WRMP 2019 Technical Document:

Managing Uncertainty and Risk

December 2019

WINNER
UtilityWeek AWARDS 2018
Utility of the Year

THE QUEEN'S AWARDS FOR ENTERPRISE: SUSTAINABLE DEVELOPMENT 2015

This is a technical report that supports our WRMP submission.

This report provides an overview of our approach to managing uncertainty and risk. It summarises the conclusions drawn from our Problem Characterisation, our approach to headroom and outage, stress testing and residual risks and uncertainties.

Contents

1. Introduction

This is our Managing Uncertainty and Risk technical document. It is part of our WRMP submission, which is comprised of several reports as set out in the diagram. The main submission is supported by technical documents that explain our methodologies and provide the detailed results of our analysis.

Figure 1.1: WRMP 2019

This report describes how we are managing risk and uncertainty in our WRMP, through the activities listed below.

- Completion of the Problem Characterisation process, which assesses the size and complexity of the planning problem, and determines an appropriate decision making approach (following WRMP 2019 Methods - Risk Based Planning guidance).
- Assessment of target headroom, which uses the basic approach to quantify key long-term risks to the supply-demand balance.
- An outage allowance, which covers the risk of legitimate unplanned outage, based on a combination of data and expert judgement.
- An assessment of residual risk and uncertainty.
- Stress testing of our Preferred Plan using a range of scenarios as well as a comparison with an appraisal of long-term runs.

We have met the technical requirements set out in the WRPG, and we cross-reference headings to relevant points in the Environment Agency Checklist (see Table 1.1 below).

Table 1.1: Checklist actions addressed in this report - Defra/EA guidance

Number	Action
8	You have followed the principles of UKWIR's 'Decision Making Process' and 'Risk Based Planning' frameworks to: • Characterise the problem you need to solve • Choose the best decision making process for appraising the options available to you • Determine your approach for dealing with risks in your plan • Determine methods for supply, demand, outage and headroom calculations that are consistent with your chosen options appraisal method and risk composition.
41	You have allowed for uncertainties in your calculations and forecasts for both supply and demand over the planning period, and have used best practice methods to quantify uncertainty.
58	You have applied the problem characterisation step of the WRMP 2019 Methods - Decision Making Process: Guidance (UKWIR, 2016) to determine the nature of the planning problem (including scale and complexity) as well as related issues, risks and uncertainties.
71	You have described how/where you have allowed for uncertainty in your demand forecast and how this is appropriate to your selected methods.
87	Your approach to calculating your supply forecast is consistent with your risk composition choice, and the risk and uncertainty involved have been quantified using appropriate methods.
98	Where you abstract water for supply, your supply forecast for that WRZ sets out the deployable output, future changes to deployable output (e.g. from sustainability changes or climate change), transfers and future inputs from third parties, outage and other short-term losses, operational losses related to abstraction or treatments.
126	You have clearly explained whether and how climate change has been accounted for in your headroom assessment and have reported this separately.
144	You have documented your outage allowance and your approach is in line with WRMP 19 methods - Risk based planning (UKWIR, 2016) or the Outage allowances (UKWIR 1995) approach.
145	You have entered outage calculations in the water resources planning tables.
146	You have included details of options you propose for reducing outage, particularly in cases of a supply-demand balance deficit.
195	You have reduced uncertainty by using the most up to date methods and data when determining supply and demand forecasts.
196	You have analysed, quantified and discussed any uncertainties associated with your calculations of dry year annual average demand (and critical period scenarios if applicable).
197	You have used risk-based planning techniques to assess individual components of uncertainty, avoiding any double counting for (e.g. for target headroom components) or omission of uncertainties.
198	Alternatively, if you have applied an older target headroom approach to assess individual components of uncertainty, you have justified why this is appropriate. You have evaluated target headroom with regards to risk appetite and have allowed risk to increase with time as adaptations will occur in practice.
199	You have documented all assumptions and information used in the assessment of uncertainties and have discussed the relative significance of uncertainties showing which impact most on each WRZ.
200	You have considered options for reducing uncertainty in the planning period.
201	You have communicated uncertainty such that customers can clearly understand the issues and risks.
203	You have not included an allowance for possible future sustainability changes in headroom, and where relevant you have explored this through scenario analysis.

2. Problem Characterisation

Water companies have a statutory obligation to produce a Water Resources Management Plan (WRMP), which sets out how a company intends to maintain the balance between supply and demand for water over a minimum 25 year period. In the development of a WRMP, companies must follow the Water Resource Planning Guideline[1] ('Guideline') and have regard to broader government policy objectives.

For WRMP 2019, the Guideline has been updated and now (amongst other things) introduces more flexibility in the use of decision-making approaches.

In order to select an appropriate approach to decision-making, companies are required to assess the size and complexity of the planning problem using the Problem Characterisation process.

2.1 Assessment Methodology

The Guidance states that the assessment should be done at an appropriate level to the particular water company, and may involve grouping water resource zones into 'areas'. These 'areas' represent groups of water resource zones where there is either existing significant connectivity, and/or a high potential for additional transfers to be used to satisfy the supply demand balance problem.

There are two elements to the assessment:

- Strategic Needs (the size of the problem) - a high-level assessment of the scale of need for new water resources; and
- Complexity Factors (how difficult is it to solve). An assessment of the complexity of issues that affect investment in a particular WRZ or area.

Strategic needs are assessed using three questions provided by the Guidance. Each question is scored according to whether there are 'no concerns' (score: 0), 'moderately significant concerns' (score: 1) or 'very significant concerns' (score: 2).

Complexity factors are assessed according to 11 questions. Each question is scored according to whether the factor is 'moderately significant' (score: 1) or 'very significant' (score: 2).

The Guidance suggests how the questions should be scored, but stresses that the assessment is 'necessarily subjective[2]' and requires 'expert judgement[3]' from within the water company.

The question scores are combined in the below matrix (Table 2.1), which determines whether there is a 'low', 'moderate' or 'high' level of concern. Corresponding assessment and decision making process are outlined in the Guidance.

[1] *UKWIR, 2016. WRMP 2019 Methods - Risk Based Planning. Report Ref. No. 16/WR/02/11. UK Water Industry Research, London.*
[2] *UKWIR, 2016 'WRMP 2019 Methods - Decision Making Process: Guidance', Page 16*
[3] *UKWIR, 2016 'WRMP 2019 Methods - Decision Making Process: Guidance', Page 15*

Table 2.1: Matrix to identify an appropriate level of modelling complexity (from UKWIR guidance[4])

		Strategic Needs			
		0-1 (None)	2-3 (Small)	4-5 (Medium)	6 (Large)
Complexity Factors	Low (<7)	●	●	●	●
	Medium (7-11)	●	●	●	●
	High (11+)	●	●	●	●

● = Low level of concern

'Current' approaches (EBSD) should be adequate, and specific complexities can be examined through the steps recommended in the parallel UKWIR Risk Based Planning Methods project (to assist in derivation of DO, incorporation of uncertainty etc.)

● = Moderate level of concern

'Extended' approaches to modelling may add considerably to a company's understanding.

'Extended' refers to methods not previously widely used in WRMPs, but which have been tested to at least the 'proof of concept' stage for actual UK water resource systems and have outputs that can be readily understood by planners. For example, for Aggregate methods this may mean the use of Real Options Analysis, whilst for System Simulated methods this may mean the use of non-scheduled methods, or methods that examine limited portfolios without optimisation.

● = High level of concern

Consider whether it would be useful to apply more than one of the 'Extended' approaches to decision making, or even the use of the 'Complex' approaches, as these could add considerably to the company's understanding.

Here, 'complex' approaches refers to more advanced, conceptually complex methods not yet applied to the UK water resources context, although these may be under current investigation in academia.[5]

2.2 Grouping Water Resource Zones into Areas

Our draft Problem Characterisation was undertaken using WRMP 2015 data. We grouped the 19 WRZs in WRMP 2015 into 7 areas, taking account of levels of system connectivity, vulnerabilities and similarities. In the development of our WRMP 2019 we made changes to our WRZs, including splitting many of them, and as a result we now have 28 WRZs. Although our final problem characterisation assessment was based on the 28 WRZs in WRMP 2019, we did not make any changes to the areas used in the assessment (Figure 1.2).

Figure 2.1: Areas used in Final Problem Characterisation

2.3 Draft Problem Characterisation Assessment

In accordance with the Guidance, we completed a draft Problem Characterisation assessment in May 2016. The results of the draft assessment showed that we were facing moderately significant and very significant concerns across our region, as shown in Table 2.2.

