was decided to test alternative solutions if these options were selected in the modelling as part of the preferred options portfolio.

### 10.5.4 Demand management

The unconstrained list of options was screened using the following criteria to derive the constrained list of options.

**Table 37: Demand management options screening**

| Criteria | Considerations |
|---|---|
| Yield uncertainty | What is the risk/uncertainty of the option delivering its estimated water saving? |
| Lead time | What is the time required to deliver the water savings? |
| Flexibility | Has the adaptability of an option be reflected? |
| Security of supply | How robust is the overall scheme? |
| Environmental impact | Will the option result in environmental impacts? |
| Sustainability | What is the impact of the option on wider sustainability? |
| Promotability | Will customers support the option? |
| Suitability | How well the option meets the assumed planning problem? |
| Technical difficulty | How difficult the option is to deliver? |

After the screening exercise there remained around 35 options of which some represented only very small savings. Bundles of options which delivered different volumes of saving were then created. Bundles were created for leakage activities and water efficiency and metering where bundled together. Some metering options were also kept as separate options.

Savings for all options are based on annual averages. For metering there may be some additional peak benefits but there is limited evidence to support this and therefore this has not been included.

Metering options were based on AMR meters unless otherwise stated as AMI smart meters. Options are based on programmes of five years' duration unless otherwise stated.

Leakage reduction bundles 1.0 to 1.4 (phase 1) were tested in early runs of the DMF to test the baseline leakage reduction to be committed to. Leakage reduction bundles 1.5 to 1.8 (phase 2) and the live network option replaced the earlier leakage bundles in later runs to test how much more leakage could be reduced economically.

The make-up of the leakage and metering bundles is shown in the following tables. Full details of all the demand management options are included in **appendix T**.

## Figure 25: Phase 1 leakage reduction options

| Bundles | Sub-option code | Sub-option name | Yield profile: Year first delivery | Yield profile: Year maximum yield | Yield profile: Maximum yield |
|---|---|---|---|---|---|
| Leakage Bundle 1.0 (within 1.1, 1.2, 1.3, 1.4) | 129a | Pressure Management Ph.1 | 1 | 1 | 0.21 |
| | 129b | Pressure Management Ph.2 | 1 | 1 | 0.22 |
| | 129c | Pressure Management Ph.3 | 1 | 1 | 0.28 |
| | 059_60 | Improve allowances | 2 | 3 | 0.40 |
| Leakage Bundle 1.1 (within 1.2, 1.3, 1.4) | 073a | ALC Ph.1 | 1 | 2 | 1.96 |
| | 129d | Pressure Management Ph.4 | 1 | 1 | 0.19 |
| | 073b | ALC Ph.2 | 3 | 5 | 2.82 |
| Leakage Bundle 1.2 (within 1.3, 1.4) | 088 | DMA sub-metering | 1 | 2 | 2.19 |
| | 073c | ALC Ph.3 | 6 | 10 | 4.30 |
| Leakage Bundle 1.3 (within 1.4) | 073d | ALC Ph.4 | 11 | 15 | 3.95 |
| | 057 | TMSR monitoring | 1 | 5 | 4.40 |
| Leakage Bundle 1.4 | 183 | Reduce CSPL | 1 | 25 | 2.77 |
| | 073e | ALC Ph.5 | 16 | 20 | 3.35 |
| | 052 | Accelerate Meter Optants | 1 | 25 | 0.97 |
| | 180a | LDAR Ph. 1 | 1 | 10 | 0.62 |
| | 180b | LDAR Ph. 2 | 1 | 10 | 0.60 |
| | 104 | Reduce repair times | 1 | 1 | 0.10 |
| | 177 | Reduce backlog | 1 | 1 | 0.51 |

| Bundle | Year first delivery | Year maximum yield | Maximum yield |
|---|---|---|---|
| SST Leakage Bundle 1.0 | 1 | 3 | 1.11 |
| SST Leakage Bundle 1.1 | 1 | 5 | 6.07 |
| SST Leakage Bundle 1.2 | 1 | 10 | 12.56 |
| SST Leakage Bundle 1.3 | 1 | 15 | 20.91 |
| SST Leakage Bundle 1.4 | 1 | 25 | 29.82 |

| sub-option code | sub-option name | Yield profile: year first delivery | Yield profile: Year maximum yield | Yield profile: max yield |
|---|---|---|---|---|
| 500 | Live Network | 1 | 3 | 6.51 |

