South Staffordshire and Cambridge Water

Decision Making Framework

Water Resources Problem Characterisation

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Contents

1 Introduction

1.1 South Staffs and Cambridge Water

South Staffs and Cambridge Water (SSC) includes two regional water supply only companies: South Staffs Water (SST) in the Midlands and Cambridge Water (CAM) in East Anglia.

SST supplies 1.275 million people and over 550,000 properties primarily across parts of the West Midlands, Black Country and Staffordshire. The two principle sources of water are from Bithfield Reservoir in the River Trent catchment and abstraction from the River Severn. These surface water sources provide approximately 50% of the water to meet the Company's average daily demand of 300 Ml/d, the remainder of supply being derived from groundwater. SST also bills and collects sewerage charges on behalf of Severn Trent Water.

CAM supplies 319,000 people and 133,000 properties in and around the city of Cambridge extending to Ramsey in the north, Gamlingay in the west, Balsham in the east and Melbourn in the south. It meets average daily demand of 75Ml/d entirely from groundwater sources. Cambridge Water operates in one of the driest and fastest-growing areas of the UK. Cambridge Water bills and collects sewerage charges on behalf of Anglian Water

1.2 Background

SSC is entering into the planning phase for the regulatory 2019 Periodic Review (PR19) and has identified the likely need for significant investment at its major surface water treatment works over the next several Assessment Management Plans (AMPs). This need creates an opportunity to take a holistic review of the long-term supply capabilities of the SSC network with a view to identifying whether alternative approaches might deliver greater benefits for customers particularly in light of future uncertainties.

SSC employed Arup, supported by HR Wallingford and DecisionLab, to help develop a Decision Making Framework (DMF) to guide the long term investment strategy and the selection of capital projects for the PR19 submission.

1.3 Objectives of the DMF Project

SSC are faced with a series of investment decisions for PR19 that could result in a level of capital investment that has not been seen in previous SSC price reviews. This is driven by:

- Water quality failures in the SST regions at the two existing water treatment works and within the network
- Limited flexibility to re-allocate water across the supply network
- Reductions in deployable output due to decreasing groundwater availability and quality
- An obligation to assess and address the resilience of their systems.

The objective of the DMF project is to create a framework that enables the range of capital investment options available to SSC to be compared against each other and an optimised portfolio be selected and justified. The framework is driven by both the need to ensure that trade-offs between multiple resource options are robustly evaluated (as required for the Water Resource Management Plan (WRMP)) and that the most effective investment portfolios are chosen with respect to long term asset management and the ability of SSC to respond to future uncertainty.

A component of this work has been to review the WRMP Decision Making Guidance with respect to the SSC context. This report sets out the problem characterisation process that has been undertaken.

2 Problem Characterisation

2.1 Background

UKWIR recently published new guidance on WRMP Methods for 2019 as part of the UKWIR WRMP 2019 Methods Programme. The changes reflect the evolution from the Economics of Balancing Supply & Demand (EBSD) framework (2002) and aims to guide water resource planners on framing the problem and using the full array of feasible decision making techniques. The updated decision making framework aims to provide "a clear, auditable and systematic process" for planners to follow in relation to water resource planning (UKWIR, 2016).

Central to the guidance is a risk assessment, termed the "Problem Characterisation", of the current water resource zone. This aims to identify how big the water resource supply-demand issue may be and then secondly, how difficult the problem is to solve; this approach assesses the scale and complexity of water supply planning problem.

UKWIR recommend this new method is read in parallel with 'UKWIR Guidance on Risk Based Planning Methods'. This enables a joined up approach to risks, uncertainty and appraising alternative solutions for WRMP decision making. This decision and risk based approach was the focus therefore of the Problem Characterisation workshop held in September, with the aim to integrating the results and future needs in the new Decision Making Framework. It was also understood to be a useful approach to incorporate for all decision planning needs, not just for the regulatory needs in WRMP.

2.2 Methodology

HR Wallingford, along with Arup and DecisionLab, ran a workshop for South Staffs Water on the latest requirement for the updated UKWIR guidance.

The aim of the workshop was to take South Staffs through the new guidance, identify the key issues affecting South Staffs Water WRMP19, provide an initial draft score of the Problem Characterisation and identify the evidence which will underpin this.

The workshop was completed in two parts:

1) A technical overview of the latest UKWIR guidance to a wide range of different departments in South Staffs Water. This presentation explained to different parts of the water company how the WRMP methods are changing and how this may affect South Staffs Water's WRMP19.
2) A series of breakout sessions to discuss the "Problem Characterisation" assessment in the UKWIR guidance. These sessions were used to identify key issues which South Staffs thought would affect the Supply, Demand and Investment components of the WRMP process.

At the end of each breakout session a discussion was held as a wider group to report back on the key issues which were identified. This considered risk and complexity of known problems related to the water resource zone, supply and

demand requirements and the investment level needed. Following this discussion, each participant was asked to record their score for each Problem Characterisation table. The score was a qualitative measure from 0 (no concerns) to 2 (very significant concerns) in answer to each question presented.

At the end of the workshop each Problem Characterisation table had a first draft score and a range of evidence to underpin and justify this score.

Some comments had relevance to multiple boxes. Where appropriate, a decision was made on where the comment was finally recorded in the reporting. The number of comments and the frequency of scores should not be considered equal. The change of location of comments will not necessarily change the scores or conclusions unless the evidence to support that score is changed.

[Note: two comments were moved after review of Revision A of this report with the Environment Agency in February 2017. Given that the evidence compiled on the day was not changed the Problem Characterisation scoring and conclusion itself also did not change. The change made for Revision B was agreed given the context of the characterisation questions posed].