[4] *UKWIR, 2016 'WRMP 2019 Methods - Decision Making Process: Guidance', Page 25*
[5] *UKWIR, 2016 'WRMP 2019 Methods - Decision Making Process: Guidance', Page 25*

Table 2.2: Draft Problem Characterisation Score

Area	Draft Problem Characterisation Score					
	Level of concern	Drivers				
		Growth	Sustainability reductions	Climate change	Severe drought	Investment Programme
1	Moderate	✓	✓	✓	✓	✓
2	High	✓		✓	✓	✓
3	Moderate		✓	✓		✓
4	Moderate	✓	✓	✓	✓	
5	Moderate	✓		✓		
6	Moderate	✓	✓		✓	
7	Low					

We used the results of our draft Problem Characterisation to inform our choice of Risk Composition[6], technical approach and planning objectives. The key conclusions that we drew from the assessment are set out below.

Needs:

- Our supply-demand balance is under significant pressure from population growth, climate change, sustainability reductions and the need to increase our resilience to severe drought. There are, however, multiple plausible planning scenarios, and the selection of a planning scenario has a material impact upon scheme selection. In particular, there is significant uncertainty over AMP 8 sustainability reductions driven by the Water Framework Directive no deterioration obligation. In some scenarios the reductions required are significant and drive large strategic options such as new reservoir storage.
- At the time of the draft assessment, we were concerned that our systems were vulnerable to severe and extreme drought, meaning that we would not be able to maintain supplies to customers without imposing severe restrictions[7]. This would be unacceptable to the majority of our customers.
- In addition, we had concerns that the reliable yield approach used to calculate deployable output (DO) at WRMP 2015 (this involves assessing DO at a source works level and then aggregating the results) does not fully account for non-linear effects linked to connectivity and supply-system operation. In order to better understand conjunctive DO, we needed to develop a model that could realistically simulate the company's supply system under a range of historic conditions and future scenarios.

Solutions:

- The scale of the challenge is such that, although there is great potential for future demand management, additional supply-side capacity will still be required.
- The draft assessment highlighted the existence of complex trade-offs inherent in decisions around drought resilience and demand management. As part of the development of our draft WRMP, we needed to determine:
  - What Levels of Service would be appropriate for our customers
  - An appropriate balance of demand management and supply-side options, and
  - Both of these decisions would require more work to understand the costs, options required and customer support for this investment.

[6] *The Risk Composition describes the way in which drought resilience is incorporated into the WRMP; there are three Compositions of increasing complexity, with each related to methods of assessing and integrating drought risk into the demand and supply forecasts.*
[7] *This conclusion was based in part on expert judgement and in part on the experience of the 2011-12 drought.*

2.4 Final Problem Characterisation Assessment Summary and Decision Making Approach

Between the draft and final Problem Characterisation assessments we developed our understanding of the planning problem, through the activities listed below, and this is reflected in our updated scoring.

- We built a system model in Aquator that allowed us to refine our understanding of current DO.
- We completed an extensive analysis of our vulnerability to severe drought.
- The Environment Agency issued the AMP7 Water Industry National Environment Programme (WINEP), which provided certainty over the sustainability changes required in AMP7.
- We developed an adaptive planning process to manage uncertainty over needs beyond AMP7.
- We undertook an extensive programme of customer engagement to explore the trade-offs associated with investment to reduce the risk of severe restrictions and demand management.

The results of the final assessment confirmed that our supply-demand balance is under significant pressure; however, the associated complexity was greatly reduced. Consequently we were facing lower concerns across our region compared with the draft assessment (as shown in Table 2.3), and the EBSD approach to decision making was appropriate for use. However, the limitations of least cost planning approach are now widely recognised, and there is support from regulators, stakeholders and our customers, to develop Best Value Plans. Such plans must consider more than cost and include issues such as the environmental impact, resilience and customer preferences. Defra's own Guiding Principles state: 'We expect to see evidence that you have taken a strategic approach to water resources planning that represents best value to customers over the long term.'

We therefore assessed a number of factors in developing our Preferred Plan, which went beyond the industry standard EBSD approach that only provides a narrowly defined 'least cost plan'. The 'best value' criteria used in developed our Preferred Plan include:

- **Cost -** how much does the plan cost to build and operate?
- **Adaptability and flexibility -** is the plan flexible enough to cope with uncertain future needs? Does it include potentially 'high regret' options, or limit future choices?
- **Alignment to WRE -** how well does the plan align to the regional strategy?
- **Risk and resilience -** how resilient is the plan to more extreme drought scenarios and other hazards, and what are the residual risks associated with each?
- **Customer preferences -** how well does the plan align to customer preferences?
- **Environmental and social impact -** what are the environmental and social impacts associated with each plan?

Table 2.3: Final Problem Characterisation Score

Area	Final Problem Characterisation Score				
	Level of concern	Drivers			
		Growth	Climate Change	AMP7 SRs	Severe drought
1	Low	✓	✓	✓	✓
2	Moderate	✓	✓		
3	Low			✓	
4	Low	✓	✓	✓	✓
5	Low	✓	✓	✓	
6	Low	✓		✓	✓
7	Low				

The full assessment results broken down by area are provided in the appendices.

3. Approach to risk (8, 58, 203)

The management of risk and uncertainty in a WRMP relates to the risk of under or over-estimating supply and demand and therefore the supply-demand balance and Levels of Service. This includes the potential combination of risks from certain events, for example drought and pollution events, and uncertainties such as population growth and climate change. Risks have to be considered for 'average' dry years and droughts, including critical periods of higher 'peak' demand.

Risk matters more in WRZs where there is higher vulnerability to key factors such as drought, climate change and population growth. We assessed such vulnerability and captured it in our Problem Characterisation assessment, as described above. We adopted an approach (known as Risk Composition 2) that led us to produce a 'Resilience Tested Plan'. In particular we tested a range of alternative drought events using behavioural models (see Supply Forecast report), along with scenarios of more uncertain potential impacts as described in the Stress Testing section (see section 6).

For headroom we used the Basic Approach as defined in the UKWIR Risk-Based planning guidance. This is compatible with our Problem Characterisation and in line with our use of an aggregated supply-demand balance (our use of supply-system modelling, described in Section 4, has been used to inform the aggregated method).

4. Headroom (41, 71, 87, 126, 195, 196, 197, 198, 199, 200, 201)

Headroom is a buffer between supply and demand. Actual or available headroom is the amount of water available minus demand. Target headroom is a minimum allowance - taking into account critical risks and uncertainties - required to maintain levels of service for the supply-demand situation with a given level of confidence. We are managing risk into the medium to long-term through our Adaptive Plan: some risks are managed through identification of robust options that cope well with uncertainty; other uncertainties (especially those associated with regulatory change) will be resolved in the next AMP.

For this WRMP we developed a new, simpler and standalone headroom model. This allows clear identification of critical uncertainties and easy control of the risk glide-path. We only included well-defined risks that we quantified and are critical to overall target headroom (tested through sensitivity analysis). Other uncertainties, such as sustainability reductions, were assessed in scenario testing. Risks in headroom include: base year (demand-side) uncertainties; population (growth), consumption and weather-related leakage uncertainty; climate change; long-term point source pollution and drought water quality constraints (see Table 5). As we are rapidly moving towards full metering and full measured billing, we no longer require uncertainties associated with switchers and household demand segments.

Table 4.1: Headroom components: overview

Type	Component	Description	Impact distribution
Demand-side	Base-year household	Uncertainty in the base year split of demand components. Distribution derived using water balance MLE adjustment. Varies by WRZ.	Typically +/-4.5%
	Base-year non-household		Typically +/-2.5%
	Base-year leakage		Typically +/-12.0%
	Population growth	Uncertainty in population growth; 5thand 95th percentile UKWIR factors[8], validated by upper and lower growth scenarios produced by Edge Analytics. Varies by WRZ.	c.+/-12% (large and medium WRZs) and c.+/-17% (small WRZs) by 2044-45
	Per-capita consumption	Uncertainty in household consumption, based on micro-component analysis.	-15% to +4% by 2044-45
	Non-household forecast	Uncertainty in non-household consumption, related to economic factors.	+/-5.8% by 2044-45
	Weather-related leakage	Uncertainty related to cold weather events that can increase leakage. Based on analysis of cold winters including 2010-11.	+45 Ml/d to -5 Ml/d at company level; allocated to WRZs based on DI
	Climate change	Impact of climate change on demand; 10th and 90th percentile of average UKWIR model factors[9]. Extrapolated to 2044-45. Separate factors for dry year annual average and critical peak.	+0.6 percentage points to -0.5pp (DYAA); +1.8pp to -1.6pp (DYCP)
Supply-side	Long-term point source pollution	Risk to groundwater boreholes in pollution relation to catastrophic or persistent pollution that cannot be remediated, technically or economically. Varies by WRZ depending on number of and risk to sources.	20% annual probability of loss of one source in region; weighted based on updated CRAGS^
	Drought water quality constraints	Risk associated with poorer water constraints quality in lower flow horizons and turbidity impacts in boreholes during a drought; only applied in relation to the Lincolnshire Limestone.	Impact limited due to other constraints on DO except for up to -1.1 Ml/d in Bourne WRZ
	Climate change	Conjunctive impact of climate change on surface and groundwater sources; high and low scenarios. Varies by WRZ depending on source vulnerability.	See Table 4.2

