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December 2022

Draft WRMP24 Technical Document

Supply-side option development

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1 WRMP24 Introduction

1.1 What is a Water Resources Management Plan?

We have a statutory obligation to produce a Water Resources Management Plan (WRMP) every five years. This strategic plan demonstrates how a sustainable and secure supply of clean drinking water will be maintained for our customers over the next twenty-five years.

To achieve this, we forecast the amount of water we will have available to use and how much water will be needed by our customers. When these forecasts are combined, we have our supply-demand balance which tells us if there is enough water to supply our customers.

If there is not enough water, demand management options can be implemented to reduce the amount of water used or lost in our network of pipes or in customers' homes. Examples include leakage reduction achieved by the optimisation of our water network and smart metering where customers have access to their usage data.

When demand management options alone cannot maintain a supply of water, new supply-side options are needed to produce additional water for us to use. These options include reservoirs which store raw water until needed by customers, as well as having the ability to provide additional well-being and environmental benefits. Water reuse is also a supply-side option. This is when we take the water from our water recycling centres, clean it and put it back into the environment to be abstracted again.

Our WRMP sets out a long-term vision for the water environment, and how it will protect and improve it for generations to come. It also aims to deliver wider societal benefits, looking beyond the simple economics of a 'least cost plan'. These benefits may include promoting tourism in a local area or increasing wildlife habitats.

A WRMP also needs to be affordable, which is something our customers and stakeholders have made clear to us. To achieve this, it is produced in conjunction with our company Long Term Delivery Strategy and Business Plan for the period 2025-2030.

Our draft WRMP24 builds on our current WRMP which was published in 2019. WRMP19 promoted a twin track approach. It implemented an ambitious demand management programme, building on our already industry leading performance. A significant main laying scheme is also currently in progress. This will take water from an area of surplus to areas of deficit. These approaches will ensure our customers continue to have a secure, resilient water supply and will reduce the amount of water we take from precious environments.

Figure 1 Our WRMP19 twin track approach

1.2 Our draft Water Resources Management Plan

Our draft WRMP24 is for the period 2025 to 2050. As part of this plan, we have:

- complied with the relevant legislation
- considered what has changed since the development of our previous WRMP19
- forecasted how much water on a sustainable basis we have available

- predicted how much demand there will be for water each year for a minimum of 25 years
- allowed for uncertainty in calculations and forecasts
- identified options to reduce demand/and or increase supply to achieve a sustainable and secure supply of water
- outlined risks associated with our future planning
- produced a best value plan which considers factors alongside cost and provides an overall benefit to the environment, customers and society, and
- explained how customers, stakeholders and Regional Plans have informed each stage of our draft WRMP24.

1.3 Strategic context of the draft WRMP24

Our draft WRMP24 aligns with our business goals, as well as other internal and external strategic plans and initiatives. We have worked collaboratively with internal and external stakeholders, regulators and other water abstractors to achieve this.

These interactions are highlighted throughout our draft WRMP24 submission, showing the importance of collaborative planning. Regional Plans led by Water Resources East and Water Resources North have been highly significant in shaping our investment priorities and requirements. For instance, Water Resources East has determined which strategic regional options (SROs) are needed for the East of England; these have been fed into our draft WRMP24 decision making.

WRMP24 will also help to shape our company investment strategy for the next Price Review submission (PR24), as well as our Long-Term Delivery Strategy. We have also maintained close links with the Drainage Wastewater Management Plan and our Drought Plan.

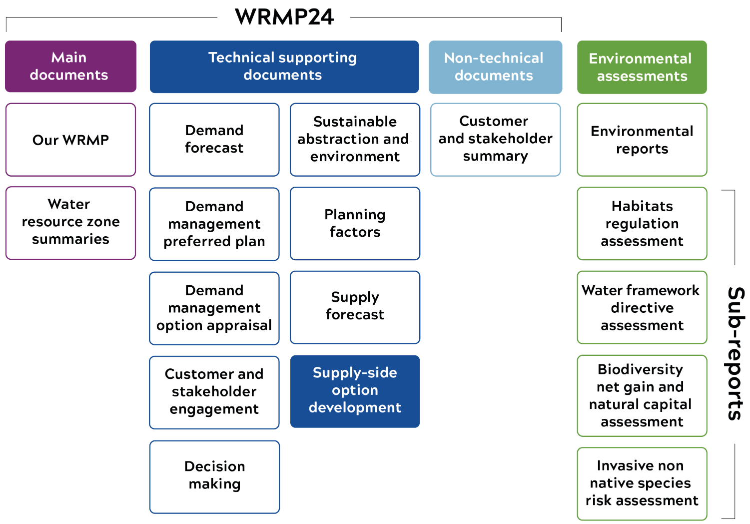
Collaborative cross company and partnership working has enabled a successful start to the development of SROs, Fens and South Lincolnshire reservoirs. It is hoped that these reservoirs will allow many multi-sector benefits to be realised.

1.4 Guide to our draft WRMP24 submission

Our submission comprises a non-technical customer and stakeholder summary, our main report and nine technical supporting documents. This is supported by a suite of independent environmental assessments. Water resource zone summaries will also be available, as well as associated tables.

This technical document details the customer and stakeholder engagement that has been undertaken to inform the development of our draft WRMP24, and associated decision making.

Figure 2 Our draft WRMP24 reports



1.5 How customer engagement for draft WRMP24 interacts with the Regional Plan

Our customer engagement has been synthesised with the views of other companies and stakeholders in Water Resources East, ensuring their views are represented at a regional level.

These views have fed into the development of the Regional Plan, as well as during the decision-making process.

1.6 Next steps

Our customers and stakeholders have been informed and consulted with throughout the development of our draft WRMP24. This discussion will continue during the 14 week consultation for the plan, starting in December 2022[1].

1.7 How to respond to our consultation

Details of our consultation, and how to respond, can be found at anglianwater.co.uk/wrmp.

1.8 Consultation responses

Consultation responses will be reviewed prior to a Statement of Response being issued in June 2023, with our revised draft WRMP24 being published in the Autumn of 2023[2].

1 Subject to instruction from the Defra Secretary of State
2 Subject to instruction from the Defra Secretary of State

2 Supply-side option development process

The supply-side options have been developed following the 8-stage framework set out in UKWIR Guidance on decision making processes and the WRPG.

Stage 1 - Prepare supply-demand balance information

Stage 2 - Develop a list of unconstrained options that takes account of government policy and aspirations

Stage 3 - Undertake a problem characterisation and evaluate strategic needs and complexity

Stage 4 - Decide on a modelling method

Stage 5 - Identify and define data inputs to model(s)

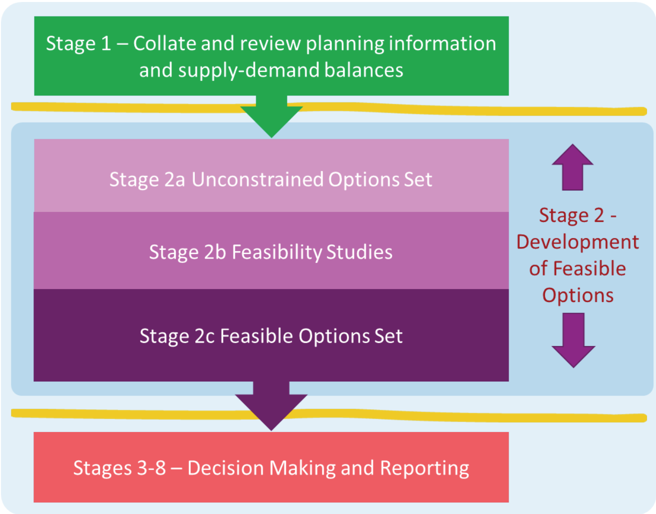
Stage 6 - Undertake decision making (options appraisal) modelling

Stage 7 - Stress testing and sensitivity analysis

Stage 8 - Produce a final planning forecast.

For the development of the options we have expanded Stage 2 of the decision making framework, this is shown in Figure 3. Stage 2 is the focus of this report. Figure 4 shows the high level process of screening stages and feasibility studies, illustrating how the option set is reduced to a constrained feasible list.

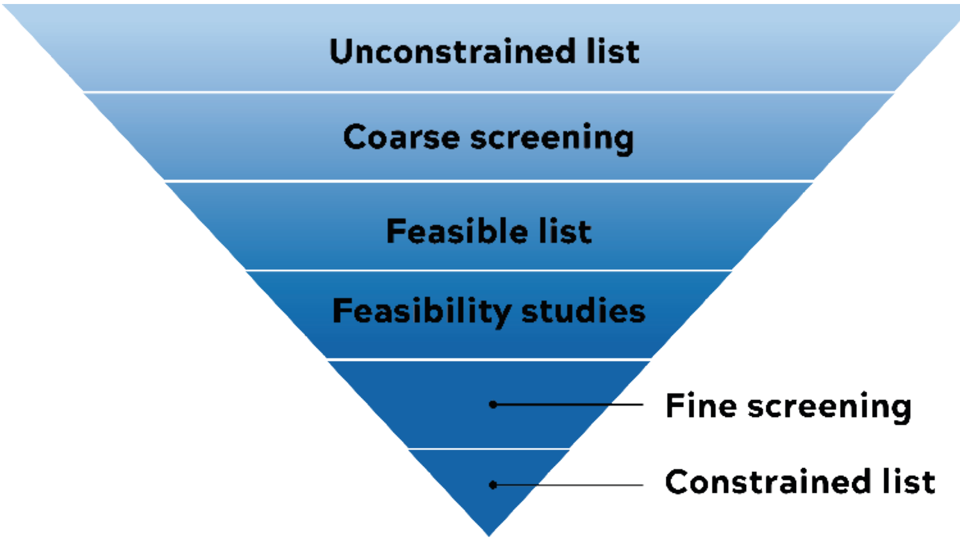
Figure 3 The 8-stage option appraisal process



This report describes our process for development of a constrained supply-side options set. The development of the constrained options set is part of the options appraisal process to decide on solutions to develop our best value plan. The objectives for the option appraisal process is to,

- Complete a clear and transparent appraisal of options. This will include equal consideration to all new resource options, demand management, water trading and third-party options,
- Demonstrate compliance with legislation and Government policy/aspirations, including the Strategic Environment Assessment Directive and Habitats Regulations,
- Ensure that customers, regulators and other stakeholders have been involved throughout the process and that their preferences are taken into account.
- Provide evidence to fully justify the selection of the preferred solutions and be able to demonstrate long-term best-value for customers whilst protecting the environment.
- Align with, and support the WRE option appraisal process, identifying options that can support the region as a whole and developing options in a way that supports and enables regional processes.

Figure 4 The outline process from the unconstrained list of options to the constrained list



3 Stage 2a Unconstrained options

Table 1 WRPG: Section 8.1 Unconstrained list

Water Resources Planning Guidance: Section 8.1 Unconstrained list
You should compile a list of all possible options that could reasonably be used in your plan. This unconstrained list should be developed from a generic list of option types. The *UKWIR Water resources planning tools 2012: summary report* produced a comprehensive list of water management option types which you can consider.
As a minimum, the unconstrained list should include all the options considered in the previous planning round, as well as any options that have been identified since.
In forming your list of options, you should explore those presented by regional groups, including regionally scaled and joint-company options. For England, you should also identify other potential transfers from neighbouring water companies and consider third party options.
An unconstrained option may not be completely free from restrictions, such as environmental or planning issues, but should be technically feasible. You should provide an indicative deployable output or range for your unconstrained options.

Table 2 describes how we have considered WRPG Section 8.1 in the development of our unconstrained options.

Table 2 Unconstrained list development summary

Unconstrained list development	
UKWIR generic option type	The list of generic options was consulted with a view to openly considering options that had previously discounted. This didn't identify any new option types suitable for inclusion in the unconstrained list
WRMP24	All options considered at WRMP19 were reviewed, those that met the pre-screening criteria have been included in the unconstrained list.
Regional and sharing opportunities	Through a series of workshops all options identified by Water Resources East (WRE) have been considered and those that are appropriate have been included in our WRMP unconstrained list. Furthermore all unconstrained options identified by us and other WRE Water Company members have been included in the regional option list. Initially options with a DO benefit greater than 10 Ml/d were considered for the regional plan. Following WRE's Emerging Regional Plan feedback, supply-side options with greater than 1 Ml/d benefit have been progressed in WRE modelling processes, along with options that could benefit the region or another water company, is multi-sector and/or supports the regional environmental ambition. In addition, we have regular meetings with neighbouring water companies to discuss our WRMPs to seek opportunities to manage a 'borderless' supply-demand balance and consider options collaboratively.

Unconstrained list development	
Technical feasibility studies	Feasibility studies have been carried out for each option type. A summary of this can be found in Section 6 of this report.

The supply-side options have been developed following the 8-stage framework set out in UKWIR Guidance on decision making processes and the WRPG. For the development of the options we have expanded Stage 2 of the decision making framework, this is shown in Figure 3. Steps 2a-2c are the focus of this report. Figure 4 shows the high level process of screening stages and feasibility studies, illustrating how the option set is reduced to a constrained feasible list.

We have compiled a list of all possible options that could reasonably be used in our plan. The unconstrained options identified are not all completely free from environmental or planning issues but are considered technically feasible. We have included known resource sharing with other water companies and third party trading options in the unconstrained list, other options may emerge through our market information platform.

We have developed a template based on the list of "generic" options provided in Economics of Balancing Supply and Demand (EBSD)[3] and in the UKWIR WR27[4] report. The template was populated at a series of workshops with key internal staff covering regional areas of Anglian Water:

- North and West - which covered Lincolnshire and the Ruthamford system
- East - which covered Norfolk, and
- South - which covered Essex and Suffolk.

The workshops were attended by representatives from Water Services, Water Resources Management Team and Asset Delivery Planning.

At the workshops we reviewed all the unconstrained options developed for previous WRMPs and identified new technically feasible options. Unconstrained options were considered for all water resource zones (WRZs), even those without a deficit, including Hartlepool.

3.1 Stage 2b Constrained options

A series of screening stages were used to refine the unconstrained list to develop the constrained options set. The criteria used to screen the unconstrained options are describes in the following sections. The options discounted at this stage are recorded in the rejection register along with the reasons why they were not considered suitable to investigate further, see Section 8.

3.1.1 Coarse screening criteria

Table 3 Pre-screening quality checks

Pre-screening quality checks	
Criteria	**Quality check**
Option description	Could a third party understand it easily? Does it describe the water source adequately in terms of the opportunity and location? If an option cannot be described, it will be rejected. Similarly, generic options used to aid the option identification process will also be rejected.

3 UKWIR,2002, The Economics of Balancing Supply and Demand (EBSD) Guidelines, Report Ref 02/WR/27/4, Table 3.1
4 UKWIR, 2012, Water Resources Planning Tools: Economics of Balancing Supply and Demand Report Ref. WR27, Table 5

Pre-screening quality checks	
Deployable output (DO)	Is there a reported DO figure for the option? If it is not a DO driven option is the wider benefit clearly described? If the DO or the benefit cannot be defined, the option will be rejected as it does not address the problem
Is the option categorisation correct	Is the correct UKWIR category applied to the option?
GIS data	Does the GIS data accurately represent the boundaries of the option?
Rejection reason	If previously rejected in WRMP19, is the reason given still valid? If so, the option can be rejected.
Duplication	Check for duplicates and delete any identified.

The coarse screening criteria were developed expanding the criteria set out in the EBSD methodology[5]. Table 4 shows the main screening criteria along with sub-categories. Each option was tested against the sub criteria described below.

Table 4 Course screening criteria

Main screening criteria	Sub-criteria category	Sub-criteria description
Does not address problem	Programme	• Is the forecast Deployable Output (DO) likely to be ready in xx period/by year xx? (i.e. from a water resource availability point of view)
	Sustainability	• Will the option be resilient and deliver the predicted DO and water quality both now and in the future (i.e. within the option's life)?
	Technical	• Does the option provide the required DO? (average and peak) Are there any likely significant outage risks?
Breaches unalterable planning constraint	Third party	• Are there any likely significant risks at this stage from regulators, planning authorities or other third parties that may make the option difficult to implement (e.g. abstraction licence issues, etc.)?
Option is not promotable	Cost	• Is the option likely to involve disproportionately high whole life cost (capex and opex), relative to alternatives that can provide the same outcome, and as such is not worth progressing further for more detailed costing?
	Sustainability	• Are there any likely significant environmental/ecological risks (including Water Framework Directive compliance risks) that would make the option too risky when an environmental / social assessment is undertaken?
	Third party	• Are there any likely significant risks at this stage to regulators and other third parties that may make the option difficult to implement (e.g. abstraction licence issues, etc.)?

5 UKWIR,2002, The Economics of Balancing Supply and Demand (EBSD) Guidelines, Report Ref 02/WR/27/4, Page 24

Main screening criteria	Sub-criteria category	Sub-criteria description
		• Are there any likely significant risks to Anglian Water customers that may make the option difficult to implement?
High Risk of Failure	Programme	• Is the forecast DO output likely to be ready in xx period/by year xx? (i.e. from a water resource availability point of view) • Are the likely construction / technology complexity/supply chain risks acceptable to ensure the option will be delivered on time? (i.e. forecasted time)
	Technical	• Are technical/technology risks acceptable to ensure technical viability of the option? • Does the option involve the use of available and reliable data to be able to progress the technical assessment and the option being delivered on time? • Does the option provide the required DO? (average and peak) Are there any likely significant outage risks?
	Sustainability	• Will the option be resilient deliver the predicted DO and water quality both now and in the future (i.e. within the option's life)? • Are there any likely significant environmental/ecological risks (including WFD compliance risks) that would make the option too risky when an environmental / social assessment is undertaken?

3.1.2 Catchment Abstraction Management Strategies

As part of the unconstrained options workshops we identified all possible new resources within each WRZ. In order to determine if water is available for the options identified, we reviewed the Environment Agency's Catchment Abstraction Management Strategies (CAMS). This resulted in the rejection of options such as new groundwater abstractions in catchments that are currently over-abstracted or over-licenced.

3.1.3 Environmental coarse screening

We completed high-level environmental screening, designed to identify environmental risks and constraints. Where impacts were identified, the process either recommended high level mitigation or the rejection of the option.

This process was also used to refine the transfer pipeline routes. The initial environmental screening identified that some pipelines were passing too close to environmental designated sites and these routes were refined to account for this, see Section 4.1.