## Figure 26: Phase 2 leakage reduction options

| Bundles | Sub-option code | Sub-option name | Yield profile: Year first delivery | Yield profile: Year maximum yield | Yield profile: Maximum yield |
|---|---|---|---|---|---|
| SST Leakage Bundle 1.5, SST Leakage Bundle 1.6, SST Leakage Bundle 1.7, SST Leakage Bundle 1.8, SST Leakage Bundle 1.9 | 057 | TMSR monitoring | 1 | 5 | 4.40 |
| SST Leakage Bundle 1.6, SST Leakage Bundle 1.7, SST Leakage Bundle 1.8, SST Leakage Bundle 1.9 | 073d | ALC Ph.4 | 11 | 15 | 3.95 |
| SST Leakage Bundle 1.7, SST Leakage Bundle 1.8, SST Leakage Bundle 1.9 | 183 | Reduce CSPL | 1 | 25 | 2.77 |
| SST Leakage Bundle 1.8, SST Leakage Bundle 1.9 | 073e | ALC Ph.5 | 16 | 20 | 3.35 |
| SST Leakage Bundle 1.9 | 052 | Accelerate Meter Optants | 1 | 25 | 0.97 |
| SST Leakage Bundle 1.9 | 180a | LDAR Ph. 1 | 1 | 10 | 0.62 |
| SST Leakage Bundle 1.9 | 180b | LDAR Ph. 2 | 1 | 10 | 0.60 |
| SST Leakage Bundle 1.9 | 104 | Reduce repair times | 1 | 1 | 0.10 |
| SST Leakage Bundle 1.9 | 177 | Reduce backlog | 1 | 1 | 0.51 |

| | | | |
|---|---|---|---|
| SST Leakage Bundle 1.5 | 1 | 5 | 4.4 |
| SST Leakage Bundle 1.6 | 1 | 15 | 8.35 |
| SST Leakage Bundle 1.7 | 1 | 25 | 11.12 |
| SST Leakage Bundle 1.8 | 1 | 25 | 14.47 |
| SST Leakage Bundle 1.9 | 1 | 25 | 17.26 |