^*Catchment Risk Assessment for Groundwater Sources.*

[8] *UKWIR, 2015. WRMP19 Methods - Population, Household Property and Occupancy Forecasting: Guidance Manual. Report Ref. No. 15/WR/02/8. UK Water Industry Research, London.*

[9] *From Appendix 6 (Look-Up Tables for Regional Climate Change Water Demand Factors) of UKWIR, 2013. Impact of Climate Change on Water Demand - Main Report. Report Ref. No. 13/CL/04/12. UK Water Industry Research, London.*

Table 4.2: Headroom components: supply-side climate change

WRZ	2044-45	
	High impact (Ml/d)	Low impact (Ml/d)
Bourne		
Bury Haverhill		
Central Essex		
Central Lincolnshire		
Cheveley		
East Lincolnshire		
East Suffolk	3.1	-1.9
Ely		
Happisburgh		
Hartlepool		
Ixworth		
Newmarket	1.3	
North Fenland		
North Norfolk Coast		
Norfolk Rural North		
Norfolk Rural South		
Norwich and the Broads	4.4	0
Nottinghamshire		
Ruthamford Central		
Ruthamford North	29.1	-25.7
Ruthamford South	24.8	-21.9
Ruthamford West		
South Essex	1.3	0
South Fenland		
South Lincolnshire		
Sudbury		
Thetford		

In line with our adaptive planning approach we are able to reduce our headroom glide-path so that headroom is no greater than 7.5% of baseline DI in AMP8-10 and 6.5% of baseline DI in AMP11 (Table 4.4). The equivalent risk glidepath is set out in Table 4.3.

Table 4.3: Headroom risk glidepath by WRZ at end of AMPs

WRZ	2024-25	2029-30	2034-35	2039-40	2044-45
Bourne	95th	95th	90-95th	90-95th	85-90th
Bury Haverhill	95th	95th	95th	95th	90-95th
Central Essex	95th	95th	95th	95th	90-95th
Central Lincolnshire	95th	95th	95th	95th	90-95th
Cheveley	95th	95th	95th	90-95th	85-90th
East Lincolnshire	95th	95th	90-95th	90-95th	85-90th
East Suffolk	95th	95th	95th	90-95th	90-95th
Ely	95th	90-95th	90-95th	85-90th	80-85th
Happisburgh	95th	95th	95th	95th	90-95th
Hartlepool	95th	95th	95th	95th	95th
Ixworth	95th	95th	90-95th	90-95th	85-90th
Newmarket	90-95th	90-95th	85-90th	85-90th	80-85th
North Fenland	95th	95th	95th	95th	90-95th
North Norfolk Coast	95th	95th	95th	95th	95th
Norfolk Rural North	95th	95th	95th	95th	95th
Norfolk Rural South	95th	95th	95th	95th	90-95th
Norwich and the Broads	85-90th	85-90th	80-85th	80-85th	70-75th
Nottinghamshire	95th	95th	95th	95th	95th
Ruthamford Central	95th	95th	95th	95th	95th
Ruthamford North	95th	90-95th	90-95th	90-95th	85-90th
Ruthamford South	80-85th	80-85th	80-85th	80-85th	75-80th
Ruthamford West	95th	95th	95th	95th	95th
South Essex	95th	95th	95th	95th	95th
South Fenland	95th	95th	95th	95th	90-95th
South Lincolnshire	95th	95th	95th	95th	90-95th
Sudbury	95th	95th	90-95th	90-95th	85-90th
Thetford	95th	95th	90-95th	90-95th	90-95th

Headroom varies by WRZ and year depending on the risks and uncertainties, and the adopted glidepath (Table 4.4). It is typically 5% of baseline DI in 2020-21, increasing notably in 2024-5 at the point that climate change is introduced (see Supply Forecast report), and then increasing in response to longer-term risks, especially population growth and long-term point source pollution (the latter for groundwater dominated WRZs only). Weather-related leakage uncertainty is constant throughout.

Table 4.4: Headroom by WRZ at end of AMP7 and end of planning period

WRZ	2024-25		2044-45	
	Headroom (Ml/d)	Headroom (% baseline DI)	Headroom (Ml/d)	Headroom (% baseline DI)
Bourne	2.4	5.7%	2.9	6.5%
Bury Haverhill	1.4	4.7%	1.9	6.5%
Central Essex	0.4	4.4%	0.6	5.7%
Central Lincolnshire	4.9	4.7%	7.3	6.5%
Cheveley	0.1	4.9%	0.1	6.5%
East Lincolnshire	5.3	5.1%	6.7	6.5%
East Suffolk	4.1	5.9%	4.8	6.5%
Ely	1.2	5.8%	1.5	6.5%
Happisburgh	0.2	4.7%	0.3	6.4%
Hartlepool	1.2	5%	1.53	6.0%
Ixworth	0.2	4.9%	0.3	6.5%
Newmarket	0.9	7.5%	0.8	6.5%
North Fenland	1.2	4.6%	1.6	6.0%
North Norfolk Coast	1.0	4.6%	1.3	5.9%
Norfolk Rural North	1.1	4.4%	1.5	5.5%
Norfolk Rural South	0.6	4.7%	0.8	6.5%
Norwich and the Broads	4.4	6.4%	4.7	6.5%
Nottinghamshire	0.9	4.5%	1.2	5.6%
Ruthamford Central	3.1	4.5%	4.4	5.8%
Ruthamford North	16.9	7.3%	16.1	6.5%
Ruthamford South	8.1	7.5%	7.7	6.5%
Ruthamford West	1.0	4.4%	1.4	5.5%
South Essex	3.0	4.9%	4.0	6.1%
South Fenland	1.5	4.7%	2.1	6.5%
South Lincolnshire	1.2	4.7%	1.6	6.2%
Sudbury	0.3	5.0%	0.5	6.5%
Thetford	0.5	4.9%	0.8	6.5%

The uncertainty from climate change and other sources, and the combined uncertainty, is provided in the WRP Tables (note, these are uncapped target headroom; the adopted target headroom, provided separately in the WRP Tables, is capped as discussed above). Table 8 presents the proportion of uncapped headroom that is made up of supply and demand-side climate change uncertainties. Prior to 2024-25 the only component is demand-side and this remains the case for some zones that have no sources (e.g. Ruthamford Central), sources that are resilient, or where there is low uncertainty about future supply-side impacts.

Table 4.5: Proportion of uncapped headroom from climate change uncertainties

WRZ	% total target headroom	
	2024-25	2044-45
Bourne	0.5%	1.4%
Bury Haverhill	0.6%	3.6%
Central Essex	0.6%	3.8%
Central Lincolnshire	0.5%	3.2%
Cheveley	0.5%	3.1%
East Lincolnshire	0.5%	3.3%
East Suffolk	30.3%	25.5%
Ely	0.5%	1.4%
Happisburgh	0.7%	4.4%
Hartlepool	0.5%	3.2%
Ixworth	0.6%	3.5%
Newmarket	50.3%	24.6%
North Fenland	0.6%	4.2%
North Norfolk Coast	0.7%	4.7%
Norfolk Rural North	0.7%	4.5%
Norfolk Rural South	0.6%	3.3%
Norwich and the Broads	43.4%	45.0%
Nottinghamshire	0.6%	3.7%
Ruthamford Central	0.7%	5.1%
Ruthamford North	58.3%	59.6%
Ruthamford South	71.6%	71.9%
Ruthamford West	0.5%	3.9%
South Essex	20.7%	22.1%
South Fenland	0.5%	3.3%
South Lincolnshire	0.6%	4.5%
Sudbury	0.6%	3.2%
Thetford	0.5%	1.0%

Headroom in the critical period scenario was scaled according to the WRZ demand peaking factor (see the Demand Forecast report). The proportional caps to headroom defined for the DYAA scenario were also applied.

Uncertainty in relation to options is described in the Supply-Side Option Development report. There is no headroom allowance relating to options because the options included in the Preferred Plan (transfers and re-use) are reliable and not subject to the uncertainties included in headroom such as climate change.

5. Outage (98, 144,145,146)

Outage describes an allowance of water which represents the risk of short-term (less than 3 months) supply-side failure. This may be caused for example by pollution incidents or an unexpected need to repair a water treatment works. Such incidents rarely affect the amount of water available to go into supply because of spare capacity (redundancy) in resources and treatment; supply interruptions are further minimised by short-term storage in the distribution network. More local failures, typically associated with bursts in pipes, are not considered as part of outage and are subject to separate investment drivers.