4 Stage 2b Feasibility studies

Table 5 WRPG Section 8.2. Feasible list

WRPG - Feasible list
You should develop your feasible list of options from your unconstrained list of options. The feasible list is a set of options that you consider to be suitable to assess for inclusion in your preferred programme of options. As such, it should not include options with unalterable constraints that make them unsuitable for promotion. For example, unacceptable environmental impacts that cannot be overcome or options which have a high risk of failure. For example, WFD regulations and habitats regulations constraints.
You should discuss your feasible options with the Environment Agency or Natural Resources Wales as early as possible. You should also discuss feasible options with relevant non-statutory consultees as early as possible, for example engaging Forestry Commission in England where options may affect woodland.
You have the flexibility to decide on the most appropriate screening method for your situation. You should clearly show the criteria you have used to select feasible options. You should clearly state the reasons for rejecting any options.
You should consider and justify schemes that are 'non-drought resilience only' (they do not contribute to the supply-demand balance) through your business plan. These could include system resilience to other hazards or asset reliability and redundancy. However you can describe these options in your WRMP. To be considered in your WRMP a scheme should have some benefit to one or more components of the supply-demand balance. For example, through providing deployable output or reducing outage.

We have completed feasibility studies for the constrained options to confirm the feasible option set. As shown in Figure 4, the option set is further refined with the output from the various environmental assessments (see the accompanying Environmental Report[6]). These assessments suggest mitigation measures which need to be added to the scope of some feasible options or they may mean options are moved onto the rejection register.

6 Mott Macdonald (2022) Draft WRMP Environmental Report.

4.1 Transfer options

4.1.1 Transfer option routes

The unconstrained list of transfer options was developed from the WRMP19 list. Some additional routes have been identified through internal workshops with operational teams and by aligning with the WRE options set.

All of these options have been assessed using the MRO route optimisation tool developed by our consultants.

MRO aims to minimise the CAPEX and TOTEX of a transfer route, in addition to avoiding key land use and environmental constraints. It evaluates topographical data along a route (OS tiles) and carries out hydraulic calculations, adjusting route outputs to minimise the pumping costs that would be needed, by optimising the vertical profile of the transfer route. This is done by evaluating pumping costs against costs of key pipeline features that can be avoided by route adjustments e.g. air valves, washout out valves, valve chambers.

The full list of feasible transfers is presented in the Water Resource Zone Option, Section 7. The software processes this information and directs the pipeline route accordingly. For example, a feature that implies either a very high cost such as a lake, or an area to be avoided such as an SSSI, will not be crossed by the pipeline unless there is no reasonable alternative. The sensitivity of the software may be adjusted to control the length of the route.

The environmental coarse screening identified pipeline routes that required altering so that pipeline and working zones avoided areas of environmental significance. This included:

- 500m buffer for ecological areas such as SSSI, RAMSAR, SPA, SAC, LNR
- 10m buffer on heritage sites, listed buildings, registered parks gardens and battlefields, and
- 15m buffer on ancient woodlands.

The pipeline routes been omitted from this report due to the requirements of the Security and Emergency Measures (SEMD)[7] , however, below is a map showing connectivity of WRZs by feasible modelled options and details of each are described in Section 7.

Figure 5 Transfer Options

4.1.2 Potable transfer option capacities

The potable water transfers are just conduits for transferring water between WRZs rather than new resources of water. They can either transfer:

- Existing surpluses from one zone to another, and
- Or a new resource development in one WRZ to another zone in deficit.

7 Water Industry Act 1991, The Security and Emergency Measures (Water and Sewage Undertakers) Direction 1998

We have provided our economic model with a number of alternative capacities for each transfer route to allow real choices to be made when developing our plan. To enable the flexibility of options to adapt to future uncertainty, the transfers have been sized to meet deficits in all scenarios, see Figure 5.

4.1.3 Transfer option risks

Many of the risks associated with new long distance pipeline transfers (potable or raw) are generic and so they have been listed here rather than against the individual options described in the WRZ summaries in Section 7.

The identified risks with transfer options:

- Cost risks: Any modifications to the pipeline route could have an impact on both capex and opex costs and the time to implement the solution
- Programme risks: Detailed consultation with Highways England, Environment Agency, Local Authorities and land owners could impact the costs and the time to implement the solution.

4.2 New Resources

The new resources options were grouped together into option type and the feasibility of each option assessed and reported.

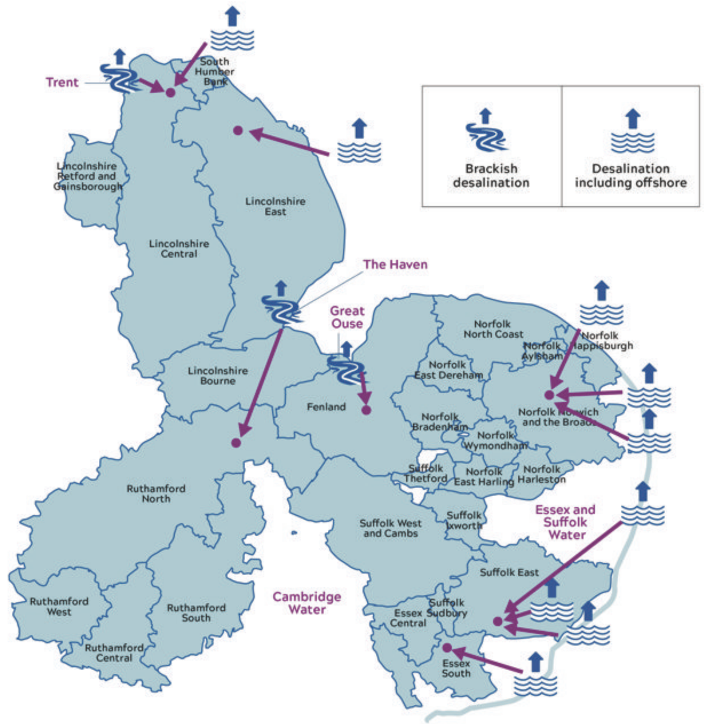
For the options not considered feasible the reasons are recorded in the rejection register.

4.2.1 Feasible desalination options

Desalination has been assessed to be a viable option to provide additional water.

A high-level spatial screening of the east coast of England was carried out to identify possible viable locations for desalination. 500 km of coastline including estuaries was evaluated in this process. The identified locations were then cross-checked with the WRMP19 options. All of the 24 WRMP19 unconstrained options were re-evaluated. The developed WRMP24 unconstrained list comprised 83 options.

Figure 6 Desalination Options



Three alternative types of desalination were identified:

- Coastal - on shore desalination plant with intake and outfall to sea.
- Estuarial (brackish) - desalination plant located in an estuary with intake and outfall to the estuary system.
- Floating - desalination plant located on a barge, moored off shore then piped inland.

Some of these desalination options contained a conjunctive use element, for instance, we have been discussing possibilities to share outfall structures with energy producers to reduce construction cost and where possible. We are also looking into a number of co-location and resource sharing opportunities with green hydrogen production and renewable energy producers.

Figure 7 Outline seawater desalination process

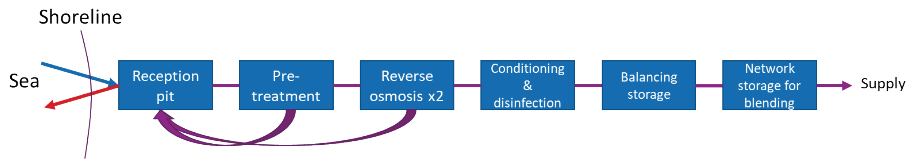
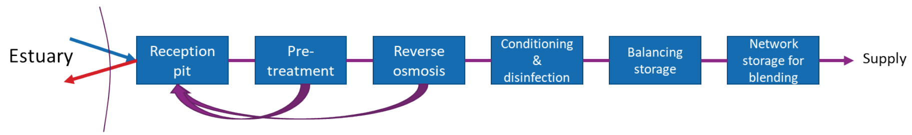
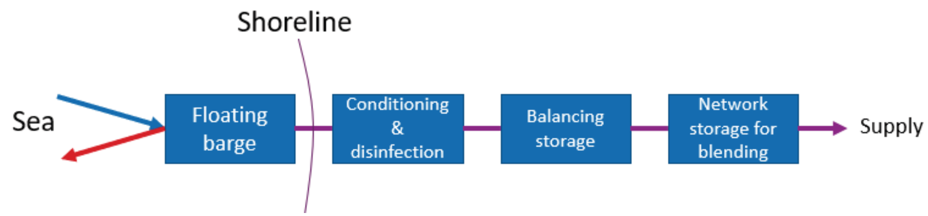


Figure 8 Outline brackish desalination process



Floating desalination consists of the same processes of pre-treatment and two-stage reverse osmosis but it would be entirely housed onboard a floating barge, moored offshore.

Figure 9 Outline offshore desalination process



The following pre-High Level Screening (HLS) screening criteria were applied to all desalination options:

- Land available for a site-can the site fit in the desired location?
- Land use in the vicinity-are there adjacent land uses that would make the option unfeasible?
- Environmental designations-does the location have an environmental designation e.g. RSPB, SSSI, SPA, RAMSAR, AONB?
- Characteristics of adjacent marine or estuarial environment -does the marine or estuarial environment have aspects that would make the development of new intakes or pipelines unfeasible e.g. existing structures, submarine cables, sand?
- Superiority to other local options-is there another local option that would be better?

Additional High Level Screening (HLS) criteria applied to coastal (seawater) options:

- Proximity to water depth >6m-is the marine environment adjacent to the coast too shallow for too far, meaning intakes or outfalls have to be unfeasibly long?
- Navigation and marine usage through navigation charts-does the marine environment adjacent to the coast experience such heavy traffic that the option would be unfeasible?

Additional HLS criteria applied to estuarial (brackish) options:

- Salinity in the estuary -if the water is fresh desalination would not be used, so is there sufficient salinity in the raw water to make desalination a feasible treatment?
- Variability of salinity in the waterbody -is the variation of salinity with the tidal cycle sufficiently predictable that a consistent salinity of feedwater into the process could be obtained?
- Contaminant concentrations -are there contaminants in the estuary (e.g. from industrial discharges) that would make treatment by desalination unfeasible?

While estuarial desalination is technically feasible it carries with it some additional risks over sea water desalination. Abstraction and discharges into estuary systems like the Humber and rivers that feed into The Wash may mean these options are rejected when further environmental assessment is carried out. Acknowledging this risk to these options, some modelling has been run with these options excluded, however, they remained in the feasible list, see the Decision Making technical report.

No additional HLS criteria was applied to floating options, though it was noted that some onshore infrastructure would be required so land availability remained a HLS consideration.

Through pre-screening, HLS and feasibility study, a feasible list of options was passed for further development and fine screening.

During fine screening we carried out a number of workshops with internal stakeholder and capital delivery partners to review deliverability of these options. From this some additional risks associated with floating desalination options were raised. This prompted another workshop involving one potential supplier of floating desalination.

We concluded that there were residual risks associated with these options what would be complex to resolve and, while this didn't make the options technically unfeasible, they demonstrated no benefit over the onshore equivalent options.

Risks identified:

- No precedent in the UK and the technology has not been demonstrated in the North Sea.
- Examples elsewhere in the world tend to be used reactively and not permanently moored for continuous supply. This made it difficult to establish if additional maintenance to the vessel is required leading to further outage.
- Operability - complexities around staffing. Staff with water treatment experience would also need to be trained to work offshore..
- Water Quality issues around ensuring Materials In Contact compliance. Not insurmountable but additional layer of complexity.
- Outage and reliability and the need for storage - it's unclear what conditions may lead to outage (e.g. storms or pollution events) and what the duration of these events may be. This makes it difficult to quantify resilience storage required and therefore difficult to cost the option.
- Security - insufficient information available at time of appraisal to establish how SEMD compliance would be met at sea.

Floating desalination options were only identified at locations where onshore desalination is also feasible, so, as the options offer no benefit over onshore and carry these additional risks they have been rejected from the WRMP24 feasible option list.

It is, however, acknowledged that if further resource from desalination is needed in the future and designations or land availability reduces the capacity to develop desalination on shore, floating option could be revisited.

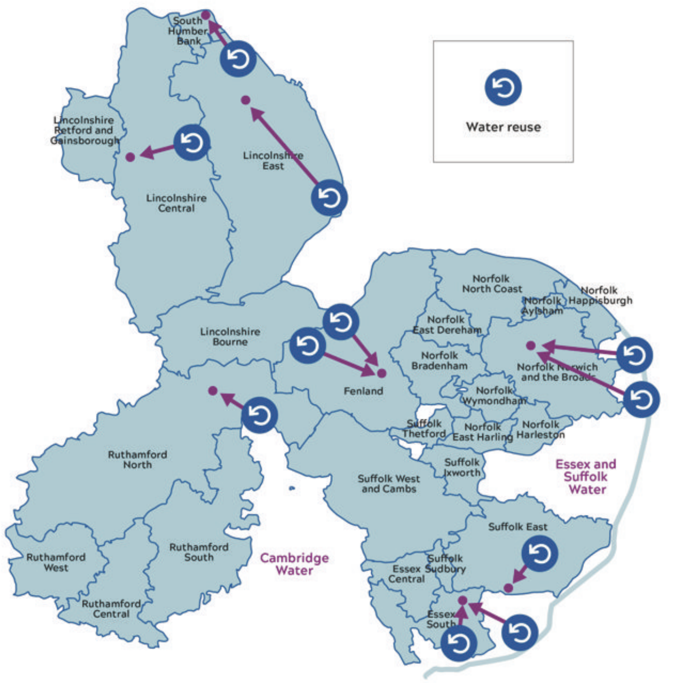
4.2.2 Water reuse

We assessed the suitability of all of our Water Recycling Centres for the development of water reuse options. The criteria we used for suitability of a Water Recycling Centre (WRC) effluent for reuse were:

- The WRC should be able to provide a sufficient output. Due to advanced water reuse treatment, the process losses would be around 30% of the inlet flow rate to the Water Reuse Plant (WRP). All WRCs with a licenced Dry Weather Flow (DWF) of under 10 Ml/d were rejected.
- The flow from WRCs support river flow, and development of a scheme should not deprive sensitive rivers of flow. The CAMS (catchment abstraction management strategy) report identifies particularly stressed water courses that would not be suitable for water reuse due to the diversion of effluent that would usually be put into the watercourse. The CAMS report uses a red, amber green (RAG) system to show the amount of water available for abstraction with red being 'no water available', amber being 'restricted amount of water available' and green being 'water available'. Sites in CAMS assessment that were shown as red for all Q95-30 were removed.

When assessed against these criteria the number of viable WRCs reduced from over 1000 to 27. For each location a number of alternative option types, the various alternatives for implementing reuse are described in Figures 11 to 15. Below is a map showing distribution of the viable WRCs in our region along with an indication of where the option's WAFU would be deployed.

Figure 10 Water reuse options



We have explored a number of reuse options with different process configurations.

Each of the reuse sub option types is described in Figures 11 to 15.

Figure 11 Transfer to river for indirect re-abstraction reuse outline process

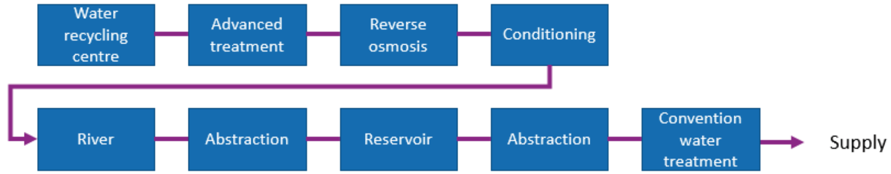


Figure 12 Transfer to reservoir for abstraction outline reuse process

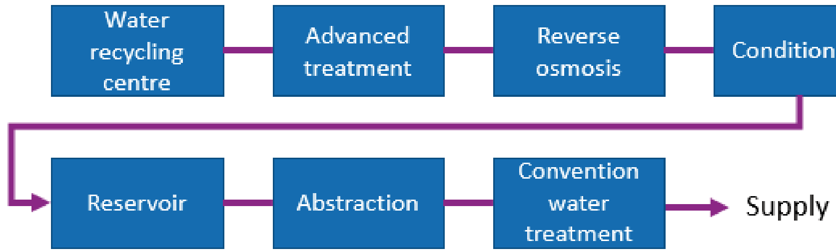


Figure 13 Transfer to river for re-abstraction outline reuse process

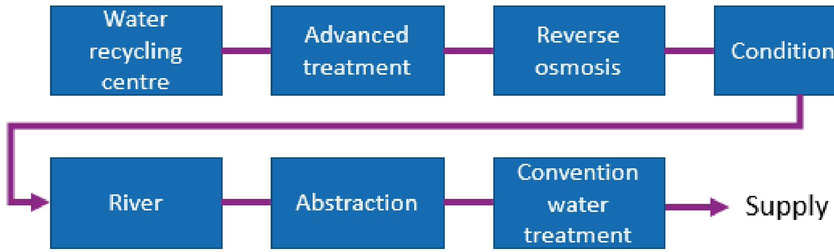


Figure 14 Dual source transfer to river for re-abstraction outline reuse process

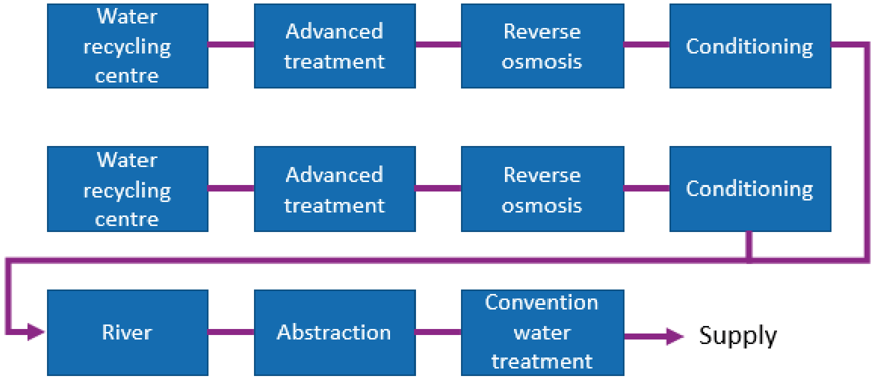


Figure 15 Direct reuse for non-potable supply outline process

In addition to the screening criteria here some of our options were further informed by internal and external stakeholder workshops.

In discussion with the DWI it was noted that the route a water reuse scheme should take to the water treatment works should be the subject of a drinking water risk assessment and to be covered in the Drinking Water Safety Plan. There were no stipulations made on residence time in water bodies or necessity to pass through a natural water course such as a river.

Some of our options consisted of a transfer to a river for re-abstraction to a reservoir, as described in Figures 11, 13 and 14. In some instances, particularly our Colchester reuse option, this resulted in excessively long pipeline routes.