Due to the different expectations and demands between the two regions represented by South Staffs, scores were recorded separately for South Staffs and Cambridge areas. The scores that were provided by the participants at the workshop were analysed to provide a first draft score for each WRZ. Each question was evaluated based on the most frequent score that was given by the workshop participants. This was deemed the most appropriate approach based on a consensus view as opposed to using average scores.

3 Problem Characterisation Tables

These tables use S to denote Supply, D for demand and I for Investment when defining the risks.

Table 1: Water Resource Zone – Strategic Risks

Strategic WRMP risks	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
S. Level of concern that customer service could be significantly affected by current or future supply side risks, without investment				
D. Level of concern that customer service could be significantly affected by current or future demand side risks, without investment				
I. Level of concern over the acceptability of the cost of the likely investment programme, or that the likely investment programme contains contentious options (including environmental/planning risks)				

Attendees were asked to differentiate between South Staffs (SS) network and the Cambridge (C) network as they have very different drivers and needs.

Table 2: Supply Side Complexity of Risk

Strategic WRMP risks	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
S(a) Are there concerns about near term supply system performance, either because of recent Level of Service failures or because of poor understanding of system reliability /resilience under different or more severe droughts than those contained in the historic record? Is this exacerbated by uncertainties about the benefits of operational interventions contained in the Drought Plan?				
S(b) Are there concerns about future supply system performance, primarily due to uncertain impacts of climate change on vulnerable supply systems, including associated source deterioration (water quality, catchments etc.), or poor understanding?				
S(c) Are there concerns about the potential for 'stepped' changes in supply (e.g. sustainability reductions, bulk imports etc.) in the near or medium term that are currently very uncertain?				
S(d) Are there concerns that the 'DO' metric might fail to reflect resilience aspects that influence the choice of investment options (e.g. duration of failure), or are there conjunctive dependencies between new options(i.e. the amount of benefit from one option depends on the construction of another option). These can both be considered as non-linear problems.				

Table 3: Demand Side Complexity of Risk

Strategic WRMP risks	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
D(a) Are there concerns about changes in current or near term demand, e.g. in terms of demand profile, total demand, or changes in economics/demographics or customer characteristics?				
D(b) Does uncertainty associated with forecasts of demographic / economic / behavioural changes over the planning period cause concerns over the level of investment that may be required?				
D(d) Are there concerns that a simple 'dry year/normal year' assessment of demand is not adequate, e.g. because of high sensitivity of demand to drought (so demand under severe events needs to be understood), or because demand versus drought timing is critical.				

Table 4: Investment Programme Complexity Factors

Strategic WRMP risks	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
I(a) Are there concerns that capex uncertainty (particularly in relation to new or untested technologies) could compromise the company's ability to select a 'best value' portfolio over the planning period?				
I(b) Does the nature of feasible options mean that construction lead time or scheme promotability are a major driver of the choice of investment portfolio?				
I(c) Are there concerns that trade-offs between costs and non-monetised 'best value' considerations (social, environment) are so complex that they require quantified analysis (beyond SEA) to justify final investment decisions.				
I(d) Is the investment programme sensitive to assumptions about the utilisation of new resources, mainly because of large differences in variable opex between investment options?				

4 Summary of Results

The scores that were provided by the participants at the workshop were analysed to provide a first draft score for each WRZ (Table 5). Each question was evaluated based on the most frequent score that was given by the workshop participants. This was deemed the most appropriate approach based on a consensus view as opposed to using average scores.

The Strategic Needs of both WRZs were scored as 4 which equates to "Medium" scale of problem in the terms of the UKWIR guidance. The Complexity Factor was higher for Cambridge at 11 compared with the 9 of South Staffs. However for both WRZs this indicates a 'Medium' level of complexity, although Cambridge could be viewed as High. An overview of these results is shown in Figure 1 with both WRZs in a Medium area which leads to the the use of "Extended" decision making methods.

Table 5: Summary of Problem Characterisation Results. [Note these are based on the most frequently recorded scores and not the average scores]

	South Staffs WRZ Score	**Cambridge WRZ Score**
Strategic Needs	4	4
Total Complexity Factor (CF)	9	11
Supply CF	3	4
Demand CF	2	3
Investment Programme CF	4	4

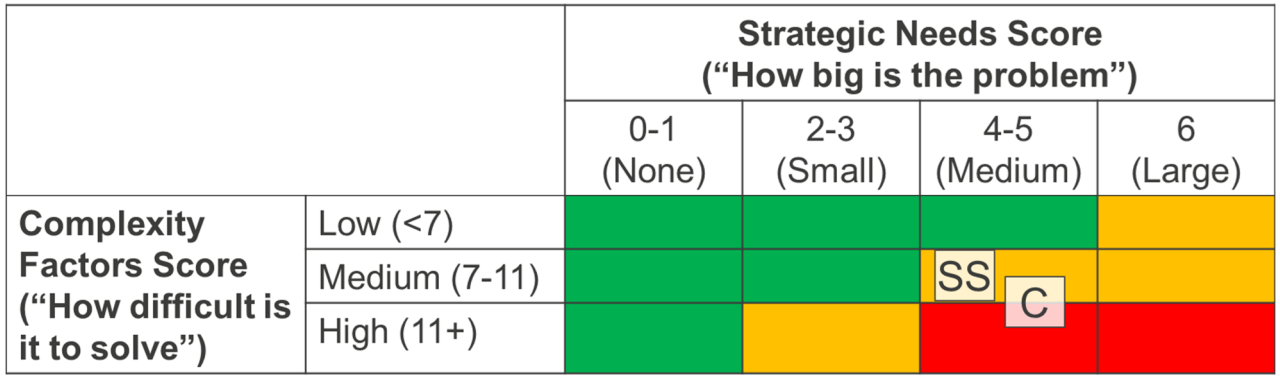

Figure 1: Problem Characterisation results.