For the WRMP our outage assessment was based on the same approach as for WRMP14. This is based on the principles set out in the Outage allowances guidance[10], whereby the distributions for each outage type and location are developed describing duration and magnitude, and are then combined using Monte Carlo simulation. This is consistent with the Basic 'reference' method described in the UKWIR Risk-Based planning guidance[11]. We did not include planned outage but adopted the 95th percentile of (unplanned) outage as a precautionary approach.

Outage is evaluated in relation to asset failure rates and resource failures due to pollution. We considered water quality issues as part of outage, rather than in our system modelling at this stage. Pollution impacts on water quality are split into surface and groundwater risks; we updated the assessment for groundwater risks based on a new version of our Catchment Risk Assessment for Groundwater Sources (CRAGS). The inputs to the outage modelling are described in Table 9.

For the WRMP we adjusted the outage allowances to reflect our progress in reducing the population served by a single source of supply. We are now in a position that more than half of our customers are served by more than one source of supply[12]. This means that if a WTW failed to output the demand required (for whatever reason), another works would be able to make up the demand. Therefore, in the revised assessment we halved the outage risk for the part of each WRZ where there is more than one source of supply. This reduced overall outage to just under 2%.

Table 5.1: Outage components

Component	Description	Impact distribution
Point source pollution (groundwater)	Transient pollution event or where source can be effectively remediated. Varies by WRZ depending on number of and risk to sources.	25% reduction in source-works DO with 6% annual probability of occurring at one source-works in region; weighted based on updated CRAGS^
Point source pollution (surface water)	Transient pollution event or where source can be effectively remediated. Varies by WRZ depending on number of sources.	5% reduction in source-works DO with 20% annual probability of occurring at one source-works in region
Asset failure	Temporary breakdown in equipment at an intake, borehole or source-works that prevents source-works running at full capacity.	Minimum 1%; most likely 1.5%; maximum 2.5%; of source-works DO

^*Catchment Risk Assessment for Groundwater Sources.*

Outage is 1.6% of DO on average across the company. It ranges from 1.3% to 3.5% of DO at WRZ level, in relation to the type and risk of sources. The risk (relative to DO) is the same in each year of the planning period. Outage is recorded in the WRP Tables, and is summarised in Table 5.2 below.

[10] *UKWIR, 1995. Outage allowances for water resource planning: Operating methodology. UK Water Industry Research, London.*
[11] *UKWIR, 2016. WRMP 2019 Methods - Risk Based Planning. Report Ref. No. 16/WR/02/11. UK Water Industry Research, London.*
[12] *In the base year (2017-18) this was 54.7%.*

Table 5.2: Outage by WRZ in the first forecast year

WRZ	2020-21	
	Outage (Ml/d)	Outage (% DO)
Bourne	0.9	1.6%
Bury Haverhill	0.6	2.2%
Central Essex	0.2	1.6%
Central Lincolnshire	2.5	1.8%
Cheveley	0.1	3.5%
East Lincolnshire	2.1	1.5%
East Suffolk	1.3	1.7%
Ely	0.3	1.4%
Happisburgh	0.1	1.9%
Hartlepool	0.9	2.5%
Ixworth	0.1	1.8%
Newmarket	0.2	1.4%
Norfolk Rural North	0.6	2.0%
Norfolk Rural South	0.3	1.8%
North Fenland	0.7	1.7%
North Norfolk Coast	0.3	1.3%
Norwich and the Broads	1.3	1.6%
Nottinghamshire	0.5	2.3%
Ruthamford Central	0.0	0.0%
Ruthamford North	4.5	1.5%
Ruthamford South	4.2	1.6%
Ruthamford West	0.0	0.0%
South Essex	1.2	1.7%
South Fenland	0.6	1.8%
South Humber Bank	0.0	0.0%
South Lincolnshire	0.4	1.3%
Sudbury	0.2	1.5%
Thetford	0.2	1.4%

Outage in the critical period scenario was scaled according to the increase in WRZ DO (see the Supply Forecast report).

6. Residual risk and uncertainty

6.1 Risks and uncertainties included in the WRMP

Risks and uncertainties are included in our WRMP from 2020 as they materialise. This includes those relating to:

- Population growth and associated uncertainties in timing and location
- Per capita consumption levels
- Impact of climate change (commencing in 2020)
- Sustainability reductions (throughout AMP7), and
- Drought risk relating to improved Level of Service (2024).

We used our headroom model to quantify uncertainties, as described above.

6.2 Residual deficits in the WRMP

We have one WRZ with a residual deficit: Ruthamford South. Ruthamford South has a large deficit starting in 2020, mainly due to climate change, which is resolved in 2024 by the transfer of additional resource from Lincolnshire into the Ruthamford system. We will manage this risk by being prepared to request a Drought Permit at Offord, which would provide sufficient temporary resource in the event of a severe drought. In discussion with the Environment Agency we have developed a new trigger level, which if reached would activate detailed assessment on the need for a permit. The trigger level has not been reached in recent drought events. The permits would be a temporary, winter-only application.

6.3 Residual risks and uncertainties

In our WRMP we continue to implement low regret options up front. Principally these are demand management options including metering, leakage reduction and water efficiency measures. Such options ensure the prudent use of natural resources and reduce the need for supply-side options even with a rising population. Demand management measures are also strongly supported by our customers and stakeholders.

The strategic transfers were selected as the least cost way of meeting future deficits and we have adjusted the capacity of the transfers as described in chapter 6 of the main WRMP report. This enables us to avoid stranded assets whilst maintaining security of supply over the whole WRMP planning horizon. The adjustment takes into account the following residual risks and uncertainties:

- Further drought resilience, e.g. potential in future to move to <0.2 per cent annual probability of severe restrictions
- Future sustainability reductions, including the potential for the impact of climate change to be incorporated in this process, as described in one of the draft WRMP consultation responses
- Uncertainties about demand management savings
- The potential for future transfers to neighbouring water companies, and
- Pre-planning considerations for strategic options.

We will be working to better understand these uncertainties and risks in the next two to three years (see chapter 7 of the WRMP report) and how they relate to the need for strategic supply-side options.

7. Stress testing and long-term assessment

In all of the Problem Characterisation areas, the transfers within the Preferred Plan provide adequate capacity for meeting the stress test scenarios. In the West, Norfolk, and Cambridgeshire and West Suffolk areas, additional transfers (e.g. into Norfolk) would be required to address new deficits. This additional investment would further enhance the strategic grid and could be delivered at a later date without impacting the Preferred Plan schemes. To meet the deficits created by the scenarios, additional resources would also be required. The stress testing shows that these could be a number of smaller options (e.g. water company imports, desalination or raw water transfers) or a larger single strategic option such as a winter storage reservoir. In both cases water would be moved between areas by the Preferred Plan and additional transfers described above. The full results of the stress testing are show in Table 7.1.

Table 7.1: Stress testing results

Problem Characterisation Area	Scenario	Least Cost Analysis compared against Least Cost Plan	Options required in scenario in addition to Preferred Plan	Options required in addition to Preferred Plan if a strategic supply-side option was developed
Area 1 - North	Extreme Drought	T: ✓ R: > (Pyewipe)	T:✓ R: ✓	T: ✓ R: ✓
	High CC	T: ✓ R: > (Pyewipe)	T: ✓ R: ✓	T: ✓ R: ✓
	DMO -15%	T: ✓ R: > (Pyewipe)	T: ✓ R: ✓	T: ✓ R: ✓
	DMO -30%	T: ✓ R: > (Pyewipe)	T: ✓ R: ✓	T: ✓ R: ✓
	Affinity Export	T:✓ R: > (Pyewipe)	T: ✓ R: ✓	T: ✓ R: ✓
Area 2 - West	Extreme Drought	T: > (Ruthamford North to South, South Fenland to Ruthamford North) R: > (Trent, imports, water reuse)	T: > (Ruthamford North to South) R: > (Trent, imports, water reuse)	T: > (Ruthamford North to South) R: > (Trent, imports, water reuse)
	High CC	T: > (Ruthamford North to South) R: > (Trent, import)	T: > (Ruthamford North to South) R: > (Trent, imports)	T: > (Ruthamford North to South) R: > (Trent, imports)
	DMO -15%	T: ✓ R: ✓	T: ✓ R: > (import)	T: ✓ R: > (Winter storage reservoir)
	DMO -30%	T: ✓ R: ✓	T: > (Ruthamford North to South) R: > (Trent)	T: > (Ruthamford North to South) R: > (Trent)
	Affinity Export	T: > (Ruthamford North to South) R: > (import)	T: > (Ruthamford North to South) R: > (Trent, imports)	T: > (Ruthamford North to South) R: > (Winter storage reservoir)