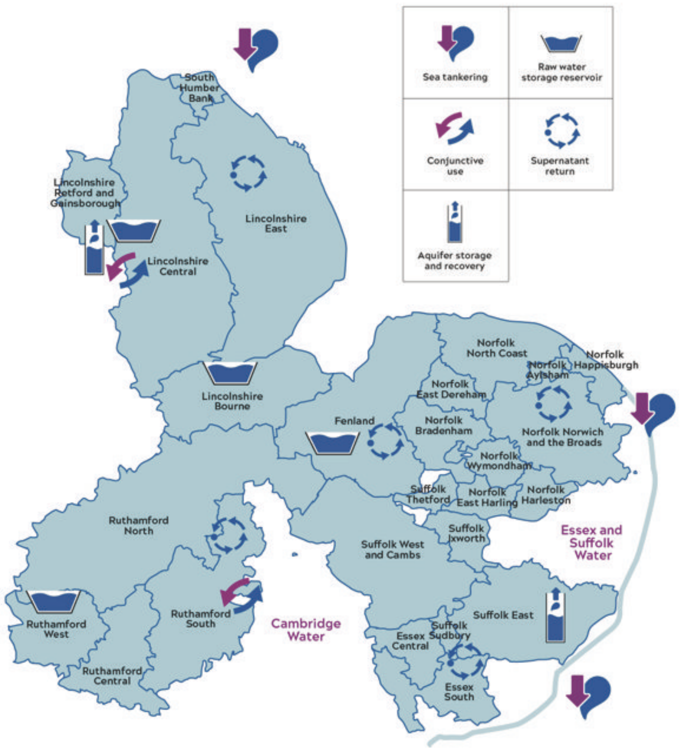
The Environment Agency also noted that by passing through a natural watercourse it could be difficult to quantify losses to the environment. Licence to abstract would be granted on the water available at the point of abstraction and not necessarily what was transferred to the watercourse by the scheme. This means that, without complex monitoring, there is additional risk that DO might not be the volume anticipated by the option feasibility study.

As a result of these risks we considered the reuse options that transferred water via a river before abstraction less favourable and removed them from some modelling scenarios, however, they remain in our feasible list. If other options are ruled out and deficits can't be met, the options can be appraised in more detail to look for mitigations to the issues raised.

At this stage some of the option DO volumes were updated based on output from supply forecast modelling.

4.2.3 Other feasible options

Figure 16 Other new resource options



A number of other resource supply side option types were identified as feasible in our region. These are:

- Aquifer storage and recovery
- Conjunctive use
- Raw water storage reservoirs
- Sea Tankering
- Supernatant return (backwash water recovery)

This map shows where these options are distributed around our region. Below are brief description of the option types.

4.2.4 Aquifer Storage and Recovery

Aquifer storage and recovery (ASR) is a technique used to replenish and store groundwater in aquifers for subsequent abstraction and supply.

We do not currently operate any ASR schemes, and there are only limited operational examples in the UK. Four options were deemed feasible at WRMP19, so these were taken forward for development of feasibility studies for WRMP24.

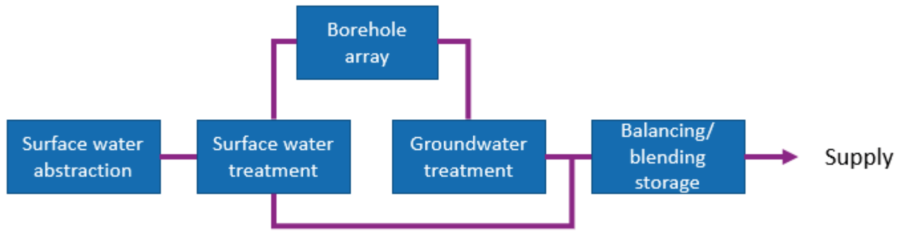
The WRMP24 screening criteria was that ASR must have a sufficient benefit on an average year. A threshold of 2 Ml/d was set for this. To assess this the amount of surplus water available from an existing abstraction in an average year was used. The average year benefit is calculated as the anticipated yield from re-abstraction.

- Norfolk Wymondham WRZ ASR - no nearby surface abstraction to utilise.
- Essex South WRZ ASR - falls below the yield threshold.
- Suffolk East WRZ and Lincolnshire Central* WRZ ARS options were progressed as feasible for WRMP24.

*Due to very limited knowledge and experience of ASR in the UK the Sherwood Sandstone ASR is the subject of a WRMP19 adaptive planning detailed investigation to develop our understanding of the option.

Figure 17 shows the outline process for ASR. Water is abstracted and treated when there is surplus water available then injected into the aquifer via an array of boreholes. The water is then left in the aquifer to be abstracted during drier months when less water is available from conventional sources. This water then undergoes conventional groundwater treatment before distribution.

Figure 17 ASR outline process



4.2.5 Conjunctive use

Conjunctive use in the context of this study is the sharing of resources with companies in other sectors. There are a number of instances where a power company possesses a consumptive abstraction licence that is not fully utilised. We could purchase the unused volume of these licences, abstract and treat it, to support our own supply needs. There are risks with these options, rising wholesale energy unit prices mean that energy production is likely to increase. This could result in less water being available at the locations we identified. At present these options remain technically feasible more work is needed to understand the long term risks associated with trading licence with the energy sector.

Further to this where a desalination plant is located near to a power plant there is the option for power sharing, whereby we have the potential to buy power directly from the power plant at a discounted price. Additionally in some instances there is the potential for the brine waste from the desalination plant to be discharged into the existing power plant outfall, which would be a significant capital expenditure saving.

4.2.6 Reservoirs

Pre-screening was carried out on 104 options from the WRMP19 rejection register. Of those options five passed the pre-screening as no reason for rejection could be found for these options. (Note. This excludes options currently being developed through the RAPID process. These are summarised in Section 5 of this report and sources for further detail are referenced there).

4.2.7 Sea Tankering

The process of sea tankering involves the importing of potable water overseas, such as Norway, into UK ports. The aim is to guarantee water resilience at times of high demand in water networks or during drought events. The water is delivered from the tanker to a service reservoir via pipeline, and then from the service reservoir is delivered via pipeline to an existing WTW.

The sea tankering options have been developed based on a proposal received from a third party.

The only criterion for pre-screening of the sea tankering options was that they could provide sufficient benefit. All options do provide a benefit of 20 Ml/delivery. Therefore none of the options were screened out at this stage.

Subsequently we asked for enhancements to the proposal to consider some areas in more detail, namely water quality, invasive non-native species and security during shipping.

After some further discussions it was agreed to submit an offer to WRE later in 2022 instead. Therefore, we will not progressthese option further for WRMP24, though the concept remains technicallyfeasible.

4.3 Resource sharing and third-party options

The purpose of these collaborations is to develop a common understanding of water resource planning issues and to identify cost-effective options for sharing available resources, including transfers and trading.

Through our membership of WRE we have been able to work closely with other water company members to ensure that we've developed our options collaboratively. This in turn has aided the development of WRMP and WRE Best Value Plans.

A key set of options option developed in conjunction with Cambridge Water are detailed in Section 7 Resource Zone Options.

5 Strategic Resource Options

The regional water resources plan outlines the strategic case or regional need for water-related infrastructure. As part of the development of the Water Resources East (WRE) draft Regional Plan, an advanced stakeholder decision-making process was followed. The aim of this was to determine which supply-side options would be low regret, robust solutions to meet the challenges faced by water resource planning in the East of England.

As part of this process, it was established that the Fens and South Lincolnshire Reservoirs were low-regret, strategic regional options and pivotal to WRE's Regional Plan. In response, and in accordance with the Water Resource Planning Guideline, we have incorporated these solutions as 'must do' in our draft WRMP.

5.1 Fens Reservoir

The water resource modelling carried out has confirmed the following parameters for the development of this solution:

- A useable volume of 50Mm3 is an optimal size for the Fens Reservoir
- The proposed sources of water for the Fens Reservoir are the River Great Ouse(300Ml/d) and the River Delph (400Ml/d)
- The deployable output (DO) to use for design is modelled at 87Ml/d
- The reservoir must be in supply by 2035.

At this stage only one option is presented for the concept plan for the proposed site, which will be optioneered and developed before gate three. Options to be considered and investigated during the next stage include:

- the site layout and on-site benefits which will be influenced by consultation response;
- location and routings of abstraction points;
- transfers and treatment works which will be influenced by site screening criteria;
- on-site investigation works and land referencing;
- drawdown facilities which will be informed by further technical studies.

The provisional design incorporates a solar installation (land based and floating) to provide a combined 24MW energy generation capacity to power the associated water treatment and pumping facilities. At certain times this would provide enough energy to meet the full needs of the project. Energy storage and other forms of renewable energy, including wind, will also be considered.

In addition, the reservoir scheme will provide a conventional surface water treatment facility with the capacity to treat maximum deployable output and onward transfers to deploy the potable water into the strategic interconnector pipeline network.

Application for a Development Consent Order (DCO) to be submitted in 2025 so that works can start on site in 2029 and water be in supply by 2035 to 2037, in line with the WRE and WRMP programmes.

5.2 SLR

The water resource modelling carried out has confirmed the following parameters for the development of this solution:

- A useable volume of 50MCM is an optimal size for SLR
- The source water for SLR should come from the River Witham (400Ml/d) with a back-up transfer to the River Witham from the River Trent (300Ml/d)
- The DO to use for design is modelled at 166Ml/d
- The reservoir must be in supply by 2039-41

At this stage only one option is presented for the concept plan for the preferred site, which will be optioneered and developed before gate three. Options to be considered and investigated during the next stage include the site layout and on-site benefits which will be influenced by consultation responses; location and routings of abstraction points, transfers, and treatment works which will be influenced by site screening criteria, on-site investigation works and land referencing; and drawdown facilities which will be informed by further technical studies.

5.3 A2AT

Solution summary

- The Anglian to Affinity Transfer, or A2AT, is a strategic regional water resource solution for the transfer of water from the Anglian Water region to supply Affinity Water customers.
- The scheme relies on the development of a new source supply of water in the Anglian Water region, and options include a new South Lincolnshire Reservoir (SLR), a new Fens Reservoir or a new intake from the River Trent via Rutland Water.
- An options development and screening process has been carried out, which has resulted in four shortlisted options that have been carried through to gate two. These four different transfer options have been assessed for the different Anglian Water source options and Affinity Water network connection locations.
- The A2AT is being sized to provide a deployable output benefit to Affinity Water of between 50Ml/d and 100Ml/d.
- Whole life costs and Average Incremental Cost (AIC) are presented for "whole solutions" including the SLR and Fens Reservoir sources. This evaluation is complex due to the conjunctive use benefits that occur when the source water options are shared between Anglian and Affinity Water, so the AIC analysis is only intended to allow comparison between options in this submission, rather than as a comparison against other Strategic Resource Options (SROs).

This option is not going to be progressed by either party beyond RAPID Gate Two.

6 Stage 2c Feasible options set

Table 6 WRPG Section 8.3: Information you should provide for each option

Information you should provide for each option	Location of information
(a) A profile of the deployable output, contribution to the supply-demand balance or demand saving (based on the capacity of the option) or water saved over 80 years. For a supply option, the deployable output should be based on the same assumptions as your baseline options. The yield of a demand side option should be based on a dry year (see Sub-Section 4.6).	Section 7 of this report
(b) An estimate of the lead-in time needed to investigate and implement the option, including the earliest date the option could put water into supply or reduce demand.	Section 6.5 of this report
(c) An assessment of the risks and uncertainty associated with the option, including the likelihood and impact on yield of climate change, environmental constraints or customer behaviour (for demand options). You should include an assessment of INNS (where relevant).	Section 6.2 Draft WRMP 2024: Supporting Technical Reports - Supply Forecast report[8]. Draft WRMP24 Environmental Report[9]
(d) A drinking water safety plan assessing the risks to drinking water quality. If there is a risk to wholesomeness, (such as discolouration, nitrates, pesticides) or a risk of deterioration in the quality of supply, the option will not be permitted until steps to mitigate those risks are in place.	Section 6.1
(e) An explanation of whether the option depends on an existing scheme or a proposed option, or is mutually exclusive with another option.	Section 7 of this report
(f) Any constraints specific to the option.	Section 7 of this report
(g) An assessment of your customers' support for the option.	Section 6.3 of this report. Customer and Stakeholder Engagement report[10]
(h) An assessment of the flexibility of the option to adapt to future uncertainty.	Section 6.2 & Section 7 of this report. Draft WRMP 2024: Supporting Technical Reports -Supply Forecast Decision Making (Managing Risk and Uncertainty)[11]

8 Anglian Water, Draft WRMP 2024: Supporting Technical Reports -Supply Forecast
9 Mott Macdonald (2021) draft WRMP24 Environmental Report.
10 Anglian Water (2021) draft WRMP24 Customer and Stakeholder Engagement..
11 Anglian Water (2021) draft WRMP24 Decision Making (Managing Risk and Uncertainty).

Information you should provide for each option	Location of information
(i) A description of how the option will be utilised and the impact on operating costs and carbon costs. You should describe the expected utilisation in both an average year (assumed long term utilisation scenario) and a theoretical annual maximum utilisation scenario.	Decision Making (Managing Risk and Uncertainty)[12]
(j) An assessment of the environmental and social impacts of the option, including any SEA at an option level, an evaluation of the impacts on RBMP objectives, nature recovery objectives (England), Ecosystem resilience biodiversity duty (Wales) and well-being goals (Wales).	Draft WRMP24 Environmental Report[13]
(k) A HRA, if the option could affect any designated habitats site	Draft WRMP24 Environmental Report[10]
(l) (for supply and transfer options) a natural capital assessment including an assessment of the predicted impact of the option on natural assets and service flows.	Draft WRMP24 Environmental Report[10]
(m) (England only) an assessment of the contribution of the option to the conservation and enhancement of biodiversity and a high-level assessment of biodiversity net gain (if the option requires planning permission)	Draft WRMP24 Environmental Report[10] Anglian Water (2021) Draft Sustainable Abstraction and Environment Report[14]
(n) Cost information	Section 6.4. WRP Tables 5a and 5b
(o) Greenhouse gas emissions	Appendix D in Decision Making (Managing Risk and Uncertainty)[15]
(p) Other information relating to metrics developed to inform selection of your preferred programme	Section 7

12 Anglian Water (2021) draft WRMP24 Decision Making (Managing Risk and Uncertainty).
13 Mott Macdonald (2021) draft WRMP24 Environmental Report
14 Anglian Water (2021) Draft Sustainable Abstraction and Environment Report
15 Anglian Water (2021) draft WRMP24 Decision Making (Managing Risk and Uncertainty).

6.1 Water quality

We have undertaken a high level Drinking Water Safety Plan (DWSP) risk assessment for the overarching WRMP options completing an initial DWSP for desalination, water reuse and water transfer. Following a typical hazard and control template based approach risks have been identified and have been linked to a hazardous activity or event, an uncontrolled and controlled risk (RAG rating) has been applied and a likelihood and consequence score given where applicable at this stage. Specific data source parameters have been taken from the WHO document WHO/HSE/WSH/11.03 Safe Drinking-water from Desalination (2011) and a DWSP developed at a compound level looking at potential source contaminants likely to be present in sea water and which contaminants could be caused by a shipping accident for example. The high level screening approach will be further developed when individual options have been refined , with risk data being sourced to enable further iteration of the DWSP. Future work will look at the identification of residual risks and data gaps looking at available water quality data used to design the options. Feasibility option reports have been developed for the design options for water treatment.

This is not an exhaustive list, some highlights and main points from the high level screening exercise for the potential options are :

6.1.1 Desalination:

- Boron is likely to be present in brackish or seawater up to concentrations of 4 to 5 mg/l. This will require reverse osmosis to treat, once water quality data is further understood this will dictate the number of passes required.
- Bromide likely to be present at values between 65 to 80 mg/l. The preferred choice of disinfection will be critical to minimise the risk of PCV failure and Disinfection By Product formation potential.
- Regulation 31 compliance will be required with adherence to the regulation and evidence of that at all times this must include all raw water conveyance systems and treated water processes.
- Risk of adverse weather conditions for example flooding risk, impact of high tides, surges, storm impacts and detrimental impact on water quality and asset capability and availability.
- Risk of shipping accidents and subsequent risk of contamination of the raw water which could pose a potential treatment risk.
- Risk of PFAS in the brackish or seawater and potential for the requirement for additional treatment processes to ensure compliance on final treated water.
- Risk of customer lack of confidence in the water if it looks, tastes or feels different. Panel trials on remineralisation and optimal blend scenarios are required to inform this along with customer engagement and support.

6.1.2 Water re-use:

- Risk of non - compliance with the upstream water recycling works and understanding how this could potentially have a detrimental impact on the raw water quality.
- Risk of PFAS in the water recycling final water effluent and potential for the requirement for additional treatment processes to ensure compliance on final treated water.
- Risk of non - permitted chemicals discharged into the water recycling works via tankers from a wide area, with tankers bringing effluent/waste from variety of locations. Management and controls would need to be identified.
- Permitted industrial discharges; additional monitoring is likely for parameters such as BOD, COD, ammonia, TSS etc
- Regulation 31 compliance will be required with adherence to the regulation and evidence of that at all times this must include all raw water conveyance systems and treated water processes
- Risk of customer lack of confidence in the water if it looks, tastes or feels different. Panel trials on optimal blend scenarios might be required to inform this along with customer engagement and support.
- Risk of customer perception that the water may be unsafe.

6.1.3 Water Transfer (for example Strategic Pipeline Alliance):

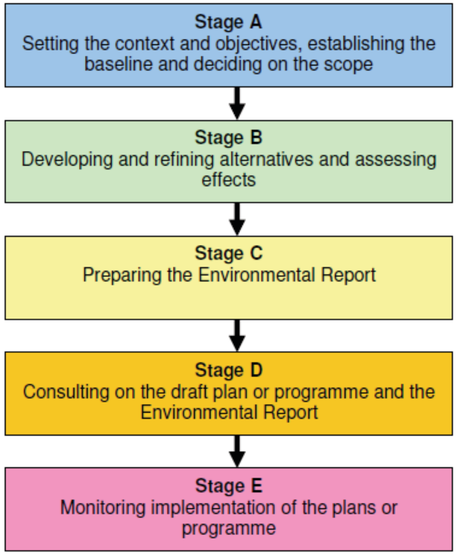
- Mixing of waters from different sources for example surface and ground water sources, there is an inherent risk that customers could reject the water on appearance , taste and odour . Customer engagement and evidence of that engagement are required.
- Mixing of waters with significantly different chlorine residuals which customers could identify and reject the water on taste or odour. Free chlorine and chloraminated systems will not be mixed in order to remove the risk of taste. Customer engagement and evidence of that engagement are required.

- General risk of a perceived change in the water quality due to changes in hardness, taste and odour or general appearance. Customer engagement and evidence of that engagement are required.
- Risk of discolouration with transfer systems. Mains conditioning and effective control and management will be required to minimise the risk of discolouration.
- Risk of water age in particular on Disinfection By Product formation potential
- Risk of customer lack of confidence in the water if it looks, tastes or feels different. Customer engagement and evidence of that engagement are require.
- Regulation 31 compliance will be required with adherence to the regulation and evidence of that at all times where fittings, materials or chemicals are used in the distribution system.