For WRMP14 both regions would have been assessed as green if this methodology had been applied at that time. There are a number of new risks to the overall supply demand balance in both regions which the Company now faces. For Cambridge the key challenges which have arisen since PR14 can be summarised as:

- Long-term regional growth
- Environmental pressure to reduce licence volumes
- Limited opportunities for new supply side options in view of environmental pressures
- Longer-term resilience concerns arising from the potential for a supply demand deficit and particularly drought resilience in the context of more extreme droughts than previously experienced.

For South Staffs the key challenges can be summarised as:

- Aging strategic surface water treatment works requiring significant investment to maintain quality and volume output which potentially requires parallel upgrades
- Environmental pressure to reduce licence volumes
- Longer-term resilience concerns arising from drought resilience in the context of more extreme droughts than previously experienced.

5 Detailed Characterisation

5.1 Strategic Needs

This section provides the evidence that supports each of the problem characterisation tables. Table 6 and Table 7 show a summary of the scores against supply, demand and investment risks. Table 8 through to

Table 21 gives reason for why these scores were proposed and differences between the two regions.

Table 6: South Staffs WRZ Strategic Needs Table

	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know	Average Score	Most Frequent Score
S	0	8	5	0	1.4	**1.0**
D	1	11	1	0	1.0	**1.0**
I	0	5	8	0	1.6	**2.0**
Totals	1	24	14	0	4.0	**4.0**

Table 7: Cambridge WRZ Strategic Needs Table

	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know	Average Score	Most Frequent Score
S	0	3	10	0	1.8	**2.0**
D	0	9	4	0	1.3	**1.0**
I	0	9	3	1	1.3	**1.0**
Totals	0	21	17	1	4.3	**4.0**

Table 8: Strategic Needs - South Staffs

Strategic WRMP risks	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
S. Level of concern that customer service could be significantly affected by current or future **supply side** risks, without investment	**Frequency of Score = 0**	**Frequency of Score = 8** License claw back due to WFD no deterioration Raw water quality risks to groundwater Unforeseeable future water quality issues Pesticides in the short term 2-3 years Climate change and risk of extreme events e.g. flooding. Treatment works assets reliability concerns leading to reduced DO, WQ and increased process losses	**Frequency of Score = 5** Network constraints which are limiting peak supply Metaldehyde and algae	**Frequency of Score = 0**

Strategic WRMP risks	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
		Replacement of assets with more complex facilities with shorter term life-span. Hampton Lode capacity uncertainty – changes in treatment plant operation present some constraints on output which can impact peak capability and present some challenge to achieve figures assumed in last WRMP. Limited flexibility in use of sources between Hampton Lode and Blithfield reservoir Drought risk to Blithfield Reservoir from more extreme droughts Increasing export to STW		
D. Level of concern that customer service could be significantly affected by current or future **demand**	**Frequency of Score = 1**	**Frequency of Score = 11** Increasing customer side leakage. Lack of ownership of	**Frequency of Score = 1**	**Frequency of Score = 0**

Strategic WRMP risks	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
side risks, without investment	Burton is a strategic growth point	issue but political and regulatory pressure Ageing level of customer infrastructure e.g. meters Low meter penetration limits impact on demand Large proportion of shared supplies limiting external meters which also misses supply pipe leakage Wholesale retail separation leading to lack of control of demand – no direct contact with customers using water		Continued assumption of maintaining a lack of growth but this could change e.g. HS2
I. Level of concern over the acceptability of the cost of the likely **investment programme**, or that the likely investment programme contains contentious options	**Frequency of Score = 0**	**Frequency of Score = 5** Higher uncertainty in the benefits of demand side investment decisions for the business due to reliance on customer behaviour.	**Frequency of Score = 8** Two treatment works require work which may not be able to happen in parallel due to scale of investment and operational constraints.	**Frequency of Score = 0** Network mains improvement. Water UK national water resources strategy suggest that could be water "travelling"

Strategic WRMP risks	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
(including environmental/planning risks)		Increasing complexity of investment in asset life within SSW due to being a small company Challenge to move into significantly higher investment and justify the step change. Potential confidence issues between customers, regulators and the board over changing investment needs and stakeholder drivers/expectations to gain overall agreement. Political implications of bigger investment need this cycle and future AMP cycle. May result in challenges from investment profile changes. Potential scale of investment from options being considered may be significant inter-		through SS WRZ – would need to make sure this has potential to benefit SSW.

Strategic WRMP risks	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
		generational investment over multiple AMPs.		

Table 9: Strategic Needs - Cambridge

Strategic WRMP risks	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
S. Level of concern that customer service could be significantly affected by current or future **supply side** risks, without investment	**Frequency of Score = 0** Regional water resource challenges may increase desire of neighbours to increase exports to them but Company will not agree to any new trades until options for CAM SDB are identified	**Frequency of Score = 3** License claw back due to WFD no deterioration Availability of new licenses Raw water quality risks to groundwater Unforeseeable future water quality issues Climate change and risk of extreme events e.g. flooding.	**Frequency of Score = 10** Time limited licenses Drought resilience relies on surplus which is at risk of being removed Risk of multi-season dry winter droughts	**Frequency of Score = 0**

Strategic WRMP risks	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
		Replacement of assets with more complex facilities with shorter term life-span.		
D. Level of concern that customer service could be significantly affected by current or future **demand side** risks, without investment	**Frequency of Score = 0** Positive environment of sustainability for reduced demand (C)	**Frequency of Score = 9** Increasing customer side leakage. Lack of ownership of issue but political and regulatory pressure Ageing level of customer infrastructure e.g. meters Wholesale retail separation leading to lack of control of demand – no direct contact with customers using water Higher levels of grey water use and rain water harvesting during normal years could increase potable water use during drought creating more peak demands.	**Frequency of Score = 4** Regional growth driven in part by government planning Customer attitudes towards leakage	**Frequency of Score = 0** Will the Oxford to Cambridge expressway and development corridor bring additional growth to Cambridge?
I. Level of concern over the acceptability of the cost of the likely **investment**	**Frequency of Score = 0**	**Frequency of Score = 9**	**Frequency of Score = 3**	**Frequency of Score = 1** Network mains improvement.