Problem Characterisation Area	Scenario	Least Cost Analysis compared against Least Cost Plan	Options required in scenario in addition to Preferred Plan	Options required in addition to Preferred Plan if a strategic supply-side option was developed
Area 3 - Central	Extreme Drought	T: < R: > (Desalination)	T: ✓ R: ✓ (None)	T: ✓ R: ✓ (None)
	High CC	T: < R: > (Desalination)	T: ✓ R: > (Desalination)	T: ✓ R: > (winter storage reservoir)
	DMO -15%	T: < (better utilisation of West to Central link) R: ✓ (None)	T: ✓ R: ✓ (None)	T: ✓ R: ✓ (None)
	DMO -30%	T: < R: ✓ (none)	T: ✓ R: > (Desalination)	T: ✓ R: > (winter storage reservoir)
	Affinity Export	T: ✓ R: ✓ (none)	T: ✓ R: ✓ (None)	T: ✓ R: ✓ (None)
Area 4 - Norfolk	Extreme Drought	T: ✓ R: ✓ (None)	T: ✓ R: ✓ (None)	T: ✓ R: ✓ (None)
	High CC	T: > R: ✓ (None)	T: > (Central to Norfolk) R: ✓ (None)	T: > (Central to Norfolk) R: ✓ (None)
	DMO -15%	T: ✓ R: ✓ (None)	T: ✓ R: ✓ (None)	T: ✓ R: ✓ (None)
	DMO -30%	T: ✓ R: ✓ (None)	T: > (Central to Norfolk) R: ✓ (None)	T: > (Central to Norfolk) R: ✓ (None)
	Affinity Export	T: ✓ R: ✓ (None)	T: ✓ R: ✓ (None)	T: ✓ R: ✓ (None)
Area 5 - Essex and East Suffolk	Extreme Drought	T: ✓ R: < (Ardleigh extension not required)	T: ✓ R: ✓	T: ✓ R: ✓
	High CC	T: ✓ R: < (Ardleigh extension not required)	T: ✓ R: ✓	T: ✓ R: ✓
	DMO -15%	T: ✓ R: ✓	T: ✓ R: ✓	T: ✓ R: ✓
	DMO -30%	T: > (transfer to Central Essex) R:✓	T: > (transfer to Central Essex) R: ✓	T: > (transfer to Central Essex) R: ✓
	Affinity Export	T: ✓ R: < (Ardleigh extension not required)	T: ✓ R:✓	T: ✓ R: ✓

Problem Characterisation Area	Scenario	Least Cost Analysis compared against Least Cost Plan	Options required in scenario in addition to Preferred Plan	Options required in addition to Preferred Plan if a strategic supply-side option was developed
Area 6 - Cambridgeshire and West Suffolk	Extreme Drought	T: > R: ✓ (None)	T: > (Ruthamford to Newmarket) R: ✓ (None)	T: > (Ruthamford to Newmarket) R: ✓ (None)
	High CC	T: > R: ✓ (None)	T: > (Ruthamford to Newmarket) R: ✓ (None)	T: > (Ruthamford to Newmarket) R: ✓ (None)
	DMO -15%	T: > R: v (None)	T: > R: ✓ (None)	T: > R: ✓ (None)
	DMO -30%	T: > some larger and in different direction R: ✓ (None)	T: > (Ruthamford to Newmarket) R: ✓ (None)	T: > (Ruthamford to Newmarket) R: ✓ (None)
	Affinity Export	T: ✓ R: ✓ (None)	T: ✓ R: ✓ (None)	T: ✓ R: ✓ (None)

Key: T=Transfers, R=Resource options, ✓=same capacity or resource options, >=larger capacity transfers or additional resource options, <=smaller capacity transfers or resource schemes not required.

We assessed our Preferred Plan over two extended durations, 45 years (up to 2065) and 65 years (up to 2085) and for two supply forecast scenarios (with and without Affinity Water trade). The results are shown in the Table 7.2.

In addition to the resource options in the Preferred Plan the South Lincolnshire reservoir option RTN1 (maximum deployable output 76Ml/d) was selected along with a number of other smaller resource options in all scenarios. We then tested if a single larger reservoir (up to 200Ml/d) would meet demand as an alternative to the least cost selection of smaller options.

The trade with Affinity Water impacted the timing of when new resource options would be required.

Table 7.2: Long-term assessment

Duration	Supply forecast Scenario	Resource options required in scenario in addition to Preferred Plan	Resource options required in addition to Preferred Plan if a strategic supply-side option was developed
45 years up to 2065	Without trade to Affinity Water	• South Lincolnshire reservoir (RTN1) in 2042	• South Lincolnshire reservoir in 2038
65 years up to 2085		• STW import 2044 • South Lincolnshire reservoir (RTN1) 2058 • Water reuse 2068 • Fenland Reservoir 2080	• South Lincolnshire reservoir 2038
45 years up to 2065	With 50Ml/d trade to Affinity Water	• STW import 2032 • Water reuse 2032 • South Lincolnshire reservoir (RTN1) in 2037	• South Lincolnshire reservoir in 2032
65 years up to 2085		• STW imports 2032, 2037 • Water reuse 2032, 2062, 2068 • South Lincolnshire reservoir (RTN1) in 2055	• South Lincolnshire reservoir in 2032 • Water reuse 2067

Appendix 1: Final Problem Characterisation Detailed Results*

Area 1: Lincolnshire and Nottinghamshire

Area 1 is assessed as having low levels of concern

	Area 1: Pressures on supply demand balance			
	Growth	Sustainability reductions	Climate change	Severe drought
Bourne	✓	✓		
Central Lincolnshire	✓	✓		✓
East Lincolnshire		✓		
Nottinghamshire	✓	✓		
South Lincolnshire	✓	✓	✓	
South Humber Bank				

** Note the results of the Final Problem Characterisation were correct at the time of the assessment (Autumn 2017).*

Area 1: Strategic needs

Question (needs)	
S. Level of concern that customer service could be significantly affected by current or future supply side risks, without investment.	2 - Very significant concerns
D. Level of concern that customer service could be significantly affected by current or future demand side risks, without investment.	1 - Moderate concerns
I. Level of concern over the acceptability of the cost of the likely investment programme, and/or that the likely investment programme contains contentious options (including environmental/planning risks).	2 - Very significant concerns
Total needs score	**5**

Baseline Supply Demand Balance

- Central Lincolnshire goes in to deficit in 2027-28.
- Nottinghamshire WRZ goes into deficit in 2022-23.
- Bourne WRZ goes into deficit in 2022-23.
- South Humber Bank and East Lincolnshire remain in surplus over the planning period.

Area 1: Supply complexity

Questions: Supply complexity	
S(a). Are there concerns about understanding of 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?	0 - No significant concerns
S(b). Are there concerns about understanding of future supply system performance, primarily due uncertain impacts of climate change on vulnerable supply systems, including associated source deterioration (water quality, catchments etc.)?	0 - No significant concerns
S(c). Are there risks of 'stepped' changes in supply (e.g. sustainability reductions, bulk imports etc.) in the near or medium terms that are currently very uncertain?	1 - Moderate concerns
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 - this is also referred to as a non-linear problem).	0 - No significant concerns
Total supply complexity score	**1**

Area 1: Demand complexity

Questions: Demand complexity	
D(a). Has the nature of current or near term demand recently changed or is likely to change, e.g. because of large scale metering programmes or sudden changes in economics/demographics.	0 - No significant concerns
D(b). Does uncertainty associated with forecasts of demographic/ economic changes over the planning period cause concerns over the level of investment that may be required?	0 - No significant concerns
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.	0 - No significant concerns
Total supply complexity score	**0**

Area 1: Investment programme complexity

Questions: Demand complexity	
IP(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?	1 - Moderate concerns
IP(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?	1 - Moderate concerns
IP(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?	0 - No significant concerns
IP(d). Do uncertainties about relative opex or utilisation of resources cause concerns about the adequacy of a simple, deterministically derived investment portfolio?	0 - No significant concerns
Total supply complexity score	**2**

Area 1: Results

		Strategic Needs			
		0-1 (None)	**2-3 (Small)**	**4-5 (Medium)**	**6 (Large)**
Complexity Factors	**Low (<7)**			X (Area 1)	
	Medium (7-11)				
	High (11+)				

Area 1 has been assessed as follows.

- Needs score of 5 (out of a total possible 6).
- A total complexity score of 3 (out of a total possible 22).
- As a result it is assessed has having low and moderate levels of concern. This implies that traditional EBSD approaches should be adequate.