# Figure 26: Water efficiency and metering options

| Option Code | Option | modified | year first delivery | Year maximum yield | year stop delivery | yield profile | Max Yield (Ml/d) | 2079/2080 Yield |
|---|---|---|---|---|---|---|---|---|
| 021 | Household WEFF programme company led plumber install (2 runs) | Y | 1 | 10 | 14 | | 0.6 | |
| 200.00 | Partnership with retailers for more efficient white goods (2 runs) | Y | 1 | 10 | 14 | | 0.5 | |
| 157a | Dual flush toilets social housing | N | 1 | 5 | 14 | | 0.4 | |
| 307 | Variable infrastructure charge | N | 1 | 10 | 14 | | 0.3 | |
| 023a | Non HH water efficiency programme - company led site visit with installation | N | 1 | 5 | 14 | | 0.7 | |
| 207A | Compulsory Metering AMR | N | 1 | 25 | none | | 12.3 | |
| | SST - WEM 1.0 | | 1 | 10 | none | | 14.2 | 12.3 |
| 021 | Household WEFF programme company led plumber install (2 runs) | Y | 1 | 10 | 14 | | 0.6 | |
| 200.00 | Partnership with retailers for more efficient white goods (2 runs) | Y | 1 | 10 | 14 | | 0.5 | |
| 157a | Dual flush toilets social housing | N | 1 | 5 | 14 | | 0.4 | |
| 307 | Variable infrastructure charge | N | 1 | 10 | 14 | | 0.3 | |
| 023a | Non HH water efficiency programme - company led site visit with installation | N | 1 | 5 | 14 | | 0.7 | |
| 206A | 206 FMO AMR | N | 1 | 25 | none | | 2.4 | |
| | SST - WEM 1.1 | | 1 | 10 | none | | 4.2 | 2.4 |
| 021 | Household WEFF programme company led plumber install (2 runs) | Y | 1 | 10 | 14 | | 0.8 | |
| 200.00 | Partnership with retailers for more efficient white goods (2 runs) | Y | 1 | 10 | 14 | | 0.6 | |
| 157a | Dual flush toilets social housing | N | 1 | 5 | 14 | | 0.4 | |
| 307 | Variable infrastructure charge | N | 1 | 10 | 14 | | 0.3 | |
| 023a | Non HH water efficiency programme - company led site visit with installation | N | 1 | 5 | 14 | | 0.7 | |
| 111A | 111 Change of Occupier AMR | N | 1 | 25 | none | | 4.1 | |
| | SST - WEM 1.2 | | 1 | 10 | none | | 6.9 | 4.1 |
| 021 | Household WEFF programme company led plumber install (2 runs) | Y | 1 | 10 | 14 | | 0.6 | |
| 200.00 | Partnership with retailers for more efficient white goods (2 runs) | Y | 1 | 10 | 14 | | 0.5 | |
| 157a | Dual flush toilets social housing | N | 1 | 5 | 14 | | 0.4 | |
| 023a | Non HH water efficiency programme - company led site visit with installation | N | 1 | 10 | 14 | | 0.7 | |
| 207S | Compulsory Metering AMI | N | 1 | 25 | none | | 14.9 | |
| | SST - WEM 1.3 | | 1 | 10 | none | | 16.0 | 14.9 |
| 021 | Household WEFF programme company led plumber install (2 runs) | Y | 1 | 10 | 14 | | 0.6 | |
| 200.00 | Partnership with retailers for more efficient white goods (2 runs) | Y | 1 | 10 | 14 | | 0.6 | |
| 157a | Dual flush toilets social housing | N | 1 | 5 | 14 | | 0.4 | |
| 307 | Variable infrastructure charge | N | 1 | 10 | 14 | | 0.3 | |
| 023a | Non HH water efficiency programme - company led site visit with installation | N | 1 | 5 | 14 | | 0.7 | |
| | SST - WEM 1.4 | | 1 | 10 | 14 | | 2.6 | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 207S | Compulsory Metering AMI | N | 1 | 25 | none | | 14.9 | 14.9 |
| 207A | Compulsory Metering AMR | N | 1 | 25 | none | | 12.3 | 12.3 |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | SST - WEM 1.5 | Y | 1 | 5 | none | | 1.8 | 1.8 |
| 206A - Committed | 206 FMO AMR | N | 1 | 25 | none | | 2.8 | 2.8 |

### 10.5.5 Resilience options

A number of options have been considered specifically for resilience purposes only. These include:

- enhanced levels of rebuild or refurbishment of existing assets to ensure that all processes are dual streamed and provide a level of resilience;
- diversifying the asset base by considering options whereby we split surface works into smaller independent sites; and
- increasing the transfer capacity of the strategic spine main, therefore enabling potentially larger surface works to be considered.

These options have been appraised within the DMF in the same way as all the other supply- and demand-side options, and all options have been scored for how they affect operational resilience. Where included in the preferred portfolio customer support can be demonstrated.

## 10.6 Customer support for options

Our approach to customer engagement and the findings from that work are described in detail in section 5.

In general terms, customers are more in favour of all aspects of demand management including:

- leakage reduction;
- Metering; and
- education to help change behaviours.