Strategic WRMP risks	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
programme, or that the likely investment programme contains contentious options (including environmental/planning risks)		Environmental issues over new surface water sources in Cambridge region. Water availability for groundwater licencing is likely to be limited. A new surface water scheme would therefore be the most likely option and this would potentially be a regional scheme not just a SSW/CW scheme due to scale economy. Implication will be longer planning time requirements CAM currently manages drougths using SDB surplus. If surplus is removed or eroded then additional / new drought sources may be needed – high cost and low utilisation. Higher uncertainty in the benefits of demand side investment decisions for the business due to reliance on customer behaviour.	Impacts of significant investment on customer bills	Water trading options. Complexity of procurement between companies and modelling of a wider network

Strategic WRMP risks	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
		Increasing complexity of investment in asset life within SSW due to being a small company Challenge to move into significantly higher investment and justify the step change. Potential confidence issues between customers, regulators and the board over changing investment needs and stakeholder drivers/expectations to gain overall agreement. Political implications of bigger investment need this cycle and future AMP cycle. May result in challenges from investment profile changes Potential scale of investment from options being considered may be significant inter-		

Strategic WRMP risks	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
		generational investment over multiple AMPs.		

5.2 Strategic Factors

The factors that had material impact on this characterisation can be summarised as follows:

Supply:

- Surface water treatment works asset life and need to undertake treatment improvements to meet modern expectations and quality challenges.
- Cambridge potential groundwater licence reductions (up to ~38 Ml/d out of 113 Ml/d available) and associated complexity to replace lost DO
- South Staffs potential licence reductions (could be significant)
- Scale of impact from raw water surface water and groundwater pollution, including localised sources (e.g. pesticide) and more general causes long term (e.g. climate change)
- Network constraints on flexibility e.g connecting mains between north area and south area
- Scale of impact of multi-season drought

Demand:

- Cambridge forecast population growth
- Scale of South Staffs customer side leakage
- Impact of South Staffs meter penetration
- Potential contribution from reuse resources

Investment Planning:

- Impact of proposed investments on customer bills
- Scale of potential difference from previous periods
- More onerous expectations by regulators (i.e. DEFRA, Ofwat, EA) over time. For example upstream costing approach, resources pricing control, upstream market reform.

5.3 Complexity

5.3.1 Supply Complexity

Table 10: Supply Complexity - South Staffs

S	Supply side complexity factors	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
S(a)	Are there concerns about **near term supply system performance**, either because of recent Level of Service failures or because of poor understanding of system reliability /resilience under different or more severe droughts than those contained in the historic record? Is this exacerbated by uncertainties about **the benefits of operational interventions contained in the Drought Plan**?	**Frequency of Score = 0**	**Frequency of Score = 8** No modelling of system under additional drought scenarios System reliability unproven under extreme events Recent near misses which were potentially close to source failure Need better understanding of River Severn water quality risks during droughts. Risk of extreme events (both flood and droughts, both single major events or repeat events over a number of seasons compounding impacts) to GW	**Frequency of Score = 5** Drought resilience of Blithfield reservoir Peak capacity from Central Worksfollowing installation of new UV plant in 2016 unproven. Understanding of new plant operation still being tested and developed. Current level of unplanned outage is higher than planned for thus reducing operational headroom. Need to understand if this is a temporary short-term issue or whether this level of outage will continue	**Frequency of Score = 0**

S	Supply side complexity factors	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
			resource in terms of quality and quantity Will historical system operational rules which worked in past events work during different types of droughts. Pesticide risks and emerging pollutants in the near term e.g. chlorthal. Historically SSW has maintained Blithfield Reservoir levels by putting potable water back in under extreme and infrequent events. Would require regulatory approval to do again. Operational drought plan doesn't necessarily tie up with the practical drought plan in terms of Blithfield control rules.		

S	Supply side complexity factors	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
S(b)	Are there concerns about **future supply system performance**, primarily due to uncertain impacts of **climate change** on vulnerable supply systems, including associated source deterioration (water quality, catchments etc.), or poor understanding?	**Frequency of Score = 1** Hampton Loade River Severn abstraction water quality – bankside storage OK. No concerns over climate change	**Frequency of Score = 11** Must improve understanding of longer term asset reliability under climate change. Blithfield algae interactions under higher temperatures and the interaction with treatment process. THM interactions with temperature	**Frequency of Score = 1**	**Frequency of Score = 0** Increase risk of flooding and impacts on supply

S	Supply side complexity factors	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
S(c)	Are there concerns about the potential for **'stepped' changes in supply** (e.g. sustainability reductions, bulk imports etc.) in the near or medium term **that are currently very uncertain**?	**Frequency of Score = 0**	**Frequency of Score = 11** Uncertainty of River Severn abstraction and STW	**Frequency of Score = 2** AMP6 sustainability reductions confirmed at 10 Ml/d. As context, SST PR14 DO = 380Ml/d (before TWL) Uncertainty over future reductions and associated replacement challenges to meet WFD no deterioration, could be up to 38 Ml/d. Political uncertainty with EA/Brexit Abstraction Reform	**Frequency of Score = 0**

S	Supply side complexity factors	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
S(d)	Are there concerns that the '**DO**' **metric might fail to reflect resilience** aspects that influence the choice of investment options (e.g. duration of failure), or are there **conjunctive dependencies between new options** (i.e. the amount of benefit from one option depends on the construction of another option). These can both be considered as ***non-linear problems.***	**Frequency of Score = 9** No real concerns	**Frequency of Score = 4**	**Frequency of Score = 0**	**Frequency of Score = 0** DO at a WRZ level does not represent the risk to customers at a supply zone level which will cause problems at