6.2 Environmental assessment of options

Option specific assessments were completed as part of the WRMP24 Environmental Assessments and further information on environmental destination, strategy and ambitions in our Sustainable Abstraction and Environment Report.

Figure 18 The stages involved in this approach



The scoping stage of the SEA process (Stage A in Figure 18) sets the context and scope for the SEA and Environmental Report. During scoping key plans and programmes are reviewed, baseline conditions and key issues and opportunities are identified, and the SEA Framework is developed. The scoping stage for the WRMP was undertaken and a SEA Scoping Report produced in early 2021[16].

The approach proposed in the Scoping Report aimed to build on the environmental context defined in our WRMP19. Furthermore, as regional water resource plans are required to undertake the same suite of

16 Anglian Water (2021). Water Resource Management Plan 2024 Strategic Environmental Assessment Scoping Consultation

environmental assessments as water company WRMPs, the proposed approach aligned with the Integrated Environmental Assessment (IEA) approach of the Water Resources East (WRE) regional planning group.

The Scoping Report was issued for a formal five-week consultation between March-April 2021 to the three statutory bodies: Environment Agency, Natural England, and Historic England.

Key themes arising from the Scoping Report consultation included:

- Consistency between approaches, that is aligning with, and where necessary building on/ refining, previous work and regional-level plans (including Water Resources East's Integrated Environmental Assessment approach), as well as relevant guidance, planning and policy frameworks.
- Coverage of a full range of socio-environmental issues including interactions and synergistic impacts in both construction and operation, including but not limited to air quality, climate change, pollution, biodiversity, and aesthetic/character values.
- Mitigating potential impacts on the historic environment and heritage assets, including designated and non-designated heritage sites, and recognising that some heritage assets may currently be unknown.
- Representativeness across locations, customers, and stakeholders, and engagement of experts including local groups and advisors.
- Opportunities to have positive impacts, including in relation to biodiversity, responsible recreation and engagement with the natural and historic environments, climate resilience, and development of green infrastructure.

6.2.1 Strategic Environmental Assessment (SEA)

The purpose of the SEA is to provide high-level protection for the environment and to consider likely significant effects (LSE) across a series of environmental and social topics / objectives. SEA is the only assessment that considers the impact of the plan as a whole and has the aim of influencing key decisions on option selection across as series of different proposed plans, whilst aiming to avoid or reduce the impact of negative effects and enhance positive effects. Increasingly, SEA has been used to aid the integration of the wider necessary environmental assessments, identifying how each assessment can provide adequate outputs to assess SEA objectives to ensure proportionality and coherence. Typical activities in SEA include:

- A review of relevant policies
- Scoping and consultation
- High-level screening of options
- Establishing environmental baselines
- Assessment of individual options
- Assessment of preferred plans, reasonable alternatives and in-combination effects
- Environmental reporting and consultation (along with draft WRMP)

6.2.2 Water Framework Directive (WFD)

The Water Framework Directive (WFD) considers legally binding objectives from the River Basin Management Plans (RBMP), ensuring feasible options bear no risk of deterioration to waterbodies such as rivers, groundwater, lakes, wetlands and coastal waters. Furthermore, there is an emphasis on practical, catchment-based solutions and partnerships that help waterbodies achieve 'good ecological status' in characteristics such as flow, water quality, morphology and habitats.

6.2.3 Habitats Regulations Assessment (HRA)

Habitats Regulations Assessments (HRA) must be carried out to ensure any likely significant effects to protected European sites ('Natura 2000' network) are considered. Examples of protected sites are Special Areas of Conservation (and candidate SACs), Special Protection Areas (and potential SPAs) and Ramsar sites (and proposed Ramsar sites). Typical stages of HRA include:

- Initial screening to test for any likely significant effects (LSE) of an option or plan on protected sites (using the 'Precautionary Principle' as a guide).
- Formulating the scope and methods for Appropriate Assessment (AA). Detailed assessment of effects of an option or plan.
- Where there are adverse effects, an assessment of alternative solutions and mitigations should be undertaken for comparative purposes.
- In the unlikely event where no alternative solution to the assesses plan exists (less-damaging alternatives exist and adverse effects remain), a case for Imperative Reasons of Overriding Public Interest (IROPI) will need to be made.

6.3 Customer support for options

The approach, principles of engagement and details of finding of our customer and stakeholder engagement can be found in our Customer and Stakeholder Engagement report[17] .

The key findings of this

- Our customers believe that we need to achieve our environmental targets as they are crucial for the future of the planet.
- The environmental destination of 'restore' is seen as the preferential scenario by our customers. This view is driven by financial security and concerns over affordability.
- The majority of our customers feel we should achieve our environmental destination sooner than 2050.
- Our customers feel that our Levels of Service for Temporary Use Bans and Non-essential use bans are acceptable. However, they did welcome moving to a higher level of drought resilience.
- Most of our customers were unaware of drought permits.
- Just under half of those engaged with believed that the use of drought permits should be reduced, citing possible environmental impacts. However, when explored holistically this became less of a priority, with affordability and other environmental impacts coming to the fore.
- Achieving drought resilience by 2039 was largely seen as the right timescale by our customers.
- Making the most of what we have remains a priority for our customers with demand management measures being seen as the preferential way of tackling deficits.
- Reservoirs and water reuse were the most preferred supply-side options.
- Seventy nine percent of our customers felt people should pay their water bills on the basis of the amount of water they use.
- Customers support the principle of a best value plan, but there is a core desire from customers for bills to be fair and affordable.

Table 7 below shows customer prioritisation for options in descending order. These results are from engagement activities discussed on detail in the Customer and Stakeholder Engagement report[18] .

For context the table shows all supply and demand side option types.

17 Anglian Water (2022) draft WRMP24 Customer and Stakeholder Engagement.
18 Anglian Water (2022) draft WRMP24 Customer and Stakeholder Engagement.

Table 7 Customer prioritisation for option types

Priority	Option Type
1	Leak reduction (company side)
2	Higher water efficiency
3	Water reuse
4	Using grey or rainwater
5	Reservoir
6	Leak reduction (customer side)
7	ASR
8	Smart metering
9	Universal metering
10	Desalination
11	Transferring water (between companies/regions)
12	Sea Tankering

6.4 Costs estimates

6.4.1 Financing cost methodology

All our supply options have been entered into our C55 Asset Investment Planning and Management tool, a proprietary software tool we use for the estimation of all Business Plan investments. The cost estimation module within C55 contains a comprehensive asset cost model library covering assets from treatment steps (e.g. pumping station, filter) C55 has been used to develop capital and operational carbon quantity estimates for each feasible option in terms of tonnes of carbon dioxide equivalent (tCO_2e).), pipelines and equipment (e.g. starter, pump). The cost models are common for all investments and the cost is driven by the asset attributes entered (i.e. pump kW). Once the options are developed in C55, they follow a Quality Assurance process, where the Anglian Water Cost Base Team challenges the scope, in order to ensure alignment with current business practice. The cost models in C55 have been updated to 2017 prices using AWS cost data from completed projects. We have uplifted these costs to 2020/21 prices outside of C55 as described in section 6.4.2.

To calculate financing costs as a stream of annual costs over the life of the option, we have followed an approach based on the Regulated Capital Value and Net Book Value (NBV) of capital assets. In this approach, the full NBV of an asset is added to the RCV at the start of the first year of the period, and is reduced incrementally by a constant amount in each subsequent year to zero as its value depreciates, giving an annual "net capital value". If the asset is renewed at the end of its useful life, the full NBV is incurred again and the depreciation cycle renews. Annual financing costs are calculated by applying the WACC to the annual net capital value amount (the RCV adjusted for depreciation), and adding back depreciation. These annual financing costs are then discounted using the standard declining long-term discount rate (STPR) reported in the HM Treasury Green Book.

The worked example shows the calculation for an asset with an NBV of £1,000 and an asset life of five years, depreciating at a constant rate of £200,000 per year. In Year 1, the average net capital value is £900,000 after adjusting for depreciation. The financing cost is calculated by applying the WACC (2.92% in this example) to the £900,000 and then adding back depreciation, resulting in a total of £226,000. That financing cost is then discounted using the discount rate (in this case, 3.5% for all five years - the rate will change for longer time horizons as per Green Book guidance), and the sum of the stream of discounted costs results in a total NPV of financing costs of £988,000. Note that the NPV will be lower when the discount rate is greater than the WACC.

6.4.2 Inflation Uplifts

We ran the cost reports from C55 before all of the cost models had been updated, so the raw data was in our September 2017 cost base.

To compensate for this and bring our data up to 2020/2021 cost base some uplift factors were applied.

All option costs were uplifted by a factor of 1.1284 to account for CPIH from September 2017 to September 2022.

A further uplift factor of 1.22 was applied to account for change in material, plant, labour, preliminary works and changes associated with engineering requirements and our minimum asset standards.

6.4.3 Optimism Bias

An Optimism Bias methodology was developed by an all company working group (ACWG) comprising the nine water companies with SRO projects. The methodology was used by Water Resources East (WRE) in regional planning as so has been applied in the same way to WRMP options for consistency.

Optimism Bias for each option can be found in WRMP Table 5a.

Table 8 shows the percentage of optimism bias applied by option type.

Table 8 Percentage of optimism bias applied by option type

Option type	% optimism bias applied
Terrestrial desalination (onshore)	56.9
Barge (offshore and quayside) desalination	57.9
Water reuse	57.9
Reservoirs	56.0
Sea Tankering	35.6
Conventional treatment	20.3
Conjunctive use	20.3

Option type	% optimism bias applied
Aquifer Storage and Recovery	32.2
Transfers	31.2

6.4.4 Capital and Operational Carbon Assessment

We use C55 to develop capital and operational carbon quantity estimates for each feasible option in terms of tonnes of carbon dioxide equivalent (tCO_2e).

Capital Carbon

In calculating the capital carbon of our assets we use a methodology verified against PAS2080 - Carbon Management in Infrastructure.

We have a host of carbon models pertaining to the materials, products and construction methods we use in the construction of our assets. As a design progresses we use a carbon modeller to bring together the carbon models and calculate the total capital carbon associated with each asset. Our capital carbon value is for the asset 'as built' - it includes the capital carbon associated with the production of materials and products, their transport and the methods used to construct the asset.

Operational Carbon

Our operational carbon footprint is built up from an understanding of the energy consumption required to operate our asset - for example the energy required to pump water. Through our design approaches we understand the various elements of our design, the energy required to operate these elements and the operational profile. Together with an understanding of the carbon associated with the various energy sources used (primarily electricity) this allows us to calculate the operational carbon assessment.

6.4.5 C55 Lifecycle report

We use the C55 'Lifecycle report' to extract cost information for ESBD input data and completion of WRP Tables 5a and 5b.

This report provides, capex profile, annual opex (fixed and variable), capex repeats and carbon quantities (embodied and operational).

6.4.6 Capex repeats

The investment needed to renew an asset at the end of its useful life is referred to as capex repeats in C55. These have standard renewal periods (asset life) based on asset type. For the WRMP we are using 'plant class' cost models and these use the following asset lives,

- C01 - Studies / Models - Repeat zero
- C04 - Civils - Repeat 50 years
- C05 - Sewers and Mains - Repeat 200 years
- C06 - Mech & Elec - Repeat 15years
- C07 - Instrument and Control - Repeat 7 years

The capex repeats are different to the original CAPEX. The repeat only adds up the cost for that account (i.e. C07 instrumentation) then the on-cost equation is applied to the account. This ensures that the future costs are not overestimated by activities that may not be carried out as expected at that time, therefore the value should be lower than the original one.

The duration for the repeat is dependent on the length of time the original capex is profiled over. In general, the repeat is half of the time of the original spend profile, so for most of the WRMP investments they are profiled over 4 years and as such the capex repeat is profiled over 2 years. The split between years varies with asset type but in general is approximately 20:80 over 2 years for the WRMP options.

The scale of the capex repeats also varies over time to reflect the complexity of the investment needed over the asset life.

The C55 'life cycle report' profiles costs over 40 years, however for the WRMP we need to extend the profile to 80 years. For most asset types there is a capex repeat cycle within the 40 years, but for civils we need to manually add in a capex repeat into our extended 80 year profile. For civil repeats we have assumed the original capex will be repeated after 50 years, which will be profiled over 2 years based on 20:80 split.

6.4.7 Capex depreciation

The guidance states the full Net Book Value (NBV) of an asset is included at the start of the first year and then reduced incrementally by a constant amount in each subsequent year to zero as its value depreciates, giving an annual "net capital value".

Table 9 Extract from C55 Lifecycle report

Account Types 2	Account Types 3	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11
CAPEX	C01 - Studies / Models	£18,089	£49,799	£80,405	£46,199							
CAPEX	C04 - Civils	£3,075,738	£8,438,299	£13,430,073	£7,539,406							
CAPEX	C05 - Sewers and Mains	£6,069,721	£16,397,278	£24,382,813	£12,100,122							
CAPEX	C06 - Mech & Elec	£1,925,178	£5,207,990	£7,793,073	£3,915,711							
CAPEX	C07 - Instrument and Control	£72,510	£19,9172	£318,614	£180,365							
CAPEX_REPEAT	C01 - Studies / Models - Repeat											
CAPEX_REPEAT	C04 - Civils - Repeat											
CAPEX_REPEAT	C05 - Sewers and Mains - Repeat											
CAPEX_REPEAT	C06 - Mech & Elec - Repeat											
CAPEX_REPEAT	C07 - Instrument and Control - Repeat										£131,909	£577,763

The C55 reports profiles the original capex over 3 or 4 years (depending on the scale and type of investment). The first 1 or 2 years cover planning, design and procurement, with the assets being installed within year 3 and operational 6 months into year 4. For this reason, the capex repeat periods are relative to year 3 rather than the start of the period e.g. For instrumentation and control (7 year asset life) with an option with a 4 year capex profile, the capex repeats will start in year 10 and continue into year 11, see Table 9.

For the RVC calculation we have summed the capex for Years 1,2 and 3 for each asset type and then depreciated them using the relevant rate from Year 3. Capex for Year 4 is depreciated from this date. Studies/models expenditure has not been depreciated or included in the financing costs calculation.

For example, the Instrumentation and control capex will be simplified as shown in Table 10 below.

Table 10 Simplified capex profile to be used in financing cost calculation

	Units (£)	Year 1	Year 2	Year 3	Year 4	Year 5	
Original Capex Profile		72,510	199,172	318,615	180,365	0	
Capex to be depreciated from Year 3				590,297			
Capex to be depreciated from Year 4					180,365		

The capex in Year 3 will be depreciated over 7 years and in Year 10 £131,909 (see Table 11) will be reinvested and the depreciation cycle renews. For capex in Year 4 this will be depreciated until Year 11 when £577,763 (see Table 11) will be reinvested and the depreciation cycle renews.

Table 11 Example of financing costs for instrumentation and control

		Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 12
Capex to be depreciated from Year 3	RCV at start of year	590,297	505,969	421,641	337,313	252,985	168,656	84,328	131,909	113,065	94,221	75,377
	Depreciation	84,328	84,328	84,328	84,328	84,328	84,328	84,328	18,844	18,844	18,844	18,844
	RCV at end of year	505,969	421,641	337,313	252,985	168,656	84,328	-	113,065	94221	75377	56532
	Mid-year RCV	548,133	463,805	379,477	295,149	210,820	126,492	42,164	122,487	103,643	84,799	65,955
	Financing cost	**101,430**	**98,799**	**96,168**	**93,537**	**90,906**	**88,275**	**85,644**	**22,666**	**22,078**	**21,490**	**20,902**
Capex to be depreciated from Year 4	RCV at start of year		180,365	154,599	128,832	103,066	77,299	51,533	25,766	577,763	495,226	412,688
	Depreciation		25,766	25,766	25,766	25,766	25,766	25,766	25,766	82,538	82,538	82,538
	RCV at end of year		154,599	128,832	103,066	77,299	51,533	25,766	-	495,226	412,688	330,150
	Mid-year RCV		167,482	141,715	115,949	90,183	64,416	38,650	12,883	536,494	453,957	371,419
	Financing cost		**30,992**	**30,188**	**29,384**	**28,580**	**27,776**	**26,972**	**26,168**	**99,276**	**96,701**	**94,126**
	Total financing cost	**101,430**	**129,791**	**126,356**	**122,921**	**119,486**	**116,051**	**112,616**	**48,834**	**121,354**	**118,191**	**115,028**

6.4.8 Financing costs

To calculate the annual financing costs we have applied the WACC to the mid-year RCV and added on the depreciation.

We have used a WACC of 3.12% which is the CPIH deflated real allowed return for the wholesale business from the CMA redetermination[19].

Table 12, has an example of the financing calculation for Instrumentation and control starting in Year 3. The example only shows the calculation to Year 12, but for the WRMP24 the calculation in over 80 years.

For the total financing cost profile we added the financing costs from all the asset types, see Table 12.

For EBSD we need to convert the cost into an annual average cost for each option. To do this we have averaged the costs over 78 years.

Table 12 Example of total financing costs for all Account types

Financing Costs	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
C07 - Instrument and Control	-	-	101,430	129,791	126,356	122,921	119,486	116,051	112,616	48,834	121,354	118,191
C06 - Mech & Elec Year			1,445,258	1,793,357	1,754,166	1,714,975	1,675,783	1,636,592	1,597,401	1,558,209	1,519,018	1,479,827
C05 - Sewers and Mains			1,692,309	2,122,081	2,112,885	2,103,689	2,094,492	2,085,296	2,076,100	2,066,904	2,057,708	2,048,511
C04 - Civils Year			1,269,356	1,637,456	1,617,186	1,596,917	1,576,647	1,556,377	1,536,108	1,515,838	1,495,568	1,475,298
TOTAL	**0**	**0**	**4,508,353**	**5,682,685**	**5,610,593**	**5,538,501**	**5,466,409**	**5,394,316**	**5,322,224**	**5,189,785**	**5,193,648**	**5,121,828**

19 Page 35, Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations Final report. 17 March 2021

6.5 Implementation periods

For all feasible options we have estimated the time needed to investigate, plan, design and implement the option based on the option type, see Table 13.