Customers have not expressed a desire to improve levels of service and reduce the frequency of temporary use bans.

## 10.7 Modelling results

In order to successfully demonstrate that the preferred portfolio is effective and robust in meeting a range of future uncertainties, a series of scenarios were appraised within the model.

These scenarios mainly focused on stress testing the demands or available yields within the options; however, we also looked to understand the certainty in deliverability of an option and how the model would behave if some feasible options were excluded from the analysis (for example, the Shropshire Groundwater Scheme and the River Trent). In addition to this, we optimised across a range of the other objectives included within the MCA to understand how bringing in, for example, a greater level of resilience, or a portfolio that better delivered on customer preferences would change the base portfolio.

Through the scoring of some of the objectives within the MCA approach, such as resilience and deliverability we were able to generate the following supply-side scenarios.

- **Scenario 1:** utilisation by Severn Trent Water of their full entitlement to capacity at our shared surface water works on the River Severn. (Severn Trent Water would transfer additional licence to be used at the works to enable them to use their full 68Ml/d capacity entitlement based on cost contribution not licence. DO modelling is based on current licence arrangements of 40.6Ml/d average and 48Ml/d peak use by Severn Trent Water.)
- **Scenario 2:** reduced DO as a result of a more extreme view of the impact of WINEP (additional 11Ml/d reduction on DYAA DO).
- **Scenario 3:** Exclusion of options where there was some particular uncertainty:
  - Perry Barr trade with Severn Trent – because of not yet having any contractual arrangements in place;
  - Shropshire Groundwater Scheme – because of uncertainty in availability;
  - a new surface works on the River Trent – because of uncertainty in availability; and
  - live network – because of certainty of volumes delivered.

We then overlaid the outputs of our specific WRMP customer engagement work to ensure that our customer preferences around the supply and demand options were reflected within our preferred portfolio, enabling us to demonstrate a level of customer interaction and co-creation.

The outputs of the DMF for each of these scenarios were then considered in the context of the distribution network to ensure that we maintained or improved on our customer priorities and hygiene factors such as continuous supplies and excellent water quality.

#### 10.7.1.1 Base – least cost run

Our least cost programme was derived from a combination of two modelling runs of the DMF.

- The first run had no reductions to DO for WINEP and was the baseline demand forecast. This identified the most cost effective leakage reduction.

- The second run included the leakage reduction identified in stage 1 applied to the demand forecast and also included reductions in DO applied to our groundwater sources to reflect the most likely impact from WINEP.

### Results

- Central Works – 90Ml/d capacity (smaller than current).
- River Severn Works – 210Ml/d (as current).
- Groundwater – 158Ml/d DO for DYAA (maintain all sites except MAPW1 and reduced output at KIPW1 – no nitrate treatment).
- Leakage – 12Ml/d reduction over AMP7 and 8.
- Compulsory metering – from year 27.
- Live network – earliest introduced in year 20 (6.5Ml/d).
- Trades – Perry Barr considered much later (year 54).

There were no demand management (metering or water efficiency) options selected in the least cost runs inside the first 25years.

### 10.7.1.2 Sensitivity testing

### Scenario 1 – Increase take at River Severn Works by Severn Trent

We then considered scenarios to test the least cost programme. The identified leakage reduction was applied to the demand forecast line for these runs so a 12Ml/d leakage reduction was an embedded option in all cases.

Over the last 12 months we have been in dialogue with Severn Trent Water about their plans and options for utilisation of our shared River Severn treatment works. Over the course of developing our WRMPs we have considered a range of options. However, for the final sensitivity testing we have modelled a 20Ml/d increase in use of the works by Severn Trent Water. They would need to relocate existing River Severn abstraction licences to the works to enable them to access the capacity which they are entitled to.