Table 11: Supply Complexity - Cambridge

S	Supply side complexity factors	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
S(a)	Are there concerns about **near term supply system performance**, either because of recent Level of Service failures or because of poor understanding of system reliability /resilience under different or more severe droughts than those contained in the historic record? Is this exacerbated by uncertainties about **the benefits of operational interventions contained in the Drought Plan**?	**Frequency of Score = 0** Few concerns raised in workshop over Cambridge asset base, these are generally newer and simpler (it is recognised that more stakeholder input may be needed to validate this)	**Frequency of Score = 9** No modelling of system under additional drought scenarios No drought resilience headroom if surplus is clawed back under WFD Risk of extreme events (both flood and droughts, both single major events or repeat events over a number of seasons compounding impacts) to GW resource in terms of quality and quantity Performance of resources (supply availability) under summer peak untested since 1995 peak summer Minimal drought options available and current surplus which is used for droughts is under risk due to sustainable catchments	**Frequency of Score = 4** Peak capacity from Central Worksfollowing installation of new UV plant in 2016 unproven. Understanding of new plant operation still being tested and developed. Cambridge operational headroom may reduce to minimal following renewal of Thetford TLLs with a close S-D balance. Current level of unplanned outage is higher than planned for thus reducing operational headroom. Need to understand if this is a temporary short-term issue or whether this level of outage will continue	**Frequency of Score = 0**

S	Supply side complexity factors	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
S(b)	Are there concerns about **future supply system performance**, primarily due to uncertain impacts of **climate change** on vulnerable supply systems, including associated source deterioration (water quality, catchments etc.), or poor understanding?	**Frequency of Score = 1** No concerns over climate change	**Frequency of Score = 9**	**Frequency of Score = 3**	**Frequency of Score = 0** Increase risk of flooding and impacts on supply

S	Supply side complexity factors	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
S(c)	Are there concerns about the potential for **'stepped' changes in supply** (e.g. sustainability reductions, bulk imports etc.) in the near or medium term **that are currently very uncertain**?	**Frequency of Score = 1**	**Frequency of Score = 3**	**Frequency of Score = 9** AMP6 sustainability reductions confirmed at 6 Ml/d. As context Cambridge PR14 DO = 113Ml/d Uncertainty over future reductions and associated replacement challenges to meet WFD no deterioration, could be up to 38 Ml/d Time limited renewal of licenses – 10Ml/d at risk Political uncertainty with EA/Brexit Abstraction Reform	**Frequency of Score = 0**

S	Supply side complexity factors	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
S(d)	Are there concerns that the '**DO**' **metric might fail to reflect resilience** aspects that influence the choice of investment options (e.g. duration of failure), or are there **conjunctive dependencies between new options** (i.e. the amount of benefit from one option depends on the construction of another option). These can both be considered as ***non-linear problems.***	**Frequency of Score = 9** No real concerns	**Frequency of Score = 4** Regional analysis as part of the WRE must ensure proportional contribution meets the benefits received at the right time – shared DO calculations may be more complicated	**Frequency of Score = 0**	**Frequency of Score = 0**

Table 12: South Staffs WRZ Supply Side Complexity Table - Summary

	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know	Average Score	Most Frequent Score
S (a)	0	8	5	0	1.4	1
S (b)	1	11	1	0	1.0	1
S (c)	0	11	2	0	1.2	1
S (d)	9	4	0	0	0.3	0
Totals	10	34	8	0	3.8	3.0

Table 13: Cambridge WRZ Supply Side Complexity Table - Summary

	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know	Average Score	Most Frequent Score
S (a)	0	9	4	0	1.3	1
S (b)	1	9	3	0	1.2	1
S (c)	1	3	9	0	1.6	2
S (d)	9	4	0	0	0.3	0
Totals	11	25	16	0	4.4	4.0

5.3.2 Demand Complexity

Table 14: Demand Complexity - South Staffs

D	Demand side complexity factors	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
D(a)	Are there concerns about changes in current or near term demand, e.g. in terms of demand profile, total demand, or changes in economics/demographics or customer characteristics?	**Frequency of Score = 5** Industry base is stable and/or declining as moving out of region (	**Frequency of Score = 8** Weather-demand relationship need to be better understood Significant rate of demand change from one week to the next	**Frequency of Score = 0**	**Frequency of Score = 0**

D	Demand side complexity factors	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
D(b)	Does uncertainty associated with forecasts of demographic / economic / behavioural changes over the planning period cause concerns over the level of investment that may be required?	**Frequency of Score = 4**	**Frequency of Score = 8** Wholesale retail separation leading to lack of control of demand – no direct contact with customers using water Non-household demand has fallen but it's not clear if this will continue and at what point this could stop. There has been some recovery in the last year or so	**Frequency of Score = 1**	**Frequency of Score = 0** Proposed large infrastructure schemes cause uncertainty e.g. HS2, A14, Cam-Oxford expressway Change in future water use and behavioural patterns
D(c)	Are there concerns that a simple 'dry year/normal year' assessment of demand is not adequate, e.g. because of high sensitivity of demand to drought (so demand under severe events needs to be understood), or because demand versus drought timing is critical.	**Frequency of Score = 6** No overall significant concerns	**Frequency of Score = 0** Criticality of understanding weather demand patterns Peak demand concerns due to short-term weather demand	**Frequency of Score = 1**	**Frequency of Score = 1** One off events.