Table 13 Feasible option implementation periods

Option Type	Time to investigate, plan, design and implement option (years)	Earliest start date	Notes
Desalination	7-10	2032-2035	It has been assumed that design and construction of the treatment process could be completed within 4 years but several years of planning, testing and stakeholder engagement would be required.
Potable Water Transfer	3-5	2028-2030	Due to the planning, enabling works, environmental issues, large number of land owners and procurement these transfers have been assumed to be deliverable within 3-5 years depending on the complexity and length of the pipeline.
New Reservoir	15+	2035-2040	As the reservoirs options are >30Mm^3 they are considered as Nationally significant infrastructure projects[20] (NSIPs) and would be subject to the Development Consent Order (DCO) process that accelerates the planning process.
New Reservoir (with raw water transfer)	15+	2035-2040	See above.
Water Reuse for potable water use	7-10	2032-2035	Delivery would be 4-5 years but would require up to 5 years for stakeholder engagement prior to delivery.
Water reuse for non-potable use	7-10	2032-2035	Significant stakeholder and customer engagement required prior to delivery to understand complex and diverse needs of industry.
Conjunctive use with treatment	5	2030	Planning and licence trade negotiations would take 2-3 years followed by 2 years construction and commissioning.
Aquifer Recharge	10	2035	Complex planning and permitting issues and includes time to recharge the Aquifer.

20 Planning Act 2008

6.6 Relevance to final planning problem

The final screening stage of the feasible options is to ensure that they are relevant to the planning problem to be modelled in EBSD. At this stage the following have been finalised:

- Supply forecast - the driver for reductions in WAFU in each WRZ is known (e.g. drought, climate change)
- Demand management programme
- Solutions driven by changes to existing abstraction licences.

We have ensured that we are not taking options forward that would not be available in the scenario modelled, for example if the one of the drivers for WAFU reduction is more extreme drought we have checked that all the options in that WRZ are available in that drought.

We have developed options to export resources from all WRZ in surplus to those in deficit, to allow the model to assess whether it is economical to implement long transfers of small surpluses verses developing new resources.

7 Water Resource Zone Options

The following sub-sections provide details of the unconstrained and feasible options for each Water Resource Zone (WRZ).

7.1 Cambridge Water options

7.1.1 Cambridge Water Constrained options

Cambridge Water co. is geographically between two of our WRZs, Ruthamford South and Cambridge and West Suffolk. We have developed a set of transfer options that can be mutually beneficial to us and Cambridge Water, so we have included Cambridge Water WRZ in this section to describe the options.

Table 14 Constrained option for Cambridge Water WRZ

Option type	Option ID	Option name	Feasible	Taken through to modelling
Potable transfer	CAM1	Cambs & West Suffolk to Cambridge Water Co potable transfer (10 Ml/d)	Yes	Yes
Potable transfer	CAM2	Ruthamford South to Cambridge Water potable transfer (10 Ml/d)	Yes	Yes
Potable transfer	CAM3	Ruthamford South to Cambridge Water potable transfer (20 Ml/d)	Yes	Yes
Potable transfer	CAM4	Ruthamford South to Cambridge Water potable transfer (50 Ml/d)	Yes	Yes
Potable transfer	CAM5	Cambs & West Suffolk to Cambridge Water Co potable transfer (20 Ml/d)	Yes	Yes
Potable transfer	CAM6	Cambs & West Suffolk to Cambridge Water Co potable transfer (50 Ml/d)	Yes	Yes

7.1.2 Cambridge Water Transfer options

All the options we've identified for this WRZ are potable transfers are all feasible.

Table 15 Transfer option details for Cambridge WRZ

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
CAM1	10	0.38	Cambs & West Suffolk	Cambridge Water	31	327

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
CAM2	10	0.60	Ruthamford North	Cambridge Water	39	368
CAM3	20	1.10	Ruthamford North	Cambridge Water	39	500
CAM4	50	2.16	Ruthamford North	Cambridge Water	39	700
CAM5	20	0.74	Cambs & West Suffolk	Cambridge Water	31	458
CAM6	50	1.72	Cambs & West Suffolk	Cambridge Water	31	700

7.1.3 Cambridge Water Inter-dependencies, links and synergies

None of these options are entirely dependent on another option but they can each be examined as a component of a combined option. None of the interactions with Cambridge Water's own WRMP24 options are considered in this report.

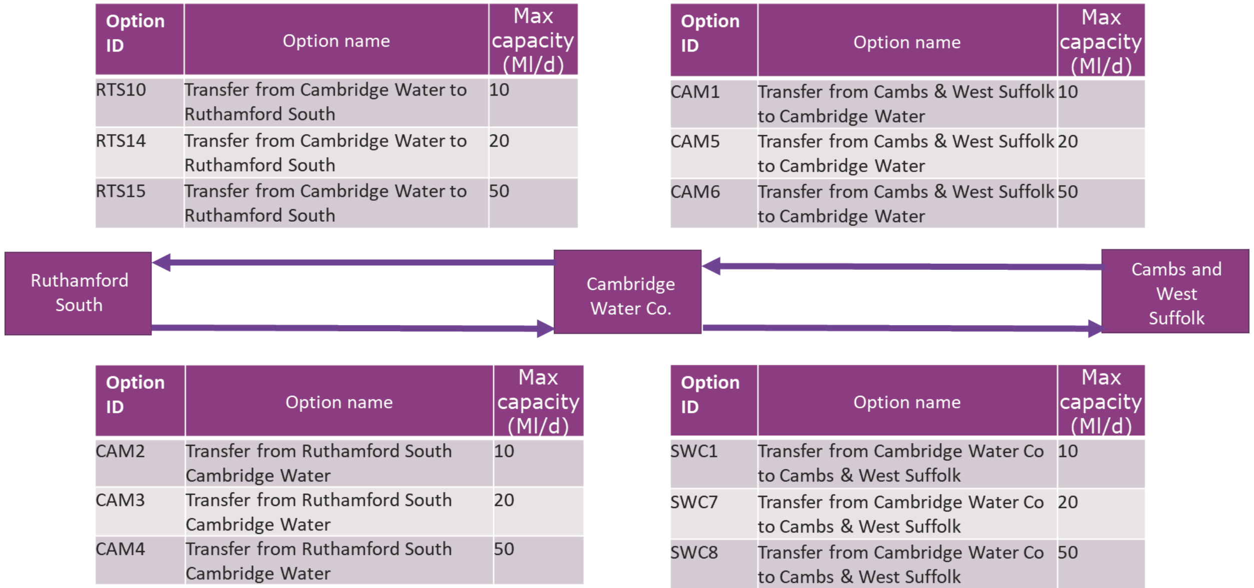
Table 16 Option dependencies and exclusivities

Option ID	Option name	Dependencies	Exclusivities
CAM1	Transfer from Cambs & West Suffolk to Cambridge Water		CAM5 & CAM6
CAM2	Transfer from Ruthamford South to Cambridge Water		CAM3 & CAM4
CAM3	Transfer from Ruthamford South to Cambridge Water		CAM2 & CAM4
CAM4	Transfer from Ruthamford South to Cambridge Water		CAM2 & CAM3
CAM5	Transfer from Cambs & West Suffolk to Cambridge Water		CAM1 & CAM6
CAM6	Transfer from Cambs & West Suffolk to Cambridge Water		CAM1 & CAM5

Figure 19 illustrates how the transfers can interact. The overall transfer is from Ruthamford South WRZ to West Suffolk and Cambridgeshire WRZ. However, through discussions with Cambridge Water Co. we have been able to develop the option in a way that is beneficial to both companies by creating a 'drop-off node' along the route. Additionally, by developing the option in this way it enables the company EBSD models or the WRE regional model to select any section of the transfer in reverse. Options of 10, 20 and 50 Ml/d have been developed in both directions. The combination of these available options gave flexibility for the modelling to provide the best value overall option.

These options are supported by resource made available from surface water enhancement and a drought permit option in Ruthamford South.

Figure 19 Illustration of how the Anglian-Cambridge transfer options interact



7.2 Essex Central options

7.2.1 Constrained options

Table 17 Essex central WRZ constrained options

	Option ID	Option name	Feasible	Taken through to modelling
Potable transfer	EXC1	Cambs & West Suffolk to Essex Central potable transfer (5 Ml/d)	Yes	Yes
Potable transfer	EXC13	Essex Central to Essex Central potable transfer (10 Ml/d)	No	No
Potable transfer	EXC14	Essex Central to Essex Central potable transfer (10 Ml/d)	No	No
Potable transfer	EXC15	Cambs & West Suffolk to Essex Central potable transfer (10 Ml/d)	Yes	Yes
Potable transfer	EXC16	Essex Central to Essex Central potable transfer (10 Ml/d)	No	No

	Option ID	Option name	Feasible	Taken through to modelling
Potable transfer	EXC2	Cambs & West Suffolk to Essex Central potable transfer (10 Ml/d)	Yes	Yes
Potable transfer	EXC3	Essex Central to Essex South potable transfer (10 Ml/d)	Yes	Yes
Potable transfer	EXC4	Essex Central to Essex Central potable transfer (10 Ml/d)	Yes	Yes
Potable transfer	EXC5	Cambs & West Suffolk to Essex Central potable transfer (10 Ml/d)	Yes	Yes
Potable transfer	EXC6	Cambs & West Suffolk to Essex Central potable transfer (10 Ml/d)	Yes	Yes

All of our Essex Central feasible options are transfers.

Table 18 Essex central WRZ feasible options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
EXC1	5	0.16	Cambs and West Suffolk	Central Essex	17	290
EXC2	10	0.25	Cambs and West Suffolk	Central Essex	17	368
EXC3	10	0.15	Central Essex	South Essex	8	409
EXC4	10	0.13	Central Essex	Central Essex	7	409
EXC5	10	0.18	Cambs & West Suffolk	Central Essex	10	409
EXC6	10	0.13	Cambs & West Suffolk	Central Essex	11	327
EXC13	10	1.00	Central Essex	Central Essex	16	458
EXC14	10	0.24	Central Essex	Central Essex	16	368
EXC15	10	0.35	Cambs & West Suffolk	Central Essex	42	458
EXC16	10	0.70	Central Essex	Central Essex	10	396

7.3 Essex South options

7.3.1 Constrained options

Table 19 Essex South WRZ feasible options

Option ID	Option Type	Option name	Gain in WAFU	Feasible?	Taken through to modelling?
EXS1	Reuse	Colchester WRC direct to Ardleigh Reservoir (with additional treatment)	15.2	Yes	Yes
EXS2	Reuse	Colchester WRC direct to Ardleigh Reservoir (no additional treatment)	8.5	Yes	Yes
EXS3	Reuse	Clacton-Holland Haven to Ardleigh Reservoir with additional treatment at Ardleigh)	9.3	Yes	Yes
EXS4	Reuse	Clacton-Holland Haven to Ardleigh Reservoir (no additional treatment at Ardleigh)	5.7	Yes	Yes
EXS5	Reuse	Colchester to Ardleigh Reservoir via the River Colne (with additional treatment)	15.2	Yes	Yes
EXS6	Reuse	Colchester to Ardleigh Reservoir via the River Colne with no extra treatment	15.2	Yes	Yes
EXS7	Supernatant	Backwash water recover, Essex South WTW	0.29	Yes	Yes
EXS8	Sea Tankering	Harwich Sea Tankering	20	Yes	No
EXS10	Desalination	Holland on Sea desalination (seawater) 25 Ml/d	25	Yes	Yes
EXS11	Desalination	Holland on Sea desalination (seawater) 50 Ml/d	50	Yes	Yes
EXS12	Desalination	Holland on Sea desalination (seawater) 100 Ml/d	100	Yes	Yes
EXS13	Desalination	Holland on Sea floating desalination (seawater) 25 Ml/d	25	Yes	No
EXS14	Desalination	Holland on Sea floating desalination (seawater) 50 Ml/d	50	Yes	No
EXS15	Desalination	Holland on Sea floating desalination (seawater) 100 Ml/d	100	Yes	No
EXS19	Reuse	Colchester WRC direct to Ardleigh Reservoir (no additional treatment)	16.8	Yes	Yes

Table 20 Additional considerations and risks with options EXS5 and EXS6

Reuse type - Transfer to river for indirect re-abstraction. See Figure 11	
Consideration	Risk
Deployable Output Limitations	Dependant on flow from WRC Difficulty in demonstrating that water discharged at outfall is available at abstraction point as a result of environmental losses/other users.
Water Quality at source	Source water has high chloride levels Temperature of water from recycling process may be higher than receiving waterbody.
Quality at brine outfall discharge location	The discharge location for the brine outfall has high levels of chloride. The reverse osmosis brine will increase the concentrations of phosphate, sodium and chloride in the plant waste effluent compared to current concentrations.

Table 21 Additional considerations and risks with options EXS1, EXS2 and EXS19

Reuse type - Transfer to reservoir for abstraction. See Figure 12	
Consideration	Risk
Deployable Output Limitations	Dependant on flow from WRC
Water Quality at source	Source water has high chloride levels
Quality at brine outfall discharge location	The discharge location for the brine outfall has high levels of chloride. The reverse osmosis brine will increase the concentrations of phosphate, sodium and chloride in the plant waste effluent compared to current concentrations.
Water quality at discharge to reservoir	Quality of water from reverse osmosis process with be different to the receiving body. Temperature of water from recycling process may be higher than receiving waterbody.

Table 22 Additional considerations and risks with options EXS10, EXS11 and EXS12

Desalination type - Seawater desalination process. See Figure 7	
Consideration	Risk
Deployable Output Limitations	Land availability. Footprint may dictate plant size and therefore capacity.

Desalination type - Seawater desalination process. See Figure 7	
Consideration	**Risk**
Water Quality at source	Limited knowledge of water quality a variability. No examples of Desalination for water supply in North Sea so unknown expected levels of outage due to turbulence or storm events
Quality at brine outfall discharge location	Plume modelling required to assess impact
Water quality at discharge to service reservoir	Remineralisation and blending ratios need to be understood.

Table 23 Essex South feasible option not progressed for modelling

Option type	Option ID	Option name	Feasible	Taken through to modelling	Reason for not modelling
Reuse	EXS3	Clacton-Holland Haven to Ardleigh Reservoir with additional treatment at Ardleigh)	Yes	No	Low DO relative to alternatives.
Sea tankering	EXS8	Harwich Sea Tankering	Yes	No	Perceived INNS risk and insufficient information of water quality, also very low support for this option from customers.
Offshore desal	EXS13	Holland on Sea floating desalination (seawater) 25 Ml/d	Yes	No	No benefit over on-shore desalination but carries additional risk.
Offshore desal	EXS14	Holland on Sea floating desalination (seawater) 50 Ml/d	Yes	No	No benefit over on-shore desalination but carries additional risk.
Offshore desal	EXS15	Holland on Sea floating desalination (seawater) 100 Ml/d	Yes	No	No benefit over on-shore desalination but carries additional risk.

7.3.2 Transfer options

Table 24 Essex South Transfer Options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
EXS9	10	0.07	South Essex	Central Essex	8	290
EXS16	10	0.40	East Suffolk	South Essex	26	368

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
EXS17	20	0.74	East Suffolk	South Essex	26	500
EXS18	10	1.16	Cambs & West Suffolk	South Essex	16	352

7.4 Fenland options

7.4.1 Constrained options

Table 25 Fenland Constrained options

Option ID	Option Type	Option name	Gain in WAFU	Feasible?	Taken through to modelling?
FND1	Reuse	Kings Lynn to Stoke Ferry via river Wissey (extra treatment at Stoke Ferry WTW)	10.3	Yes	Yes
FND2	Reuse	Kings Lynn to Stoke Ferry via river Wissey (no extra treatment at Stoke Ferry WTW)	10.3	Yes	Yes
FND3	Reuse	Kings Lynn and West Walton to Stoke Ferry WTW via the River Wissey - with additional treatment at Stoke Ferry	17.4	Yes	Yes
FND4	Reuse	Kings Lynn and West Walton to Stoke Ferry WTW via the River Wissey - no additional treatment at Stoke Ferry	17.4	Yes	Yes
FND5	Desalination	Kings Lynn (brackish) 10 Ml/d	10	Yes	Yes
FND6	Desalination	Kings Lynn (brackish) 25 Ml/d	25	Yes	Yes
FND7	Desalination	Kings Lynn (brackish) - power supply from power station (10 Ml/d)	10	Yes	Yes
FND8	Desalination	Kings Lynn (brackish) - power supply from power station (25 Ml/d)	25	Yes	Yes
FND13	Backwash water recovery	Fenland surface WTW backwash water recovery	0.61	No	No
FND21	New Reservoir	Fens reservoir 42.3 Ml/d	43.5	Yes	Yes

7.4.2 Feasibility

Table 26 Fenland WRZ feasible option not progressed for modelling

Option type	Option ID	Option name	Feasible	Taken through to modelling	Reason for not modelling
FND13	Backwash water recovery	Backwash water recover, Fenland WTW	Yes	No	While technically feasible this option could introduce a water quality risk from cryptosporidium. Retrofit supernatant return on surface water treatment works is advised against on these grounds.

7.4.3 Additional considerations and risks

Table 27 Additional considerations and risks with options FND1, FND2, FND3 and FND4

Reuse type - Transfer to river, single or dual source, for re-abstraction. See Figure 13 and Figure 14.	
Consideration	Risk
Deployable Output Limitations	Dependant on flow from WRC Difficulty in demonstrating that water discharged at outfall is available at abstraction point as a result of environmental losses/other users.
Water Quality at source	Source water has high chloride levels Temperature of water from recycling process may be higher than receiving waterbody.
Quality at brine outfall discharge location	The discharge location for the brine outfall (River Ouse) has high levels of chloride. The reverse osmosis brine will increase the concentrations of phosphate, sodium and chloride in the plant waste effluent compared to current concentrations. Possible combined environmental impacts with other discharges. Discharges into The Wash may impact migrating fish and shellfish beds.

Table 28 Additional considerations and risks with options FND5, FND6, FND7 and FND8

Desalination type - Brackish desalination process. See Figure 8	
Consideration	Risk
Deployable Output Limitations	Land availability. Footprint may dictate plant size and therefore capacity.
Water Quality at source	Limited knowledge of water quality and variability. No examples of Desalination for water supply in North Sea so unknown expected levels of outage due to turbulence or storm events

Desalination type - Brackish desalination process. See Figure 8	
Consideration	**Risk**
Quality at brine outfall discharge location	Plume modelling required to assess impact. Difficulty in managing discharges due to tides. Possible combined environmental impacts with other discharges. Discharges into The Wash may impact migrating fish and shellfish beds.
Water quality at discharge to service reservoir	Remineralisation and blending ratios need to be understood

7.4.4 Transfer options

Table 29 Fenland Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
FND9	10	0.96	Ruthamford North	Fenland	51	409
FND10	5	0.40	Bradenham	Fenland	34	327
FND11	10	0.63	Bradenham	Fenland	34	409
FND12	20	1.36	Bradenham	Fenland	34	600
FND14	10	1.32	Cambs & West Suffolk	Fenland	56	458
FND15	20	2.26	Cambs & West Suffolk	Fenland	56	600
FND16	20	2.07	Ruthamford North	Fenland	51	600
FND17	50	5.08	Cambs & West Suffolk	Fenland	56	900
FND18	50	2.41	Bradenham	Fenland	34	800
FND20	100	3.77	Bradenham	Fenland	34	1000

7.5 Lincolnshire Bourne options

We only have one option for Lincolnshire Bourne WRZ which is a potable water transfer.