### Results

- Central Works – 110Ml/d capacity as current.
- River Severn Works – 210Ml/d as current.
- Groundwater – 158 Ml/d DO on DYAA (maintain all sites except MAPW1 and reduced output at KIPW1 –no nitrate treatment).
- Leakage – 12Ml/d reduction (included by reducing demand).
- Live network – earliest introduced in year 17 (6.5Ml/d).
- Compulsory metering – post-year 27.
- Additional leakage – post-year 27.

- Trades – Perry Barr considered much later (year 56).
- No demand management.

On reviewing these results to check the modelled behaviour, we could see that because of our existing license constraints on the River Severn, our Works has the required additional capacity during both NYAA and DYAA to meet the additional Severn Trent Water demand. The DYCP was the trigger to increase the Central Works by 20Ml/d, as the River Severn Works is already fully utilised in the base run for this planning period – that is, requiring the full 210Ml/d.

### Scenario 2 – More extreme reduction in yields because of WINEP

We also considered a more extreme application of the impact on DO of WINEP. This produced the same optimised portfolio as above for the early years without the need for some of the later options as the impact was less (11Ml/d WINEP impact compared with 20Ml/d impact of greater Severn Trent Water use of the River Severn works).

When both the WINEP reductions and the greater use of the River Severn Works were modelled together the results were as follows.

- Leakage – 12Ml/d reduction (included by reducing demand).
- Central Works – 110Ml/d capacity (as current).
- River Severn Works – 210Ml/d (as current).
- Existing groundwater – 153Ml/d DO for DYAA maintained at all sites and nitrate treatment required at KPW1 to increase DO from 9Ml/d to 14Ml/d.
- Live network – earliest introduced in year 6 (6.5Ml/d).
- Compulsory metering – year13.
- Additional leakage reduction – year 28.
- Trades – Perry Barr considered much later (year 54).

Supply-side options become more diverse by including MAPW1 and treatment at KIPW1 to increase DO. The demand-side options showed no difference, they are just selected earlier than previously required.

### Scenario 3 – Excluding uncertain options

We then tested what removing some potentially uncertain schemes would do to the feasible portfolios. Those schemes were either uncertain because of contractual agreements not yet being in place, such as trades with neighbours or those which require significant construction and planning consents which are yet to be gained.

As the modelling results for scenarios 1 and 2 did not select the Shropshire Groundwater Scheme or the River Trent options we did not need to exclude them from the modelling to identify alternative more certain options. However, the Perry

Barr trade appears in all scenarios, albeit towards the end of the 80-year modelling period in some cases. Therefore, we need to identify what the alternative option would be if this were not available.

The outputs were in line with the above portfolios. However, instead of Perry Barr trade being utilised in the later years, Coven was selected in year 36.

#### Planning horizons

The model also allowed us to understand the impact of changing the planning horizons. The model has the capability to optimise over an 80-year time horizon, but we can also constrain to a shorter period, based on greater certainty on demand, water quality and costs of solutions. We ran the scenarios over a number of alternative planning horizons; this had no impact on the portfolios that were selected.

#### 10.7.1.3 Resilience

We also looked to understand the benefit of maximising the levels of resilience we could achieve by potentially doing something fundamentally different within our asset portfolio.

We had included a number of feasible options that delivered the same DO, but because of asset enhancements, such as dual streaming, or even splitting the asset in to smaller distinct standalone assets, offered more in terms of operational resilience. Coupled with this, we also included network options to enhance our transfer capabilities, improving our operational flexibility.

We ran a series of scenarios targeting increased operational resilience. There was a clear trade-off between cost and resilience.

We also tested the outputs of these scenarios with our network experts to ensure that the optimised portfolios were both feasible, in terms of network constraints, and also delivered local operational resilience.

#### 10.7.1.4 The preferred portfolio

The outputs presented in the table below show the journey from the base least cost scenario through to a hybrid portfolio that we considered demonstrates a robust flexible approach to ensuring our supply/demand balance is met. We wanted to ensure that our preferred portfolio not only met our supply/demand balance in a cost-effective way, but also was shaped by what our customers had told us was important. In essence this meant looking to promote demand-side opportunities and balancing resilience benefits against cost for supply-side options.