Table 15: Demand Complexity - Cambridge

D	Demand side complexity factors	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
D(a)	Are there concerns about changes in current or near term demand, e.g. in terms of demand profile, total demand, or changes in economics/demographics or customer characteristics?	**Frequency of Score = 0**	**Frequency of Score = 13** Significant rate of demand change from one week to the next	**Frequency of Score = 0**	**Frequency of Score = 0** Effects of regional growth on DYAA, uncertain growth and data may be out of date

D	Demand side complexity factors	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know
D(b)	Does uncertainty associated with forecasts of demographic / economic / behavioural changes over the planning period cause concerns over the level of investment that may be required?	**Frequency of Score = 0**	**Frequency of Score = 9** Wholesale retail separation leading to lack of control of demand – no direct contact with customers using water	**Frequency of Score = 4** Growth and demand in the area have significant uncertainty with government policy not clear on how much this would be and when	**Frequency of Score = 0** Proposed large infrastructure schemes cause uncertainty e.g. HS2, A14, Cam-Oxford expressway Change in future water use and behavioural patterns
D(c)	Are there concerns that a simple 'dry year/normal year' assessment of demand is not adequate, e.g. because of high sensitivity of demand to drought (so demand under severe events needs to be understood), or because demand versus drought timing is critical.	**Frequency of Score = 4** No overall significant concerns	**Frequency of Score = 6** Criticality of understanding weather demand patterns Peak demand concerns due to short term weather demand.	**Frequency of Score = 1**	**Frequency of Score = 2** One off events. Influx of seasonal populations e.g. students

Table 16: South Staffs WRZ Demand Side Complexity Table - Summary

	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know	Average Score	Most Frequent Score
D (a)	5	8	0	0	0.6	1
D (b)	4	8	1	0	0.8	1
D (c)	6	5	1	1	0.6	0
Totals	15	21	2	1	2.0	2.0

Table 17: Cambridge WRZ Demand Side Complexity Table - Summary

	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know	Average Score	Most Frequent Score
D (a)	0	13	0	0	1.0	1
D (b)	0	9	4	0	1.3	1
D (c)	4	6	1	2	0.7	1
Totals	4	28	5	2	3.0	3.0

5.3.3 Investment Complexity

Table 18: Investment Complexity - South Staffs

Investment Complexity	**Investment programme complexity factors**	**No significant concerns (Score = 0)**	**Moderately significant concerns (Score = 1)**	**Very significant concerns (Score = 2)**	**Don't know**
I(a)	Are there concerns that capex uncertainty (particularly in relation to new or untested technologies) could compromise the company's ability to select a 'best value' portfolio over the planning period?	**Frequency of Score = 0** Dumb meters are understood and have high certainty in capex	**Frequency of Score = 8** Budget for business and priorities for other investment areas Demand management and compulsory metering due to limited current metering (lack of water stress classification). Ability for Demand Management limited in SS due to low meter penetration and ability to influence customer behaviour. Significant variation in scale and phasing of possible options being considered for the metering programme Interim measures may be required. May be risk of stranded assets.	**Frequency of Score = 5** Treatment works options to undertake treatment improvements to meet modern expectations and quality challenges Complex metering - AMR would be uncertain due to unknown technology to SSW	**Frequency of Score = 0**

Investment Complexity	**Investment programme complexity factors**	**No significant concerns (Score = 0)**	**Moderately significant concerns (Score = 1)**	**Very significant concerns (Score = 2)**	**Don't know**
I(b)	Does the nature of feasible options mean that construction lead time or scheme promotability are a major driver of the choice of investment portfolio?	**Frequency of Score = 1**	**Frequency of Score = 8** Uncertainty over tariffs and metering	**Frequency of Score = 4** Short term options to cover long lead time of larger options. Phasing over successive AMP cycles.	**Frequency of Score = 0** Schemes across 2 or more AMP cycles. Would SSW be happy with long term pay back or is an immediate return on investment required General business strategy

Investment Complexity	**Investment programme complexity factors**	**No significant concerns (Score = 0)**	**Moderately significant concerns (Score = 1)**	**Very significant concerns (Score = 2)**	**Don't know**
I(c)	Are there concerns that tradeoffs between costs and non-monetised 'best value' considerations (social, environment) are so complex that they require quantified analysis (beyond SEA) to justify final investment decisions.	**Frequency of Score = 0**	**Frequency of Score = 8** Not yet identified what "best value" is	**Frequency of Score = 3**	**Frequency of Score = 2** Would a "No regrets" solution be considered alongside other non-monetised costs. Must think about customer engagement with the big picture not just tinkering with smaller options. Is there a preference for demand solutions or supply solutions? Is there a regulatory bias towards one or the other?

Investment Complexity	**Investment programme complexity factors**	**No significant concerns (Score = 0)**	**Moderately significant concerns (Score = 1)**	**Very significant concerns (Score = 2)**	**Don't know**
I(d)	Is the investment programme sensitive to assumptions about the utilisation of new resources, mainly because of large differences in variable opex between investment options?	**Frequency of Score = 1**	**Frequency of Score = 4** Depends on the solution	**Frequency of Score = 2**	**Frequency of Score = 6** Don't know without options Water trading solution – what is the OPEX with neighbouring systems

Table 19: Investment Complexity - Cambridge

Investment Complexity	**Investment programme complexity factors**	**No significant concerns (Score = 0)**	**Moderately significant concerns (Score = 1)**	**Very significant concerns (Score = 2)**	**Don't know**
I(a)	Are there concerns that capex uncertainty (particularly in relation to new or untested technologies) could compromise the company's ability to select a 'best value' portfolio over the planning period?	**Frequency of Score = 0** Dumb meters are understood and have high certainty in capex	**Frequency of Score = 11** Budget for business and priorities for other investment areas Demand management and compulsory metering due to limited current metering. Cam not water stressed and cannot pursue compulsory metering which is likely to be most economic solution Significant variation in scale and phasing of possible options being considered for the metering programme Regional reservoir scheme dependent on other parties and therefore uncertain timescales Interim measures may be required. May be risk of stranded assets.	**Frequency of Score = 2** Complex metering - AMR would be uncertain due to unknown technology to SSW	**Frequency of Score = 0**