Area 2: Ruthamford

Area 2 is assessed as having moderate levels of concern

WRZ	Area 2: Pressures on supply demand balance			
	Growth	Sustainability reductions	Climate change	Severe drought
Ruthamford North	✓		✓	
Ruthamford South	✓	✓	✓	
Ruthamford Central	✓			
Ruthamford West	✓			

Area 2: Strategic needs

Question (needs)	
S. Level of concern that customer service could be significantly affected by current or future supply side risks, without investment.	2 - Very significant concerns
D. Level of concern that customer service could be significantly affected by current or future demand side risks, without investment.	2 - Very significant concerns
I. Level of concern over the acceptability of the cost of the likely investment programme, and/or that the likely investment programme contains contentious options (including environmental/planning risks).	2 - Very significant concerns
Total needs score	**6**

Baseline Supply Demand Balance

- Ruthamford South enters a supply-demand deficit at the beginning of the period in 2020-21.
- Ruthamford North goes into deficit in 2022-23 driven by target headroom. The deficit increases over the planning period and becomes a supply-demand deficit in 2029-30.
- Ruthamford Central goes into deficit driven by headroom in 2024-25. The deficit increases over the planning period and becomes a supply-demand deficit in 2029-30
- Supply and demand are balanced in Ruthamford West as a result of transfers in. It goes into deficit in 2034-35 driven by headroom.

Area 2: Supply complexity

Questions: Supply complexity	
S(a). Are there concerns about understanding of 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?	0 - No significant concerns
S(b). Are there concerns about understanding of future supply system performance, primarily due uncertain impacts of climate change on vulnerable supply systems, including associated source deterioration (water quality, catchments etc.)?	0 - No significant concerns
S(c). Are there risks of 'stepped' changes in supply (e.g. sustainability reductions, bulk imports etc.) in the near or medium term that are currently very uncertain?	1 - Moderate concerns
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 - this is also referred to as a non-linear problem).	0 - No significant concerns
Total supply complexity score	**1**

Area 2: Demand complexity

Questions: Demand complexity	
D(a). Has the nature of current or near term demand recently changed or is likely to change, e.g. because of large scale metering programmes or sudden changes in economics/demographics.	0 - No significant concerns
D(b). Does uncertainty associated with forecasts of demographic/ economic changes over the planning period cause concerns over the level of investment that may be required?	0 - No significant concerns
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.	0 - No significant concerns
Total supply complexity score	**0**

Area 2: Investment programme complexity

Questions: Demand complexity	
IP(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?	1 - Moderate concerns
IP(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?	1 - Moderate concerns
IP(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?	0 - No significant concerns
IP(d). Do uncertainties about relative opex or utilisation of resources cause concerns about the adequacy of a simple, deterministically derived investment portfolio?	0 - No significant concerns
Total supply complexity score	**2**

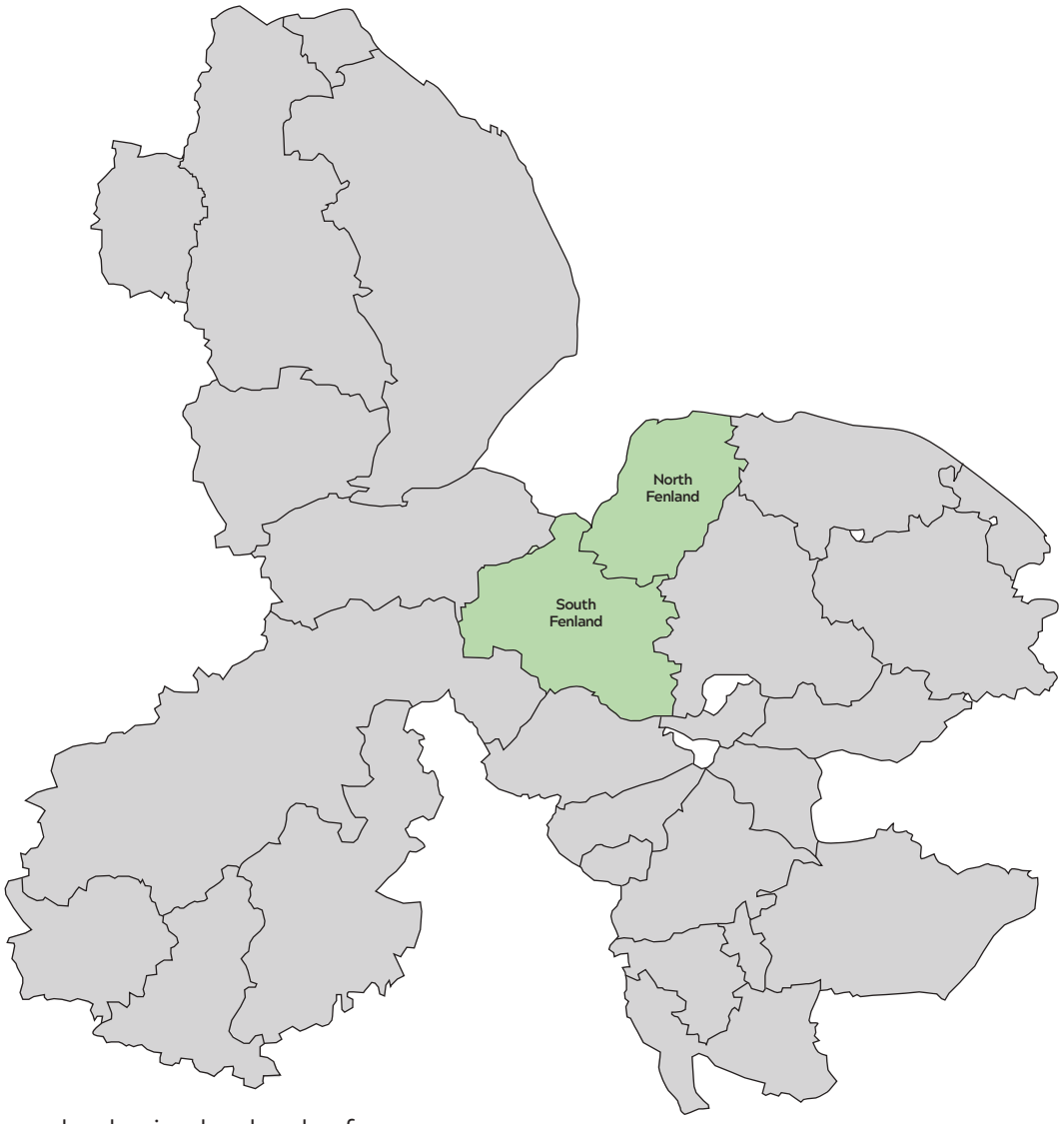
Area 2: Results

		Strategic Needs			
		0-1 (None)	**2-3 (Small)**	**4-5 (Medium)**	**6 (Large)**
Complexity Factors	**Low (<7)**				X (Area 2)
	Medium (7-11)				
	High (11+)				

Area 2 has been assessed as follows.

- Needs score of 6 (out of a total possible 6).
- A total complexity score of 3 (out of a total possible 22).
- As a result it is assessed has having moderate levels of concern. This implies that traditional EBSD approaches should be adequate, but that 'extended' modelling approaches may add to our understanding of the problem.

Area 3: Fenland



Area 3 is assessed as having low levels of concern

WRZ	Area 3: Pressures on supply demand balance			
	Growth	Sustainability reductions	Climate change	Severe drought
North Fenland	✓	✓		
South Fenland		✓		✓

Area 3: Strategic needs

Question (needs)	
S. Level of concern that customer service could be significantly affected by current or future supply side risks, without investment.	2 - Very significant concerns
D. Level of concern that customer service could be significantly affected by current or future demand side risks, without investment.	0 - No significant concerns
I. Level of concern over the acceptability of the cost of the likely investment programme, and/or that the likely investment programme contains contentious options (including environmental/planning risks).	1 - Moderate concerns
Total needs score	**3**

Baseline Supply Demand Balance

- South Fenland goes into a supply-demand deficit in 2024-25.
- North Fenland remains in surplus throughout the planning period.