7.5.1 Transfer options

Table 30 Lincolnshire Bourne Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
LNB1	20	0.32	Ruthamford North	Bourne	14	458

7.6 Lincolnshire Central options

There are potential groundwater enhancement options in Lincolnshire Central WRZ that we have not fully developed for inclusion in this report. However, we have included them in the baseline forecast for the WRZ as they form part of the North Lincolnshire Alternative Solution. This is a set of investments developed to form an alternative to Middlegate WTW, Pyewipe reuse and associated transfers.

These options will be developed for WRMP if necessary.

7.6.1 Constrained options

Table 31 Lincolnshire Central Constrained options

Option ID	Option Type	Option name	Gain in WAFU	Feasible?	Taken through to modelling?
LNC1	Reuse	Canwick WRC to the Hall via River Trent (additional treatment at Hall WTW)	10.1	Yes	Yes
LNC2	Reuse	Canwick WRC to the Hall via River Trent (no additional treatment at Hall WTW)	10.1	Yes	Yes
LNC3	Desalination	South Humber bank desalination (seawater) collocated with Power Station (25 Ml/d)	25	Yes	Yes
LNC4	Desalination	South Humber bank desalination (seawater) collocated with Power Station (50 Ml/d)	50	Yes	Yes
LNC5	Desalination	South Humber bank desalination (seawater) 27 Ml/d	27	Yes	Yes
LNC6	Desalination	South Humber bank desalination (seawater) 50 Ml/d	50	Yes	Yes
LNC7	Desalination	Desalination (brackish) on Trent between Gainsborough and the Humber (10 Ml/d)	10	Yes	Yes

Option ID	Option Type	Option name	Gain in WAFU	Feasible?	Taken through to modelling?
LNC8	Desalination	Desalination (brackish) on Trent between Gainsborough and the Humber (25 Ml/d)	25	Yes	Yes
LNC10	Raw Water Reservoir	Extension /new reservoir at Hall - conjunctive with new treatment	7	Yes	Yes
LNC11	Conjunctive use	Staythorpe DTT with Hall WTW extension	7	Yes	Yes
LNC12	Conjunctive use	New Staythorpe WTW	20	Yes	Yes
LNC13	Conjunctive use	New Staythorpe WTW and Storage	20	Yes	Yes
LNC14	Aquifer Storage	Sherwood Sandstone ASR	7	Yes	Yes
LNC20	Desalination	South Humber bank desalination (seawater) collocated with SHB Power Station (10 Ml/d)	10	Yes	Yes
LNC21	Desalination	South Humber bank desalination (seawater) 10 Ml/d	10	Yes	Yes
LNC22	New surface water	Lincolnshire Central non-potable to potable treatment (10 Ml/d)	10	Yes	Yes
LNC23	New surface water	Lincolnshire Central non-potable to potable treatment (31 Ml/d)	31	Yes	Yes
LNC24	New surface water	Lincolnshire Central non-potable to potable treatment (50 Ml/d)	50	Yes	Yes
LNC26	Reuse	Combined Reuse ASR and reservoir	28.6	Yes	Yes
LNC27	Reuse	Combined Reuse ASR and conjunctive use	28.6	Yes	Yes
LNC28	Conjunctive use	Raw water conjunctive use	7	Yes	Yes

7.6.2 Additional considerations and risks

Table 32 Additional considerations and risks with options LNC3, LNC4, LNC5, LNC6, LNC20 and LNC21

Desalination type - Seawater desalination. See Figure 7	
Consideration	**Risk**
Deployable Output Limitations	Land availability. Footprint may dictate plant size and therefore capacity.
Water Quality at source	Limited knowledge of water quality and variability. No examples of Desalination for water supply in North Sea so unknown expected levels of outage due to turbulence or storm events. The salinity on the South Humber Bank requires a seawater desalination process the intake is likely to be highly influenced by the estuary.
Quality at brine outfall discharge location	Plume modelling required to assess impact. Difficulty in managing discharges due to tides. Possible combined environmental impacts with other discharges. Discharges into Humber Estuary may impact migrating fish.
Water quality at discharge to service reservoir	Remineralisation and blending ratios need to be understood

7.6.3 Transfer options

Table 33 Lincolnshire Central Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
LNC9	10	2.12	Lincolnshire East	Lincolnshire Central	52	600
LNC15	10	1.61	Ruthamford North	Lincolnshire Central	68	458
LNC16	20	2.76	Ruthamford North	Lincolnshire Central	68	600
LNC17	100	13.22	Lincolnshire East	Lincolnshire Central	52	1500
LNC18	20	3.76	Lincolnshire East	Lincolnshire Central	52	800
LNC19	100	9.29	Ruthamford North	Lincolnshire Central	68	1100
LNC25	29	0.00	Lincolnshire East	Lincolnshire Central		
LNC29	50	2.77	Lincolnshire East	Lincolnshire Central	39	800

7.7 Lincolnshire East options

7.7.1 Constrained options

Table 34 Lincolnshire East Constrained options

Option ID	Option Type	Option name	Gain in WAFU	Feasible?	Taken through to modelling?
LNE1	Reuse	Ingoldmells to Covenham via River Eau (with additional treatment at Covenham)	6.1	Yes	Yes
LNE2	Reuse	Ingoldmells to Covenham via Rive Eau (no additional treatment at Covenham)	6.1	Yes	Yes
LNE3	Backwash water recovery	Backwash water recovery, East Lincolnshire WTW	1.3	Yes	Yes
LNE4	Sea Tankering	Immingham Sea Tankering	20	Yes	No
LNE5	Desalination	Desalination at Mablethorpe - Onshore 25 Ml/d	25	Yes	Yes
LNE6	Desalination	Desalination at Mablethorpe - Onshore 50 Ml/d	50	Yes	Yes
LNE7	Desalination	Desalination at Mablethorpe - Onshore 100 Ml/d	100	Yes	Yes
LNE8	Desalination	Desalination at Mablethorpe - Offshore 25 Ml/d	25	Yes	No
LNE9	Desalination	Desalination at Mablethorpe - Offshore 50 Ml/d	50	Yes	No
LNE10	Desalination	Desalination at Mablethorpe - Offshore 100 Ml/d	100	Yes	No
LNE12	Increase surface water utilisation	Increase Lincolnshire East WTW utilisation	5	Yes	Yes

Table 35 Lincolnshire East feasible options not progressed for modelling

Option type	Option ID	Option name	Feasible	Taken through to modelling	Reason for not modelling
LNE4	Sea Tankering	Immingham Sea Tankering	Yes	No	Perceived INNS risk and insufficient information of water quality, also very low support for this option from customers.
LNE8	Desalination	Desalination at Mablethorpe - Offshore 25 Ml/d	Yes	No	No benefit over on-shore desalination but carries additional risk.

Option type	Option ID	Option name	Feasible	Taken through to modelling	Reason for not modelling
LNE9	Desalination	Desalination at Mablethorpe - Offshore 50 Ml/d	Yes	No	No benefit over on-shore desalination but carries additional risk.
LNE10	Desalination	Desalination at Mablethorpe - Offshore 100 Ml/d	Yes	No	No benefit over on-shore desalination but carries additional risk.

7.7.2 Additional considerations and risks

Table 36 Additional considerations and risks with options LNE1 and LNE2

Reuse type - Transfer to river for indirect re-abstraction. See Figure 11	
Consideration	**Risk**
Deployable Output Limitations	Dependant on flow from WRC Difficulty in demonstrating that water discharged at outfall is available at abstraction point as a result of environmental losses/other users.
Water Quality at source	Source water has high chloride levels Temperature of water from recycling process may be higher than receiving waterbody.
Quality at brine outfall discharge location	The reverse osmosis brine will increase the concentrations of phosphate, sodium and chloride in the plant waste effluent compared to current concentrations.

Table 37 Additional considerations and risks with options LNE5, LNE6 and LNE7

Desalination type - Seawater desalination process. See Figure 7	
Consideration	**Risk**
Deployable Output Limitations	Land availability. Footprint may dictate plant size and therefore capacity.
Water Quality at source	Limited knowledge of water quality a variability. No examples of Desalination for water supply in North Sea so unknown expected levels of outage due to turbulence or storm events
Quality at brine outfall discharge location	Plume modelling required to assess impact
Water quality at discharge to service reservoir	Remineralisation and blending ratios need to be understood

7.8 Lincolnshire Retford and Gainsborough

All of the constrained and feasible options in the Lincolnshire Retford and Gainsborough WRZ are potable transfers as described in the tables below.

7.8.1 Transfer options

Table 38 Lincolnshire Retford and Gainsborough Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
LNN1	3.5	0.12	Lincolnshire Central	Lincolnshire Retford and Gainsborough	20	229
LNN2	10	0.25	Lincolnshire Central	Lincolnshire Retford and Gainsborough	20	327

7.9 Norfolk Aylsham options

All of the constrained and feasible options in the Norfolk Aylsham WRZ are potable transfers as described in the tables below.

7.9.1 Transfer options

Table 39 Norfolk Aylsham Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
NAY1	3	0.13	Norwich and the Broads	Norfolk Aylsham	22	229
NAY2	10	0.20	Norfolk Happisburgh	Norfolk Aylsham	17	327
NAY3	10	0.33	Norwich and the Broads	Norfolk Aylsham	22	368

7.10 Norfolk Bradenham options

All of the constrained and feasible options in the Norfolk Bradenham WRZ are potable transfers as described in the tables below.

7.10.1 Transfer options

Table 40 Norfolk Bradenham Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
NBR1	5	0.32	Fenland	Norfolk Bradenham	34	290
NBR2	10	0.63	Fenland	Norfolk Bradenham	34	409

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
NBR3	20	1.36	Fenland	Norfolk Bradenham	34	600
NBR4	10	0.70	Norwich and the Broads	Norfolk Bradenham	37	409
NBR5	20	1.50	Norwich and the Broads	Norfolk Bradenham	37	600
NBR6	50	2.41	Fenland	Norfolk Bradenham	34	800
NBR7	50	2.67	Norwich and the Broads	Norfolk Bradenham	37	800
NBR8	100	4.60	Norwich and the Broads	Norfolk Bradenham	37	1050

7.11 Norfolk East Dereham options

All of the constrained and feasible options in the Norfolk East Dereham WRZ are potable transfers as described in the tables below.

7.11.1 Transfer options

Table 41 Norfolk East Dereham Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
NED1	5	0.06	Norfolk Bradenham	Norfolk East Dereham	9	229
NED2	10	0.09	Norfolk Bradenham	Norfolk East Dereham	9	290

7.12 Norfolk East Harling options

All of the constrained and feasible options in the Norfolk East Harling WRZ are potable transfers as described in the tables below.

7.12.1 Transfer options

Table 42 Norfolk East Harling Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
NEH1	5	0.22	Norfolk Harleston	Norfolk East Harling	23	290
NEH2	10	0.35	Norfolk Harleston	Norfolk East Harling	23	368
NEH3	5	0.14	Norfolk Thetford	Norfolk East Harling	19	256
NEH4	15	0.35	Norfolk Thetford	Norfolk East Harling	19	409
NEH5	10	0.22	Norfolk Thetford	Norfolk East Harling	19	327
NEH6	15	0.44	Norfolk Harleston	Norfolk East Harling	23	409

7.13 Norfolk Harleston options

All of the constrained and feasible options in the Norfolk Harleston WRZ are potable transfers as described in the tables below.

7.13.1 Transfer options

Table 43 Norfolk Harleston Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
NHL1	5	0.29	Norwich and the Broads	Norfolk Harleston	30	290
NHL2	10	0.46	Norwich and the Broads	Norfolk Harleston	30	368
NHL3	10	0.28	Norfolk East Harling	Norfolk Harleston	23	327
NHL4	5	0.17	Norfolk East Harling	Norfolk Harleston	23	256

7.14 North Norfolk Coast options

All of the constrained and feasible options in the North Norfolk Coast WRZ are potable transfers as described in the tables below.

7.14.1 Transfer options

Table 44 North Norfolk Coast Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
NNC1	10	0.39	Fenland	North Norfolk Coast	26	368
NNC2	10	0.41	Norfolk Bradenham	North Norfolk Coast	27	368
NNC3	10	0.18	Norfolk Aylsham	North Norfolk Coast	15	327
NNC4	10	0.32	Norfolk East Dereham	North Norfolk Coast	21	368

7.15 Norfolk and The Broads options

7.15.1 Constrained options

Table 45 Norfolk and The Broads Constrained options

Option ID	Option Type	Option name	Gain in WAFU	Feasible?	Taken through to modelling?
NTB1	Reuse	Water Reuse at Lowestoft WRC with outfall received on the River Wensum. With additional water treatment in Norwich	11.1	Yes	Yes
NTB2	Reuse	Water Reuse at Caister WRC with outfall received on the River Wensum. With additional water treatment in Norwich	16.4	Yes	Yes
NTB3	Desalination	Great Yarmouth desalination (seawater) 25 Ml/d	25	Yes	Yes
NTB4	Desalination	Great Yarmouth desalination (seawater) 50 Ml/d	50	Yes	Yes
NTB5	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Great Yarmouth (25 Ml/d)	25	Yes	No
NTB6	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Great Yarmouth (50 Ml/d)	50	Yes	No
NTB7	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Great Yarmouth (100 Ml/d)	100	Yes	No
NTB8	Backwash water recovery	Norwich and the Broads WTW backwash water recovery	0.05	Yes	No
NTB11	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Bacton (25 Ml/d)	25	Yes	No
NTB12	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Bacton (50 Ml/d)	50	Yes	No
NTB13	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Bacton (100 Ml/d)	100	Yes	No
NTB14	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Caister (25 Ml/d)	25	Yes	No
NTB15	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Caister (50 Ml/d)	50	Yes	No

Option ID	Option Type	Option name	Gain in WAFU	Feasible?	Taken through to modelling?
NTB16	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Caister (100 Ml/d)	100	Yes	No
NTB17	Desalination	Bacton desalination (seawater) 25 Ml/d	25	Yes	Yes
NTB18	Desalination	Bacton desalination (seawater) 50 Ml/d	50	Yes	Yes
NTB19	Desalination	Bacton desalination (seawater) 100 Ml/d	100	Yes	Yes
NTB20	Desalination	Desalination (seawater) plant in the Caister area (25 Ml/d)	25	Yes	Yes
NTB21	Desalination	Desalination (seawater) plant in the Caister area (50 Ml/d)	50	Yes	Yes
NTB22	Desalination	Desalination (seawater) plant in the Caister area (100 Ml/d)	100	Yes	Yes
NTB23	Sea Tankering	Great Yarmouth Sea Tankering	20	Yes	No
NTB27	Reuse	Combined Lowestoft WRC reuse and Caster WRC reuse combined. Additional water treatment in Norwich	27.5	Yes	Yes
NTB28	reuse	Combined Lowestoft WRC reuse and Caster WRC reuse combined. Additional water treatment in Norwich	27.5	Yes	Yes

Table 46 Norfolk and The Broads feasible options not progressed for modelling

Option type	Option ID	Option name	Feasible	Taken through to modelling	Reason for not modelling
NTB5	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Great Yarmouth (25 Ml/d)	Yes	No	No benefit over on-shore desalination but carries additional risk.
NTB6	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Great Yarmouth (50 Ml/d)	Yes	No	No benefit over on-shore desalination but carries additional risk.
NTB7	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Great Yarmouth (100 Ml/d)	Yes	No	No benefit over on-shore desalination but carries additional risk.

Option type	Option ID	Option name	Feasible	Taken through to modelling	Reason for not modelling
NTB8	Backwash water recovery	Norwich and the Broads WTW backwash water recovery	Yes	No	Technically feasible but membrane (the current installed treatment) supplier raised concerns which may compromise warranty. Supernatant already in place for membrane plant therefore WAFU is uncertain.
NTB11	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Bacton (25 Ml/d)	Yes	No	No benefit over on-shore desalination but carries additional risk.
NTB12	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Bacton (50 Ml/d)	Yes	No	No benefit over on-shore desalination but carries additional risk.
NTB13	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Bacton (100 Ml/d)	Yes	No	No benefit over on-shore desalination but carries additional risk.
NTB14	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Caister (25 Ml/d)	Yes	No	No benefit over on-shore desalination but carries additional risk.
NTB15	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Caister (50 Ml/d)	Yes	No	No benefit over on-shore desalination but carries additional risk.
NTB16	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Caister (100 Ml/d)	Yes	No	No benefit over on-shore desalination but carries additional risk.
NTB23	Sea Tankering	Great Yarmouth Sea Tankering	Yes	No	Perceived INNS risk and insufficient information of water quality, also very low support for this option from customers.

7.15.2 Additional considerations and risks

Table 47 Additional considerations and risks with options NTB3, NTB4, NTB17, NTB18, NTB19, NTB20 NTB21 and NTB22

Desalination type - Seawater desalination process. See Figure 7	
Consideration	Risk
Deployable Output Limitations	Land availability. Footprint may dictate plant size and therefore capacity.
Water Quality at source	Limited knowledge of water quality a variability. No examples of Desalination for water supply in North Sea so unknown expected levels of outage due to turbulence or storm events
Quality at brine outfall discharge location	Plume modelling required to assess impact
Water quality at discharge to service reservoir	Remineralisation and blending ratios need to be understood

Table 48 Additional considerations and risks with options NTB1, NTB2, NTB27 and NTB28

Reuse type - Transfer to river, single or dual source, for re-abstraction. See Figure 13 and Figure 14	
Consideration	Risk
Deployable Output Limitations	Dependant on flow from WRC Difficulty in demonstrating that water discharged at outfall is available at abstraction point as a result of environmental losses/other users.
Water Quality at source	Source water has high chloride levels Temperature of water from recycling process may be higher than receiving waterbody.
Quality at brine outfall discharge location	The discharge location for the brine outfall (River Yare) has high levels of chloride. The reverse osmosis brine will increase the concentrations of phosphate, sodium and chloride in the plant waste effluent compared to current concentrations. Possible combined environmental impacts with other discharges. Discharges into The Wash may impact migrating fish and shellfish beds.