## Table 38: Our preferred portfolio

| | Portfolio results | | | | | | |
|---|---|---|---|---|---|---|---|
| | Baseline | WINEP applied (leakage reduction applied) | Increased take by Severn Trent Water at River Severn Works (with WINEP and leakage reduction) | Extreme application of WINEP (leakage reduction applied) | Increased operational resilience (with WINEP and leakage reduction) | Reflecting customer preferences (with WINEP and leakage reduction) | Preferred |
| Existing surface works | River Severn works – same size<br>Central works – smaller (90Ml/d CP) | River Severn works – same size<br>Central works– smaller (90Ml/d CP) | River Severn works – same size<br>Central works – same size | River Severn works – same size<br>Central works – same size | River Severn works – same size<br>Central works – same size | River Severn works – same size<br>Central works – same size | River Severn works – same size<br>Central works – same size |
| Existing groundwater | All groundwater – excluding MAPW1 | All groundwater – excluding MAPW1 | All groundwater – excluding MAPW1 | All groundwater – including MAPW1 and treatment at KIPW1 | All groundwater – including MAPW1 and treatment at KIPW1 | All groundwater – including MAPW1 and treatment at KIPW1 | All groundwater – including MAPW1 and treatment at KIPW1 |
| Leakage | 12.5Ml/d reduction – by yr10<br>6.5Ml/d – live network (yr20) | 6.5Ml/d – live network (yr17)<br>(Additional leakage option selected in yr26 reaching a further 11Ml/d by yr51) | 6.5Ml/d – live network (yr22)<br>(Additional leakage option selected in yr26 reaching a further 11Ml/d by yr51) | 6.5Ml/d – live network (yr6)<br>(Additional leakage option selected in yr26 reaching a further 14Ml/d by yr51) | Additional leakage | 6.5Ml/d – live network | 12.5Ml/d reduction<br>Explore live network |

| | Portfolio results | | | | | | |
|---|---|---|---|---|---|---|---|
| | Baseline | WINEP applied (leakage reduction applied) | Increased take by Severn Trent Water at River Severn Works (with WINEP and leakage reduction) | Extreme application of WINEP (leakage reduction applied) | Increased operational resilience (with WINEP and leakage reduction) | Reflecting customer preferences (with WINEP and leakage reduction) | Preferred |
| Demand management | Compulsory metering (yr27 – reaching 14.89Ml/d by yr51) | Compulsory metering (yr27 – reaching 14.89Ml/d by yr51) | Compulsory metering (yr27 – reaching 14.89Ml/d by yr51) | Compulsory metering (yr13 – reaching 14.89Ml/d by yr51) | Compulsory metering (yr27 – reaching 14.89Ml/d by yr51) | Increased metering and water efficiency – (2.75Ml/d at the end of 25 years and 1.82Ml/d by end of 5 years) | Increased metering and water efficiency – (2.75Ml/d at the end of 25 years and 1.82Ml/d by end of 5 years) |
| New groundwater | No options selected | No options selected | No options selected | 6.3 SOPW and SHPW (yr31) | 6.3Ml/d SOPW and SHPW<br>2Ml/d at Coven | 6.3Ml/d SOPW and SHPW | 6.3Ml/d SOPW and SHPW |
| New surface works | No options selected | No options selected | No options selected | | Trent – 40Ml/d works | No options selected | No options selected |
| Trades | Perry Barr trade with Severn Trent Water – considered much later in the 80 planning horizon (yr53) | Perry Barr trade with Severn Trent Water – considered much later in the 80 planning horizon (yr56) | Perry Barr trade with Severn Trent Water – considered much later in the 80 planning horizon (yr56) | | Perry Barr trade with Severn Trent Water – available from yr1 | Trade with Severn Trent Water at Perry Barr | Trade with Severn Trent Water at Perry Barr |