Investment Complexity	**Investment programme complexity factors**	**No significant concerns (Score = 0)**	**Moderately significant concerns (Score = 1)**	**Very significant concerns (Score = 2)**	**Don't know**
I(b)	Does the nature of feasible options mean that construction lead time or scheme promotability are a major driver of the choice of investment portfolio?	**Frequency of Score = 0**	**Frequency of Score = 6** Uncertainty over tariffs and metering	**Frequency of Score = 6** Short term options to cover long lead time of larger options. Phasing over successive AMP cycles.	**Frequency of Score = 1** Schemes across 2 or more AMP cycles. Would SSW be happy with long term pay back or is an immediate return on investment required General business strategy

Investment Complexity	**Investment programme complexity factors**	**No significant concerns (Score = 0)**	**Moderately significant concerns (Score = 1)**	**Very significant concerns (Score = 2)**	**Don't know**
I(c)	Are there concerns that tradeoffs between costs and non-monetised 'best value' considerations (social, environment) are so complex that they require quantified analysis (beyond SEA) to justify final investment decisions.	**Frequency of Score = 0**	**Frequency of Score = 9** Not yet identified what "best value" is	**Frequency of Score = 2**	**Frequency of Score = 2** Would a "No regrets" solution be considered alongside other non-monetised costs. Must think about customer engagement with the big picture not just tinkering with smaller options. Is there a preference for demand solutions or supply solutions? Is there a regulatory bias towards one or the other?

Investment Complexity	**Investment programme complexity factors**	**No significant concerns (Score = 0)**	**Moderately significant concerns (Score = 1)**	**Very significant concerns (Score = 2)**	**Don't know**
I(d)	Is the investment programme sensitive to assumptions about the utilisation of new resources, mainly because of large differences in variable opex between investment options?	**Frequency of Score = 0**	**Frequency of Score = 6** Depends on the solution	**Frequency of Score = 1**	**Frequency of Score = 6** Don't know without options Water trading solution – what is the OPEX with neighbouring systems

Table 20: South Staffs WRZ Investment Programme Complexity Table - Summary

	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know	Average Score	Most Frequent Score
I (a)	0	8	5	0	1.4	1.0
I (b)	1	8	4	0	1.2	1.0
I (c)	0	8	3	2	1.3	1.0
I (d)	1	4	2	6	1.1	1.0
Totals	2	28	14	8	5.0	4.0

Table 21: Cambridge WRZ Investment Programme Complexity Table - Summary

	No significant concerns (Score = 0)	Moderately significant concerns (Score = 1)	Very significant concerns (Score = 2)	Don't know	Average Score	Most Frequent Score
I (a)	0	11	2	0	1.2	1
I (b)	0	6	6	1	1.5	1
I (c)	0	9	2	2	1.2	1
I (d)	0	6	1	6	1.1	1
Totals	0	32	11	9	5.0	4.0

5.4 Complexity Factors

The factors that had material impacts on this characterisation can be summarised as follows:

Supply:

- Understanding of system capability in severe drought
- Extent and duration of water quality constraints at treatment works especially at peak capacity and during seasonal challenges
- Elevated unplanned outage levels.• Understanding of climate impacts on raw water reservoirs – e.g. algae
- Asset reliability
- Concurrent upgrade constraints may arise
- Uncertainty from WFD impacts, time limited licences, upstream regulatory reform
- Major expenditure in long life assets to meet quality expectations and supply uncertainties with good economic judgement giving the best outcome for stakeholders (customers, regulators, the Company)._

Demand:

- Variation in regional population growth, timing and location (including impact of Midlands Engine Growth)
- Understanding of impact of extended peak demand on system capabilities
- Ability to develop strategies to influence behaviour change – segmentation, preferences

Investment Planning:

- Need for clear rationale for step change in investment profile
- Acceptability to customers & regulators of potential increased investment
- Multi amp period planning is required
- Balancing of urgent pace to deliver quality with spreading customer impact on bills
- Uncertainty from market reforms
- Operational constraints from concurrent activity at major surface works

6 WRMP Approach

The initial score in the Problem Characterisation Process indicates that both of South Staffs Water's WRZs are Medium risk and therefore should explore using "Extended" decision making methods, as a minimum this means that an EBSD approach alone is probably too simple in order to solve the complexity of the water resource problem. In previous periods, including PR14, South Staffs and Cambridge were in the green risk area. There is now a step change requirement to meet the new challenges ahead due the potential deficit forecasted in Cambridge and the need to address the treatment works challenge in South Staffs.

The Water Resource Planner needs to decide upon a "System Modelling" approach using either an "Aggregate" or "System Simulation" approach. The Aggregate approach is the current convention where supply and demand are reduced to a single number each year as per water company planning tables. This approach is best suited to understanding the near-term scheduling of an Investment Programme and will be easier to adapt a water company's current methods and tools in the timeframes for WRMP19. Given the nature of the issues facing South Staffs an Aggregate approach is most appropriate for WRMP19.

The Risk Based Planning guidance provides the choice of different "Risk Compositions" depending on the approach the Water Resources Planner wishes to use to derive and test their Investment Programme. Where a company has identified a deficit in the supply-demand balance or a resilience issue, and therefore needs to develop an investment programme it is recommended that at least a Risk Composition 2 approach is used (Figure 2). This is a "Resilience Tested" plan which encourages the Water Resources Planner to test their investment programme to a range of drought events outside of the historical record to better understand the resilience benefits of a particular options programme. The Risk Composition 1 approach is predominantly focussed around historical droughts and therefore cannot be used to test system resilience. The highest level of Risk Composition 3 is only appropriate if all of the uncertainties in the WRMP process can be quantified allowing the removal of "Headroom". Therefore for the issues identified for South Staffs Water it is recommended that a Risk Composition 2 approach is used.