Area 3: Supply complexity

Questions: Supply complexity	
S(a). Are there concerns about understanding of 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?	0 - No significant concerns
S(b). Are there concerns about understanding of future supply system performance, primarily due uncertain impacts of climate change on vulnerable supply systems, including associated source deterioration (water quality, catchments etc.)?	0 - No significant concerns
S(c). Are there risks of 'stepped' changes in supply (e.g. sustainability reductions, bulk imports etc.) in the near or medium term that are currently very uncertain?	1 - Moderate concerns
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 - this is also referred to as a non-linear problem).	0 - No significant concerns
Total supply complexity score	**1**

Area 3: Demand complexity

Questions: Demand complexity	
D(a). Has the nature of current or near term demand recently changed or is likely to change, e.g. because of large scale metering programmes or sudden changes in economics/demographics.	0 - No significant concerns
D(b). Does uncertainty associated with forecasts of demographic/ economic changes over the planning period cause concerns over the level of investment that may be required?	0 - No significant concerns
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.	0 - No significant concerns
Total supply complexity score	**0**

Area 3: Investment programme complexity

Questions: Demand complexity	
IP(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?	1 - Moderate concerns
IP(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?	1 - Moderate concerns
IP(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?	0 - No significant concerns
IP(d). Do uncertainties about relative opex or utilisation of resources cause concerns about the adequacy of a simple, deterministically derived investment portfolio?	0 - No significant concerns
Total supply complexity score	**2**

Area 3: Results

		Strategic Needs			
		0-1 (None)	**2-3 (Small)**	**4-5 (Medium)**	**6 (Large)**
Complexity Factors	**Low (<7)**		X (Area 3)		
	Medium (7-11)				
	High (11+)				

Area 3 has been assessed as follows.

- Needs score of 3 (out of a total possible 6).
- A total complexity score of 3 (out of a total possible 22).
- As a result it is assessed has having low levels of concern. This implies that traditional EBSD approaches should be adequate.

Area 4: Norfolk

Area 4 is assessed as having low levels of concern

WRZ	Area 4: Pressures on supply demand balance			
	Growth	Sustainability reductions	Climate change	Severe drought
Happisburgh	✓	✓		
North Norfolk Coast	✓	✓		
Norfolk Rural North	✓	✓		
Norfolk Rural South	✓	✓		
Norwich and the Broads	✓			

Area 4: Strategic needs

Question (needs)	
S. Level of concern that customer service could be significantly affected by current or future supply side risks, without investment.	2 - Very significant concerns
D. Level of concern that customer service could be significantly affected by current or future demand side risks, without investment.	0 - No significant concerns
I. Level of concern over the acceptability of the cost of the likely investment programme, and/or that the likely investment programme contains contentious options (including environmental/planning risks).	1 - Moderate concerns
Total needs score	**3**

Baseline Supply Demand Balance

- Happisburgh goes into deficit in 2021-22.
- North Norfolk Rural goes into deficit in 2022-23.
- Norfolk Rural South goes into deficit in 2043-44 driven by target headroom.
- Norwich and Broads go into deficit 2032-33 driven by target headroom.

Area 4: Supply complexity

Questions: Supply complexity	
S(a). Are there concerns about understanding of 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?	0 - No significant concerns
S(b). Are there concerns about understanding of future supply system performance, primarily due uncertain impacts of climate change on vulnerable supply systems, including associated source deterioration (water quality, catchments etc.)?	0 - No significant concerns
S(c). Are there risks of 'stepped' changes in supply (e.g. sustainability reductions, bulk imports etc.) in the near or medium term that are currently very uncertain?	1 - Moderate concerns
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 - this is also referred to as a non-linear problem).	0 - No significant concerns
Total supply complexity score	**1**

Area 4: Demand complexity

Questions: Demand complexity	
D(a). Has the nature of current or near term demand recently changed or is likely to change, e.g. because of large scale metering programmes or sudden changes in economics/demographics.	0 - No significant concerns
D(b). Does uncertainty associated with forecasts of demographic/ economic changes over the planning period cause concerns over the level of investment that may be required?	0 - No significant concerns
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.	0 - No significant concerns
Total supply complexity score	**0**

Area 4: Investment programme complexity

Questions: Demand complexity	
IP(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?	1 - Moderate concerns
IP(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?	1 - Moderate concerns
IP(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?	0 - No significant concerns
IP(d). Do uncertainties about relative opex or utilisation of resources cause concerns about the adequacy of a simple, deterministically derived investment portfolio?	0 - No significant concerns
Total supply complexity score	**2**

Area 4: Results

		Strategic Needs			
		0-1 (None)	**2-3 (Small)**	**4-5 (Medium)**	**6 (Large)**
Complexity Factors	**Low (<7)**		X (Area 4)		
	Medium (7-11)				
	High (11+)				

Area 4 has been assessed as follows.

- Needs score of 3 (out of a total possible 6).
- A total complexity score of 3 (out of a total possible 22).
- As a result it is assessed has having low levels of concern. This implies that traditional EBSD approaches should be adequate.

Area 5: East Suffolk and Essex

Area 5 is assessed as having low levels of concern

WRZ	Area 5: Pressures on supply demand balance			
	Growth	Sustainability reductions	Climate change	Severe drought
Central Essex	✓			
East Suffolk	✓	✓	✓	
South Essex	✓		✓	

Area 5: Strategic needs

Question (needs)	
S. Level of concern that customer service could be significantly affected by current or future supply side risks, without investment.	2 - Very significant concerns
D. Level of concern that customer service could be significantly affected by current or future demand side risks, without investment.	2 - Very significant concerns
I. Level of concern over the acceptability of the cost of the likely investment programme, and/or that the likely investment programme contains contentious options (including environmental/planning risks).	1 - Moderate concerns
Total needs score	**3**

Baseline Supply Demand Balance

- South Essex has a deficit in the base year which increases throughout the planning period.
- East Suffolk goes into a deficit driven by target headroom in 2024-25 in the DYAA, which increases to become a supply-demand deficit by 2027-28.
- In the DYAA Central Essex goes into deficit in 2027-28, driven by target headroom, which increased to become a supply-demand deficit by 2036-7.

Area 5: Supply complexity

Questions: Supply complexity	
S(a). Are there concerns about understanding of 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?	1 - Moderate concerns
S(b). Are there concerns about understanding of future supply system performance, primarily due uncertain impacts of climate change on vulnerable supply systems, including associated source deterioration (water quality, catchments etc.)?	0 - No significant concerns
S(c). Are there risks of 'stepped' changes in supply (e.g. sustainability reductions, bulk imports etc.) in the near or medium term that are currently very uncertain?	0 - No significant concerns
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 - this is also referred to as a non-linear problem).	0 - No significant concerns
Total supply complexity score	**1**

Area 5: Demand complexity

Questions: Demand complexity	
D(a). Has the nature of current or near term demand recently changed or is likely to change, e.g. because of large scale metering programmes or sudden changes in economics/demographics.	0 - No significant concerns
D(b). Does uncertainty associated with forecasts of demographic/ economic changes over the planning period cause concerns over the level of investment that may be required?	0 - No significant concerns
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.	0 - No significant concerns
Total supply complexity score	**0**

Area 5: Investment programme complexity

Questions: Demand complexity	
IP(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?	1 - Moderate concerns
IP(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?	1 - Moderate concerns
IP(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?	0 - No significant concerns
IP(d). Do uncertainties about relative opex or utilisation of resources cause concerns about the adequacy of a simple, deterministically derived investment portfolio?	0 - No significant concerns
Total supply complexity score	**2**