7.15.3 Transfer options

Table 49 Norfolk and The Broads Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
NTB9	10	0.88	Norfolk Bradenham	Norwich and the Broads	37	458
NTB10	20	1.50	Norfolk Bradenham	Norwich and the Broads	37	600
NTB24	5	0.29	Norfolk Harleston	Norwich and the Broads	30	290
NTB25	10	0.46	Norfolk Harleston	Norwich and the Broads	30	368
NTB26	50	3.38	Norfolk Bradenham	Norwich and the Broads	37	900

7.16 Norfolk Wymondham options

7.16.1 Transfer options

Table 50 Norfolk Wymondham Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
NWY1	5	0.07	Norwich and the Broads	Norfolk Wymondham	12	229
NWY2	15	0.19	Norwich and the Broads	Norfolk Wymondham	12	368

7.17 Ruthamford Central options

7.17.1 Transfer options

Table 51 Ruthamford Central Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
RTC1	70	1.86	Ruthamford West	Ruthamford Central	26	800
RTC2	12	0.43	Ruthamford South	Ruthamford Central	23	409
RTC3	20	0.64	Ruthamford South	Ruthamford Central	23	500
RTC4	10	0.49	Ruthamford West	Ruthamford Central	26	409
RTC5	20	0.73	Ruthamford West	Ruthamford Central	26	500

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
RTC6	50	0.87	Ruthamford West	Ruthamford Central	16	700

7.18 Ruthamford North options

7.18.1 Constrained options

Table 52 Ruthamford North Constrained options

Option ID	Option Type	Option name	Gain in WAFU	Feasible?	Taken through to modelling?
RTN1	Reuse	Peterborough Flag Fen to direct to Rutland Water / Wing WTW - with extra treatment at Wing WTW	7.4	Yes	Yes
RTN2	Reuse	Peterborough Flag Fen to direct to Rutland Water / Wing WTW - No treatment at Wing WTW	7.7	Yes	Yes
RTN3	Reuse	Peterborough Flag Fen to Rutland / Wing via River Nene (with additional treatment at Wing WTW)	7.7	Yes	Yes
RTN4	Reuse	Peterborough Flag Fen to Rutland / Wing via River Nene (without additional treatment)	7.7	Yes	Yes
RTN5	Desalination	Boston Area (brackish) desalination (10 Ml/d)	10	Yes	Yes
RTN6	Desalination	Boston Area (brackish) desalination (25 Ml/d)	25	Yes	Yes
RTN7	Conjunctive use	Little Barford Declined T&T transfer to Rutland	10	Yes	Yes
RTN17	Reservoir	South Lincolnshire reservoir	166.5	Yes	Yes

7.18.2 Additional considerations and risks

Table 53 Additional considerations and risks with options RTN1, RTN2, RTN3 and RTN4

Reuse type - Transfer to river for indirect re-abstraction. See Figure 11	
Consideration	Risk
Deployable Output Limitations	Dependant on flow from WRC Difficulty in demonstrating that water discharged at outfall is available at abstraction point as a result of environmental losses/other users.

Reuse type - Transfer to river for indirect re-abstraction. See Figure 11	
Consideration	**Risk**
Water Quality at source	Source water has high chloride levels Temperature of water from recycling process may be higher than receiving waterbody.
Quality at brine outfall discharge location	The discharge location for the brine outfall (River Nene) has high levels of chloride. The reverse osmosis brine will increase the concentrations of phosphate, sodium and chloride in the plant waste effluent compared to current concentrations.

Table 54 Additional considerations and risks with options RTN5 and RTN6

Desalination type - Brackish desalination process. See Figure 8	
Consideration	**Risk**
Deployable Output Limitations	Land availability. Footprint may dictate plant size and therefore capacity.
Water Quality at source	Limited knowledge of water quality and variability.
Quality at brine outfall discharge location	Plume modelling required to assess impact. Difficulty in managing discharges due to tides. Possible combined environmental impacts with other discharges. Discharges into The Wash may impact migrating fish and shellfish beds.
Water quality at discharge to service reservoir	Remineralisation and blending ratios need to be understood

7.18.3 Transfer options

Table 55 Ruthamford North Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
RTN8	10	1.28	West Lincolnshire	Ruthamford North	68	409
RTN9	10	0.96	Fenland	Ruthamford North	51	409
RTN10	10	0.15	Ruthamford North	Ruthamford North	13	327
RTN11	20	2.76	Lincolnshire Central	Ruthamford North	68	600
RTN12	50	0.70	Lincolnshire Central	Ruthamford North	13	700

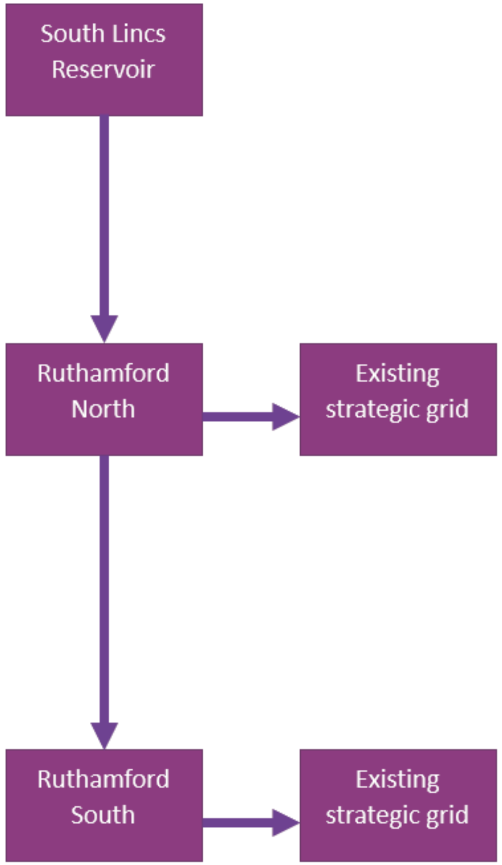
Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
RTN13	100	0.01	Ruthamford North	Ruthamford North	13	100
RTN14	150	2.07	Ruthamford North	Ruthamford North	13	1200
RTN15	20	2.82	Fenland	Ruthamford North	51	700
RTN16	100	9.29	Lincolnshire Central	Ruthamford North	68	1100
RTN21	19.9	22.83	Trent	Ruthamford North	56	1900
RTN22	100	9.73	Fenland	Ruthamford North	51	1300
RTN23	50	2.32	Ruthamford South	Ruthamford North	32	800
RTN24	100	3.62	Ruthamford South	Ruthamford North	32	1000
RTN25	20	0.37	Bourne	Ruthamford North	14	494

Figure 20 Ruthamford North option interactions

Option ID	Option name	Max capacity (Ml/d)
RTN17	Ruthamford North to Ruthamford North potable transfer (10 Ml/d)	166

Option ID	Option name	Max capacity (Ml/d)
RTN10	Ruthamford North to Ruthamford North potable transfer (10 Ml/d)	10
RTN12	Ruthamford North to Ruthamford North potable transfer (50 Ml/d)	50
RTN13	Ruthamford North to Ruthamford North potable transfer (100 Ml/d)	100
RTN14	Ruthamford North to Ruthamford North potable transfer (150 Ml/d)	150

Option ID	Option name	Max capacity (Ml/d)
RTS1	Ruthamford North to Ruthamford South potable transfer (10 Ml/d)	10
RTS11	Ruthamford North to Ruthamford South potable transfer (50 Ml/d)	50
RTS12	Ruthamford North to Ruthamford South potable transfer (100 Ml/d)	100
RTS13	Ruthamford North to Ruthamford South potable transfer (150 Ml/d)	150



Options RTN10, RTN12, RTN13 and RTN14 are intra-resource zone transfers. Figure 20 shows how these options interact with related options. These interactions are also shown on the map in Figure 21. This illustrated that, while RTN17 (SLR) isn't geographically in Ruthamford South, the benefit is to this WRZ and therefore we have modelled this way, along with the dependent downstream transfers. The map also shows how this set of options provide future support to the options described in Section 7.1.3. above.

Figure 21 Ruthamford North interactions

7.19 Ruthamford South options

7.19.1 Constrained options

Table 56 Ruthamford South Constrained options

Option ID	Option Type	Option name	Gain in WAFU	Feasible?	Taken through to modelling?
RTS7	Conjunctive use	New Little Barford WTW	5	Yes	Yes
RTS8	Backwash water recovery	Backwash water recover, Ruthamford South WTW	10.3	Yes	Yes
RTS9	Conjunctive use	Little Barford Declined T&T	20	Yes	Yes
RTS16	Drought permit	Ruthamford south drought permit	15	Yes	Yes
RTS21	Surface water	Restore WAFU of RTS surface WTW	7.8	Yes	Yes
RTS22	Surface water	Increase WAFU of RTS surface WTW	9.4	Yes	Yes

7.19.2 Transfer options

Table 57 Ruthamford South Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
RTS1	10	0.48	Ruthamford North	Ruthamford South	32	368
RTS2	10	1.73	Ruthamford North	Ruthamford South	43	600
RTS3	70	0.43	Ruthamford Central	Ruthamford South	23	409
RTS4	50	3.15	Ruthamford North	Ruthamford South	44	800
RTS5	100	5.42	Ruthamford North	Ruthamford South	44	1050
RTS6	200	9.64	Ruthamford North	Ruthamford South	44	1400
RTS10	10	0.60	Cambridge Water	Ruthamford South	39	368
RTS11	50	1.74	Ruthamford North	Ruthamford South	32	700
RTS12	100	3.55	Ruthamford North	Ruthamford South	32	1000

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
RTS13	150	5.11	Ruthamford North	Ruthamford South	32	1200
RTS14	20	1.10	Cambridge Water	Ruthamford South	39	500
RTS15	50	2.82	Cambridge Water	Ruthamford South	39	800
RTS19	50	2.32	Ruthamford North	Ruthamford South	32	800
RTS20	100	3.99	Ruthamford North	Ruthamford South	32	1050

7.20 Ruthamford West options

7.20.1 Constrained options

Table 58 Ruthamford West Constrained options

Option ID	Option Type	Option name	Gain in WAFU	Feasible?	Taken through to modelling?
RTW3	Reservoir	Foxcote/Fosscott Reservoir	9.3	Yes	Yes

Table 59 Additional considerations and risks with option RTW3

Consideration	Risk
Deployable Output Limitations	Licence unused since 1996 Reservoir
Water Quality at source	Original treatment works was decommissioned because of water quality challenges. Considerable investigation needed to develop treatment solution so the scoped and costed option may not be accurate.
Environmental	Site is a SSSI Stipulations on maintaining a level to protect habitat and minimum flows to a fishery may reduce drought resilience for this option.

7.20.2 Transfer options

Table 60 Ruthamford West Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
RTW1	10	0.66	Ruthamford North	Ruthamford West	35	409
RTW2	70	3.20	Ruthamford North	Ruthamford West	35	900
RTW4	20	0.99	Ruthamford North	Ruthamford West	35	500
RTW5	50	1.13	Ruthamford Central	Ruthamford West	16	800
RTW6	100	1.77	Ruthamford Central	Ruthamford West	16	1000

7.21 South Humber Bank options

7.21.1 Constrained options

Table 61 South Humber Bank Constrained options

Option ID	Option Type	Option name	Gain in WAFU	Feasible?	Taken through to modelling?
SHB1	Reuse	Pywipe WRC (non potable) (6 Ml/d)	6	Yes	Yes
SHB2	Reuse	Pywipe WRC (non potable- 14 Ml/d))	14	Yes	Yes
SHB3	Reuse	Pywipe WRC (non potable) 20 Ml/d))	20	Yes	Yes
SHB6	Desalination	Desalination (seawater) on the South Humber Bank feeding the non-potable network (10 Ml/d)	10	Yes	Yes
SHB7	Desalination	Desalination (seawater) on the South Humber Bank feeding the non-potable network (25 Ml/d)	25	Yes	Yes

7.21.2 Additional considerations and risks

Table 62 Additional considerations and risks with options SHB1, SHB2 and SHB3

Reuse type - Direct reuse for non-potable supply. See Figure 15	
Consideration	**Risk**
Deployable Output Limitations	Dependant on flow from WRC
Water Quality at source	Source water has high chloride levels Temperature of water from recycling process may present an issue to some non-potable users. Complex issues around providing reverse osmosis treated water to some non-potable consumers.
Quality at brine outfall discharge location	The discharge location for the brine outfall (Humber Estuary) has high levels of chloride. The reverse osmosis brine will increase the concentrations of phosphate, sodium and chloride in the plant waste effluent compared to current concentrations. Possible combined environmental impacts with other discharges. Discharges into The Wash may impact migrating fish and lamprey

Table 63 Additional considerations and risks with options SHB6 and SHB7

Desalination type - Seawater desalination. See Figure 7	
Consideration	**Risk**
Deployable Output Limitations	Land availability. Footprint may dictate plant size and therefore capacity.
Water Quality at source	Limited knowledge of water quality and variability. No examples of Desalination for water supply in North Sea so unknown expected levels of outage due to turbulence or storm events. The salinity on the South Humber Bank requires a seawater desalination process the intake is likely to be highly influenced by the estuary.
Quality at brine outfall discharge location	Plume modelling required to assess impact. Difficulty in managing discharges due to tides. Possible combined environmental impacts with other discharges. Discharges into Humber Estuary may impact migrating fish.
Water quality at discharge to service reservoir	Remineralisation and blending ratios need to be understood

7.22 Suffolk Sudbury options

7.22.1 Transfer options

Table 64 Suffolk Sudbury Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
SUS1	7	0.14	Cambs and West Suffolk	Suffolk Sudbury	12	327
SUS2	10	0.35	Cambs and West Suffolk	Suffolk Sudbury	19	409

7.23 Suffolk East options

7.23.1 Constrained options

Table 65 Suffolk East Constrained options

Option ID	Option Type	Option name	Gain in WAFU	Feasible?	Taken through to modelling?
SUE1	Reuse	Ipswich Cliff Quay direct to Alton Reservoir (with additional abstraction and treatment at Alton)	14.5	Yes	Yes
SUE2	Reuse	Ipswich Cliff Quay direct to Alton Reservoir (with no additional and abstraction treatment at Alton)	11.5	Yes	Yes
SUE3	Reuse	Ipswich Cliff Quay to Alton via River Gipping (with additional treatment at Alton)	11.5	Yes	Yes
SUE4	Reuse	Ipswich Cliff Quay to Alton via River Gipping (no additional abstraction or treatment at Alton)	11.5	Yes	Yes
SUE5	Desalination	Felixstowe desalination (seawater) 25 Ml/d	25	Yes	Yes
SUE6	Desalination	Felixstowe desalination (seawater) 50 Ml/d	50	Yes	Yes
SUE7	Desalination	Felixstowe desalination (seawater) 100 Ml/d	100	Yes	Yes
SUE8	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Felixstowe (25 Ml/d)	25	Yes	No
SUE9	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Felixstowe (50 Ml/d)	50	Yes	No

Option ID	Option Type	Option name	Gain in WAFU	Feasible?	Taken through to modelling?
SUE10	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Felixstowe (100 Ml/d)	100	Yes	No
SUE11	Desalination	Orwell Estuary desalination (25 Ml/d)	25	Yes	Yes
SUE12	Desalination	Orwell Estuary desalination (50 Ml/d)	50	No	No
SUE14	Desalination	Sizewell desalination (seawater) 25 Ml/d	25	Yes	Yes
SUE15	Desalination	Sizewell desalination (seawater) 50 Ml/d	50	Yes	Yes
SUE16	Desalination	Sizewell desalination (seawater) 100 Ml/d	100	Yes	Yes
SUE17	ASR	Bucklesham ASR	2.3	Yes	Yes
SUE23	Groundwater	Suffolk East Groundwater	1.7	Yes	Yes

Table 66 Suffolk East feasible options not progressed for modelling

Option type	Option ID	Option name	Feasible	Taken through to modelling	Reason for not modelling
SUE8	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Felixstowe (25 Ml/d)	Yes	No	No benefit over on-shore desalination but carries additional risk.
SUE9	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Felixstowe (50 Ml/d)	Yes	No	No benefit over on-shore desalination but carries additional risk.
SUE10	Desalination	Desalination barge moored offshore with a pipeline coming onshore at Felixstowe (100 Ml/d)	Yes	No	No benefit over on-shore desalination but carries additional risk.
SUE12	Desalination	Orwell Estuary desalination (50 Ml/d)	No	No	Salinity of the estuary makes the 50 Ml/d alternative of this option unfeasible due to volume of brine discharge

7.23.2 Additional consideration and risks

Table 67 Additional considerations and risks with options SUE3 and SUE4

Reuse type - Transfer to river for indirect re-abstraction. See Figure 11	
Consideration	**Risk**
Deployable Output Limitations	Dependant on flow from WRC Difficulty in demonstrating that water discharged at outfall is available at abstraction point as a result of environmental losses/other users.
Water Quality at source	Source water has high chloride levels Temperature of water from recycling process may be higher than receiving waterbody.
Quality at brine outfall discharge location	The discharge location for the brine outfall has high levels of chloride. The reverse osmosis brine will increase the concentrations of phosphate, sodium and chloride in the plant waste effluent compared to current concentrations.

Table 68 Additional considerations and risks with options SUE1 and SUE2

Reuse type - Transfer to reservoir for abstraction. See Figure 12	
Consideration	**Risk**
Deployable Output Limitations	Dependant on flow from WRC
Water Quality at source	Source water has high chloride levels
Quality at brine outfall discharge location	The discharge location for the brine outfall has high levels of chloride. The reverse osmosis brine will increase the concentrations of phosphate, sodium and chloride in the plant waste effluent compared to current concentrations.
Water quality at discharge to reservoir	Quality of water from reverse osmosis process with be different to the receiving body. Temperature of water from recycling process may be higher than receiving waterbody.

Table 69 Additional considerations and risks with options SUE5, SUE6 and SUE7

Desalination type - Seawater desalination process. See Figure 7	
Consideration	**Risk**
Deployable Output Limitations	Land availability. Footprint may dictate plant size and therefore capacity.

Desalination type - Seawater desalination process. See Figure 7	
Consideration	Risk
Water Quality at source	Limited knowledge of water quality a variability. No examples of Desalination for water supply in North Sea so unknown expected levels of outage due to turbulence or storm events
Quality at brine outfall discharge location	Plume modelling required to assess impact
Water quality at discharge to service reservoir	Remineralisation and blending ratios need to be understood.