The provisional route through the WRMP methods is shown in Figure 2 which shows the Risk Composition 2, Aggregate Decision Making Tool, leads to a "Scenario Based Method" for integrating the WRMP components. This means that different scenarios of supply and demand are used in order to understand the resilience of an Options Programme over the planning horizon, with "Target Headroom" fixed as the base year value.

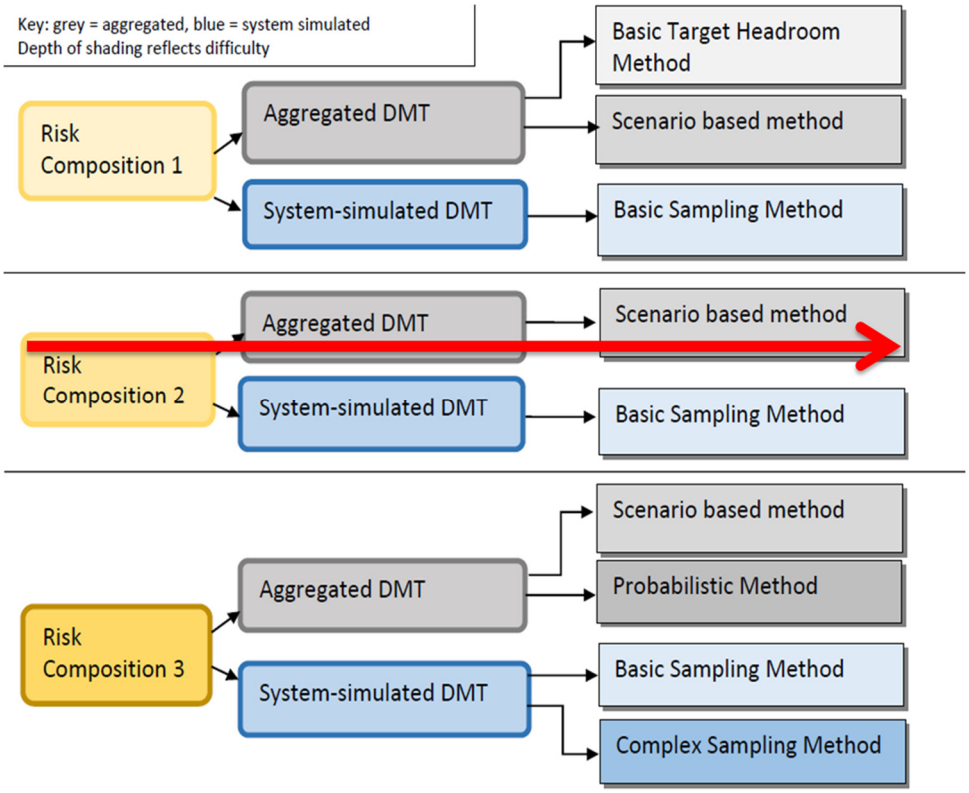

Figure 2: Overview of Risk Based Methods WRMP process (Source: Figure 8 from UKWIR WRMP 2019 Methods; Risk Based Planning)

The "Extended" decision making methods that are applicable with an Aggregate approach are;

- Modelling to Generate Alternatives
- Real Options
- Non-Linear EBSD

Multi-Criteria Analysis (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. The guidance does not highlight that many of the approaches are not mutually exclusive. For instance if a water company were to explore different Options Programmes across a range of supply and demand scenarios using MCA then this would represent an Extended Approach and should not be viewed as a "Current (Baseline) Approach". However it is recommended that this should be discussed with the regulator at the first opportunity

7 Conclusions

Compared with the position in WRMP14, both the South Staffs WRZ and Cambridge WRZs face new risks to their overall supply-demand balance. This is reflected in the results of the Problem Characterisation in Figure 1 which highlights that both WRZs are in the amber area of Medium strategic needs (scale of the problem) and complexity scores. Based on the information presented in South Staffs respective WRMP14 period, both WRZs would previously have been in the green areas of lower risk.

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

- Wider resilience issues affecting both WRZs; in South Staffs there is a potential decline in the volume, quality and reliability of available water resource without the renewal of long term treatment work assets, whereas in Cambridge there are long term growth concerns and regulatory pressures on abstractions licenses
- A wider appreciation of drought resilience across the water industry which means that both South Staffs and Cambridge may be vulnerable to droughts that are different to those experienced historically (in frequency and/or longevity). For Cambridge the supply system could be susceptible to multi-year droughts reducing successive winter recharge periods. This may be a particular issue should supply headroom become less in the future to cope with the effects of drought. In the South Staffs region the operational rules used during historical events, such as using potable water to maintain Blithfield reservoir levels, may not work or be available in different types of drought events.
- High level concerns due to future regulatory pressures and revised standards on abstraction licenses which are leading to license and sustainability reductions.
- In South Staffs added complexity is introduced due to the limited flexibility of the current water supply network which potentially requires parallel upgrades to the two strategic treatment works.
- In Cambridge, long term regional growth is being encouraged by Government but with large uncertainty over the amount and timing. Code for Sustainable Homes is in place but generally developments are designed to the lowest standard, there is no enforcement of higher levels. Future supply demand driven by new development is not yet fully defined.
- In Cambridge there are a limited number of new supply side options. They are generally complex and sometimes involve other regional partners which with associated additional uncertainty in timing, costs and access.

The implications of the problem characterisation results and subsequent discussions with SSC are that the following approach should be adopted:

- An enhanced decision making method
- using an aggregated approach
- and risk composition 2, scenario based method using multi-criteria analysis.