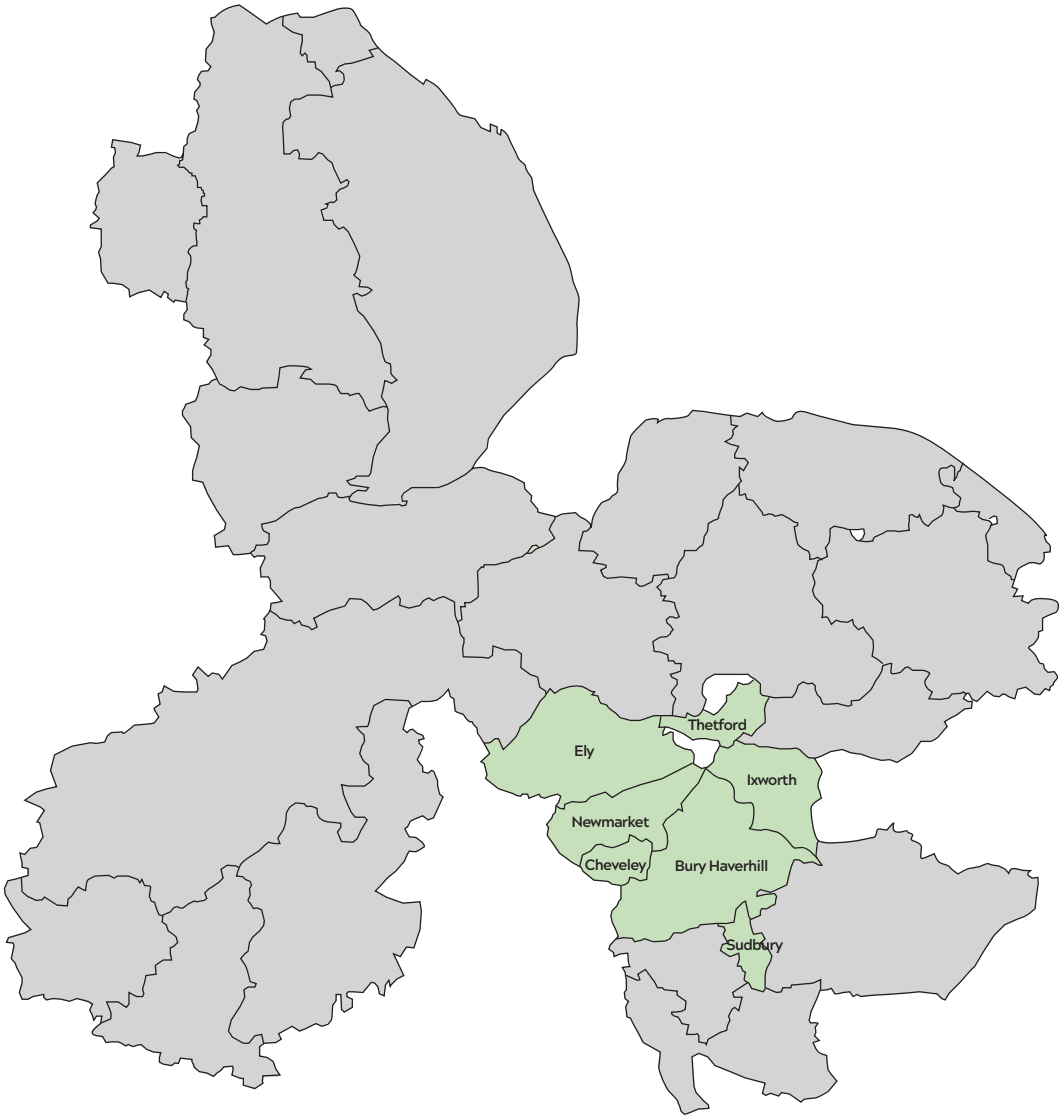
Area 5: Results

		Strategic Needs			
		0-1 (None)	**2-3 (Small)**	**4-5 (Medium)**	**6 (Large)**
Complexity Factors	**Low (<7)**		X (Area 5)		
	Medium (7-11)				
	High (11+)				

Area 5 has been assessed as follows.

- Needs score of 5 (out of a total possible 6).
- A total complexity score of 3 (out of a total possible 22).
- As a result it is assessed has having low and moderate levels of concern. This implies that traditional EBSD approaches should be adequate.

Area 6: Cambridgeshire and West Suffolk



Area 6 is assessed as having low levels of concern

WRZ	Area 6: Pressures on supply demand balance			
	Growth	Sustainability reductions	Climate change	Severe drought
Bury Haverhill	✓	✓		✓
Cheveley		✓		✓
Ely	✓	✓		
Ixworth	✓	✓		
Newmarket	✓	✓		✓
Sudbury	✓	✓		
Thetford	✓	✓		

Area 6: Strategic needs

Question (needs)	
S. Level of concern that customer service could be significantly affected by current or future supply side risks, without investment.	2 - Very significant concerns
D. Level of concern that customer service could be significantly affected by current or future demand side risks, without investment.	1 - Moderate concerns
I. Level of concern over the acceptability of the cost of the likely investment programme, and/or that the likely investment programme contains contentious options (including environmental/planning risks).	1 - Moderate concerns
Total needs score	**4**

Baseline Supply Demand Balance

- Bury Haverhill goes into supply-demand deficit in the DYAA in 2023-23
- Cheveley and Newmarket go into a supply-demand deficit in 2024-25 in the DYAA.
- In the DYAA Ely goes into supply-demand deficit in 2024-25.
- Thetford goes into supply-demand deficit in 2022-23
- Ixworth goes into supply-demand deficit in 2024-25.
- Sudbury remains in surplus throughout the planning period.

Area 6: Supply complexity

Questions: Supply complexity	
S(a). Are there concerns about understanding of 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?	0 - No significant concerns
S(b). Are there concerns about understanding of future supply system performance, primarily due uncertain impacts of climate change on vulnerable supply systems, including associated source deterioration (water quality, catchments etc.)?	0 - No significant concerns
S(c). Are there risks of 'stepped' changes in supply (e.g. sustainability reductions, bulk imports etc.) in the near or medium term that are currently very uncertain?	1 - Moderate concerns
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 - this is also referred to as a non-linear problem).	0 - No significant concerns
Total supply complexity score	**1**

Area 6: Demand complexity

Questions: Demand complexity	
D(a). Has the nature of current or near term demand recently changed or is likely to change, e.g. because of large scale metering programmes or sudden changes in economics/demographics.	0 - No significant concerns
D(b). Does uncertainty associated with forecasts of demographic/ economic changes over the planning period cause concerns over the level of investment that may be required?	0 - No significant concerns
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.	0 - No significant concerns
Total supply complexity score	**0**

Area 6: Investment programme complexity

Questions: Demand complexity	
IP(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?	1 - Moderate concerns
IP(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?	1 - Moderate concerns
IP(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?	0 - No significant concerns
IP(d). Do uncertainties about relative opex or utilisation of resources cause concerns about the adequacy of a simple, deterministically derived investment portfolio?	0 - No significant concerns
Total supply complexity score	**2**

Area 6: Results

		Strategic Needs			
		0-1 (None)	**2-3 (Small)**	**4-5 (Medium)**	**6 (Large)**
Complexity Factors	**Low (<7)**		X (Area 6)		
	Medium (7-11)				
	High (11+)				

Area 6 has been assessed as follows.

- Needs score of 4 (out of a total possible 6).
- A total complexity score of 3 (out of a total possible 22).
- As a result it is assessed has having low levels of concern. This implies that traditional EBSD approaches should be adequate.

Area 7: Hartlepool

Area 7 is assessed as having low levels of concern

WRZ	Area 7: Pressures on supply demand balance			
	Growth	Sustainability reductions	Climate change	Severe drought
Hartlepool				

Area 7: Strategic needs

Question (needs)	
S. Level of concern that customer service could be significantly affected by current or future supply side risks, without investment.	0 - No significant concerns
D. Level of concern that customer service could be significantly affected by current or future demand side risks, without investment.	0 - No significant concerns
I. Level of concern over the acceptability of the cost of the likely investment programme, and/or that the likely investment programme contains contentious options (including environmental/planning risks).	0 - No significant concerns
Total needs score	**0**

Baseline Supply Demand Balance

- Hartlepool remains in surplus throughout the planning period.

Area 7: Supply complexity

Questions: Supply complexity	
S(a). Are there concerns about understanding of 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?	0 - No significant concerns
S(b). Are there concerns about understanding of future supply system performance, primarily due uncertain impacts of climate change on vulnerable supply systems, including associated source deterioration (water quality, catchments etc.)?	0 - No significant concerns
S(c). Are there risks of 'stepped' changes in supply (e.g. sustainability reductions, bulk imports etc.) in the near or medium term that are currently very uncertain?	0 - No significant concerns
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 - this is also referred to as a non-linear problem).	0 - No significant concerns
Total supply complexity score	**0**

Area 7: Demand complexity

Questions: Demand complexity	
D(a). Has the nature of current or near term demand recently changed or is likely to change, e.g. because of large scale metering programmes or sudden changes in economics/demographics.	0 - No significant concerns
D(b). Does uncertainty associated with forecasts of demographic/ economic changes over the planning period cause concerns over the level of investment that may be required?	0 - No significant concerns
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.	0 - No significant concerns
Total supply complexity score	**0**

Area 7: Investment programme complexity

Questions: Demand complexity	
IP(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?	0 - No significant concerns
IP(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?	0 - No significant concerns
IP(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?	0 - No significant concerns
IP(d). Do uncertainties about relative opex or utilisation of resources cause concerns about the adequacy of a simple, deterministically derived investment portfolio?	0 - No significant concerns
Total supply complexity score	**0**

Area 7: Results

		Strategic Needs			
		0-1 (None)	**2-3 (Small)**	**4-5 (Medium)**	**6 (Large)**
Complexity Factors	**Low (<7)**	X (Area 7)			
	Medium (7-11)				
	High (11+)				

Area 7 has been assessed as follows.

- Needs score of 0 (out of a total possible 6).
- A total complexity score of 0 (out of a total possible 22).
- As a result it is assessed has having low levels of concern. This implies that traditional EBSD approaches should be adequate.

Cover photo shows Rutland Water

Rutland Water is a reservoir in Rutland, England, east of the county town, Oakham. It is filled by pumping from the River Nene and River Welland and provides water to the East Midlands. It is one of the largest artificial lakes in Europe.

Anglian Water Services Limited
Lancaster House
Lancaster Way
Ermine Business Park
Huntingdon
Cambridgeshire
PE29 6XU

www.anglianwater.co.uk