7.23.3 Transfer options

Table 70 Suffolk East Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
SUE13	10	0.80	Cambs & West Suffolk	East Suffolk	52	368
SUE18	10	0.32	South Essex	East Suffolk	26	327
SUE19	10	0.08	Essex and Suffolk Water	East Suffolk	8	290
SUE20	50	2.88	Cambs & West Suffolk	East Suffolk	52	700
SUE21	50	1.45	South Essex	East Suffolk	26	700
SUE24	10	0.44	Cambs & West Suffolk	East Suffolk	6	352

7.24 Suffolk Thetford options

7.24.1 Transfer options

Table 71 Suffolk Thetford Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
SUT1	5	0.22	Norfolk East Harling	Norfolk Thetford	19	327
SUT2	15	0.52	Norfolk East Harling	Norfolk Thetford	19	500
SUT3	10	0.44	Norfolk East Harling	Norfolk Thetford	19	458
SUT4	5	0.51	Norfolk Bradenham	Norfolk Thetford	33	368

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
SUT5	15	1.35	Norfolk Bradenham	Norfolk Thetford	33	600

7.25 Suffolk West and Cambridgeshire options

7.25.1 Constrained options

Table 72 Suffolk West and Cambridgeshire Constrained options

Option ID	Option Type	Option name	Gain in WAFU	Feasible?	Taken through to modelling?
SWC9	Groundwater	Suffolk & West Cambs groundwater	2.6	Yes	Yes

7.25.2 Transfer options

Table 73 Suffolk West and Cambridgeshire Transfer options

Option ID	Max Capacity	Min Capacity	From (WRZ)	To (WRZ)	Length (km)	Diameter (mm)
SWC1	10	0.74	Cambridge Water	Cambs & West Suffolk	31	458
SWC2	10	2.26	Fenland	Cambs & West Suffolk	56	600
SWC3	10	0.80	East Suffolk	Cambs & West Suffolk	52	368
SWC4	20	3.08	Fenland	Cambs & West Suffolk	56	700
SWC5	50	6.28	Fenland	Cambs & West Suffolk	56	1000
SWC6	50	2.88	East Suffolk	Cambs & West Suffolk	52	700
SWC7	20	1.26	Cambridge Water	Cambs & West Suffolk	31	600
SWC8	50	2.25	Cambridge Water	Cambs & West Suffolk	31	800
SWC10	10	0.35	Cambs & West Suffolk	Cambs & West Suffolk	15	458
SWC11	10	0.23	Cambs & West Suffolk	Cambs & West Suffolk	15	368
SWC12	10	0.13	Central Essex	Cambs & West Suffolk	11	327

8 Appendix A: Rejection register

Table 74 Rejection register

Option ID	Option Name	Option type	WRZ	Rejection reason
EXC4	Essex Central to Essex Central potable transfer (10 Ml/d)	Internal potable transfer	AWSEXC	Intra WRZ transfer. Doesn't solve planning problem.
EXC6	Cambs & West Suffolk to Essex Central potable transfer (10 Ml/d)	Internal potable transfer	AWSEXC	Not a preferred route. Superseded by EXC15
EXC13	Essex Central to Essex Central potable transfer (10 Ml/d)	Internal potable transfer	AWSEXC	Intra WRZ transfer. Doesn't solve planning problem.
EXC14	Essex Central to Essex Central potable transfer (10 Ml/d)	Internal potable transfer	AWSEXC	Intra WRZ transfer. Doesn't solve planning problem.
EXC16	Essex Central to Essex Central potable transfer (10 Ml/d)	Internal potable transfer	AWSEXC	Intra WRZ transfer. Doesn't solve planning problem.
EXS1	Colchester WRC direct to Ardleigh Reservoir (with additional treatment)	Water reuse	AWSEXS	No benefit to additional WTW capacity
EXS5	Colchester to Ardleigh Reservoir via the River Colne (with additional treatment)	Water reuse	AWSEXS	No benefit to additional WTW capacity
EXS8	Harwich Sea Tankering	International import	AWSEXS	Perceived INNS risk and insufficient information of water quality, also very low support for this option from customers.
EXS13	Holland on Sea floating desalination (seawater) 25 Ml/d	Desalination	AWSEXS	No benefit over on-shore desalination but carries additional risk.
EXS14	Holland on Sea floating desalination (seawater) 50 Ml/d	Desalination	AWSEXS	No benefit over on-shore desalination but carries additional risk.
EXS15	Holland on Sea floating desalination (seawater) 100 Ml/d	Desalination	AWSEXS	No benefit over on-shore desalination but carries additional risk.
FND2	Kings Lynn to Stoke Ferry via river Wissey (no extra treatment at Stoke Ferry WTW)	Water reuse	AWSFND	Concerns over brine discharges into The Wash. No benefit without additional WTW capacity.

Option ID	Option Name	Option type	WRZ	Rejection reason
FND4	Kings Lynn and West Walton to Stoke Ferry WTW via the River Wissey - no additional treatment at Stoke Ferry	Water reuse	AWSFND	Concerns over brine discharges into The Wash. No benefit without additional WTW capacity.
FND13	Backwash water recovery, Fenland WTW	Water treatment works loss recovery	AWSFND	Water Quality. Cryptosporidium risk from returning concentrates back to works inlet
LNC1	Canwick WRC to the Hall via River Trent (additional treatment at Hall WTW)	Water reuse	AWSLNC	Loss off effluent discharge to Witham would require compensation transfer from Trent. No overall WAFU benefit to WRZ
LNC2	Canwick WRC to the Hall via River Trent (no additional treatment at Hall WTW)	Water reuse	AWSLNC	Loss off effluent discharge to Witham would require compensation transfer from Trent. No overall WAFU benefit to WRZ
LNC12	New Staythorpe WTW	Conjunctive use	AWSLNC	No benefit to treatment at this location.
LNC13	New Staythorpe WTW and Storage	Conjunctive use	AWSLNC	No benefit to treatment at this location.
LNE2	Ingoldmells to Covenham via Rive Eau (no additional treatment at Covenham)	Water reuse	AWSLNE	No benefit without additional treatment capacity at WTW
LNE4	Immingham Sea Tankering	International import	AWSLNE	Perceived INNS risk and insufficient information of water quality, also very low support for this option from customers.
LNE8	Desalination barge moored offshore with a pipeline coming onshore at Mablethorpe (25 Ml/d)	Desalination	AWSLNE	No benefit over on-shore desalination but carries additional risk.
LNE9	Desalination barge moored offshore with a pipeline coming onshore at Mablethorpe (50 Ml/d)	Desalination	AWSLNE	No benefit over on-shore desalination but carries additional risk.
LNE10	Desalination barge moored offshore with a pipeline coming onshore at Mablethorpe (100 Ml/d)	Desalination	AWSLNE	No benefit over on-shore desalination but carries additional risk.
NBR4	Norwich and the Broads to Norfolk Bradenham potable transfer (10 Ml/d)	Internal potable transfer	AWSNBR	No resource available

Option ID	Option Name	Option type	WRZ	Rejection reason
NBR5	Norwich and the Broads to Norfolk Bradenham potable transfer (20 Ml/d)	Internal potable transfer	AWSNBR	No resource available
NNC2	Norfolk Bradenham to North Norfolk Coast potable transfer (10)	Internal potable transfer	AWSNNC	No resource available
NTB2	Water Reuse at Caister Pump Lane WRC with outfall received on the River Wensum. With water treatment extension at Heigham WTW	Water reuse	AWSNTB	No space for additional treatment capacity needed at WTW
NTB5	Desalination barge moored offshore with a pipeline coming onshore at Great Yarmouth (25 Ml/d)	Desalination	AWSNTB	No benefit over on-shore desalination but carries additional risk.
NTB6	Desalination barge moored offshore with a pipeline coming onshore at Great Yarmouth (50 Ml/d)	Desalination	AWSNTB	No benefit over on-shore desalination but carries additional risk.
NTB7	Desalination barge moored offshore with a pipeline coming onshore at Great Yarmouth (100 Ml/d)	Desalination	AWSNTB	No benefit over on-shore desalination but carries additional risk.
NTB8	Backwash water recovery, Norwich WTW	Water treatment works loss recovery	AWSNTB	Supernatant recovery from membrane filtration plant already in place. Membrane supplier recommends against returning GAC backwash water due to risk of carbon fines damaging or blocking membrane pores.
NTB11	Desalination barge moored offshore with a pipeline coming onshore at Bacton (25 Ml/d)	Desalination	AWSNTB	No benefit over on-shore desalination but carries additional risk.
NTB12	Desalination barge moored offshore with a pipeline coming onshore at Bacton (50 Ml/d)	Desalination	AWSNTB	No benefit over on-shore desalination but carries additional risk.
NTB13	Desalination barge moored offshore with a pipeline coming onshore at Bacton (100 Ml/d)	Desalination	AWSNTB	No benefit over on-shore desalination but carries additional risk.

Option ID	Option Name	Option type	WRZ	Rejection reason
NTB14	Desalination barge moored offshore with a pipeline coming onshore at Caister (25 Ml/d)	Desalination	AWSNTB	No benefit over on-shore desalination but carries additional risk.
NTB15	Desalination barge moored offshore with a pipeline coming onshore at Caister (50 Ml/d)	Desalination	AWSNTB	No benefit over on-shore desalination but carries additional risk.
NTB16	Desalination barge moored offshore with a pipeline coming onshore at Caister (100 Ml/d)	Desalination	AWSNTB	No benefit over on-shore desalination but carries additional risk.
NTB23	Great Yarmouth Sea Tankering	International import	AWSNTB	Perceived INNS risk and insufficient information of water quality, also very low support for this option from customers.
RTC6	Ruthamford West to Ruthamford Central potable transfer (50 Ml/d)	Internal potable transfer	AWSRTC	Insufficient resource, doesn't solve planning problem
RTN2	Peterborough Flag Fen to direct to Rutland Water / Wing WTW - No treatment at Wing WTW	Water reuse	AWSRTN	No benefit without additional treatment capacity at WTW
RTN3	Peterborough Flag Fen to Rutland / Wing via River Nene (with additional treatment at Wing WTW)	Water reuse	AWSRTN	Insufficient WAFU
RTN4	Peterborough Flag Fen to Rutland / Wing via River Nene (without additional treatment)	Water reuse	AWSRTN	No benefit without additional treatment capacity at WTW
RTN5	Boston Area (brackish) desalination (10 Ml/d)	Desalination	AWSRTN	Concerns over ecological impacts of brine discharges into The Wash.
RTN6	Boston Area (brackish) desalination (25 Ml/d)	Desalination	AWSRTN	Concerns over ecological impacts of brine discharges into The Wash.
RTN7	Little Barford Declined T&T transfer to Rutland	Conjunctive use	AWSRTN	Insufficient WAFU
RTS2	Ruthamford North to Ruthamford South potable transfer (10 Ml/d)	Internal potable transfer	AWSRTS	Not preferred route for this transfer. RTS1 developed instead.

Option ID	Option Name	Option type	WRZ	Rejection reason
RTS3	Ruthamford Central to Ruthamford South potable transfer (70 Ml/d)	Internal potable transfer	AWSRTS	No resource available
RTS8	Backwash water recovery, Ruthamford South WTW	Water treatment works loss recovery	AWSRTS	Water Quality. Cryptosporidium risk from returning concentrates back to works inlet
RTS9	Little Barford Declined T&T	Conjunctive use	AWSRTS	Insufficient WAFU
RTS18	Ruthamford West to Ruthamford Central potable transfer (100 Ml/d)	Internal potable transfer	AWSRTS	Option created but adds no value over alternative preferred options
RTS19	Ruthamford North to Ruthamford South potable transfer (50 Ml/d)	Internal potable transfer	AWSRTS	Option created but adds no value over alternative preferred options
RTS20	Ruthamford North to Ruthamford South potable transfer (100 Ml/d)	Internal potable transfer	AWSRTS	Option created but adds no value over alternative preferred options
RTW5	Ruthamford Central to Ruthamford West potable transfer (50 Ml/d)	Internal potable transfer	AWSRTW	No resource. Doesn't solve planning problem.
RTW6	Ruthamford Central to Ruthamford West potable transfer (100 Ml/d)	Internal potable transfer	AWSRTW	No resource. Doesn't solve planning problem.
SUE2	Ipswich Cliff Quay direct to Alton Reservoir (with no additional and abstraction treatment at Alton)	Water reuse	AWSSUE	No benefit without additional treatment capacity at WTW
SUE4	Ipswich Cliff Quay to Alton via River Gipping (no additional abstraction or treatment at Alton)	Water reuse	AWSSUE	Insufficient WAFU available
SUE8	Desalination barge moored offshore with a pipeline coming onshore at Felixstowe (25 Ml/d)	Desalination	AWSSUE	No benefit over on-shore desalination but carries additional risk.
SUE9	Desalination barge moored offshore with a pipeline coming onshore at Felixstowe (50 Ml/d)	Desalination	AWSSUE	No benefit over on-shore desalination but carries additional risk.
SUE10	Desalination barge moored offshore with a pipeline coming onshore at Felixstowe (100 Ml/d)	Desalination	AWSSUE	No benefit over on-shore desalination but carries additional risk.

Option ID	Option Name	Option type	WRZ	Rejection reason
SUE11	Orwell Estuary desalination (25 Ml/d)	Desalination	AWSSUE	Options with discharges into estuaries rejected over concerns around impact of brine on ecology
SUE12	Orwell Estuary desalination (50 Ml/d)	Desalination	AWSSUE	Options with discharges into estuaries rejected over concerns around impact of brine on ecology
SUS1	Cambs and West Suffolk to Suffolk Sudbury (7 Ml/d)	Internal potable transfer	AWSSUS	No deficit
SUS2	Cambs and West Suffolk to Suffolk Sudbury (10 Ml/d)	Internal potable transfer	AWSSUS	No deficit
SWC10	Cambs and West Suffolk to Cambs and West Suffolk potable transfer (10 Ml/d)	Internal potable transfer	AWSSWC	Option created but adds no value over alternative preferred options
SWC11	Cambs and West Suffolk to Cambs and West Suffolk potable transfer (10 Ml/d)	Internal potable transfer	AWSSWC	Option created but adds no value over alternative preferred options
SWC12	Essex Central to Cambs and West Suffolk potable transfer (10 Ml/d)	Internal potable transfer	AWSSUE	Option created but adds no value over alternative preferred options
	Desalination Barge moored at Felixstowe Harbour	Desalination	AWSNTB	The inner port will not be suitable for discharge of brine.
	Great Yarmouth desalination (Brackish)	Desalination	AWSNTB	There is a constrained site at Great Yarmouth that is not big enough to accommodate the balance tank associated with brackish water desalination
	Desalination Barge moored at Great Yarmouth Harbour	Desalination	AWSNTB	The inner port will not be suitable for discharge of brine.
	Desalination Barge moored at Lowestoft Harbour	Desalination	AWSNTB	The inner port will not be suitable for discharge of brine.
	Desalination barge moored offshore with a pipeline coming onshore at Lowestoft (25 Ml/d)	Desalination	AWSNTB	Offshore area comprises variable and highly undulating sand banks. Unlikely to be feasible to construct non-trenchless. Pipe lengths likely to be beyond that needed for cost effective/pragmatic operation.
	Desalination barge moored offshore with a pipeline coming onshore at Lowestoft (50 Ml/d)	Desalination	AWSNTB	Offshore area comprises variable and highly undulating sand banks. Unlikely to be feasible to construct

Option ID	Option Name	Option type	WRZ	Rejection reason
				non-trenchless. Pipe lengths likely to be beyond that needed for cost effective/pragmatic operation.
	Desalination barge moored offshore with a pipeline coming onshore at Lowestoft (100 Ml/d)	Desalination	AWSNTB	Offshore area comprises variable and highly undulating sand banks. Unlikely to be feasible to construct non-trenchless. Pipe lengths likely to be beyond that needed for cost effective/pragmatic operation.
	Lowestoft desalination (Sea Water) 25 Ml/d	Desalination	-	Offshore area comprises variable and highly undulating sand banks. Unlikely to be feasible to construct non-trenchless. Pipe lengths likely to be beyond that needed for cost effective/pragmatic operation.
	Estuarine rivers between Felixstowe and Lowestoft	Desalination	-	The area carries multiple environmental designations site and the options have no obvious benefits over other desalination options in the area
	Sea Water desalination Other coastal locations - East Suffolk	Desalination	AWSNTB	Generic category used in workshops. Superseded by current feasibility study which has completed a review of the East Suffolk coastline and provided specific options
	Lowestoft desalination (Sea Water) 50 Ml/d	Desalination	AWSNTB	Offshore area comprises variable and highly undulating sand banks. Unlikely to be feasible to construct non-trenchless. Pipe lengths likely to be beyond that needed for cost effective/pragmatic operation.
	Lowestoft desalination (Sea Water) 100 Ml/d	Desalination	AWSSHB	Offshore area comprises variable and highly undulating sand banks. Unlikely to be feasible to construct non-trenchless. Pipe lengths likely to be beyond that needed for cost effective/pragmatic operation.
	Desalination Barge moored at Immingham Harbour - transfer to Elsham	Desalination	AWSSHB	The inner port will not be suitable for discharge of brine. The outer berths and jetties are set aside for bulk liquid offload and ae not suitable for a permanent berth
	Desalination Barge moored at Immingham Harbour - transfer to non potable hub	Desalination	AWSSHB	The inner port will not be suitable for discharge of brine. The outer berths and jetties are set aside for bulk liquid offload and ae not suitable for a permanent berth
	South Humber Bank	Desalination	-	Duplicate option
	Brackish desalination on Ancholme	Desalination	-	Insufficient room for in-take on estuary side of the lock.

Option ID	Option Name	Option type	WRZ	Rejection reason
	Multiple Effect Distillation (MED) at the South Humber Bank	Desalination		MED is a high cost option when compared with a reverse osmosis. There is no benefit in progressing with this option.
	North / East of Immingham Port	Desalination	-	Multiple environmental designations and some very challenging sites to develop intake / outfall due to large area of sandbank / mudflats.
	Sheringham - Newgate/Blakeney	Desalination	-	Rejected following review of high level screening as there are too many overlapping designations, in particular the AONB. There is also no great benefit over this location compared with Bacton and Caister options
	Sea Water desalination - colocation with East Anglian Offshore Wind Farm infrastructure	Desalination	-	East Anglia 3 windfarm extension is due to start construction 2021 / 2022. This does not meet the time lines of desalination development.
	Vanguard Offshore Wind Farm desalination	Desalination	-	Vanguard windfarm planning consent is currently under review which does introduce risk to any colocation. There are other options in the vicinity that consider a desalination plant at this location and as such there is no benefit in considering this as a standalone option.
	Hornsea Three Offshore Wind Farm desalination (near Sheringham)	Desalination	-	The project has already been consented and therefore the timelines of delivery do not match those of a desalination plant for Anglian Water.
	Bungay Desal	Desalination	-	The river at Bungay is fresh water and as such a desalination option is not appropriate.
	Norwich and the Broads - Small schemes	Desalination	-	Generic option with insufficient detail to develop carry forward for IEA screening.
	Cantley (brackish river water or groundwater)	Desalination	-	The river at Cantley is fresh water and as such a desalination option is not appropriate.
	Brackish desalination on the river Yare / Waveney between Great Yarmouth, Reedham and St Olaves	Desalination	-	Situated in a designated function flood plain, whilst this does not prevent development an exception test would be required as well as additional costs related to flood protection. In addition there is a wide range of environmental designations in this area and no other

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				industrial developments to suggest a precedence has been set to allow development
	Inland (Wisbech) desal	Desalination	-	Superseded option
	Cloves Bridge	Desalination	-	Very limited non designated area to build on and a great deal of uncertainty regarding the operation of the channel during flood events and droughts
	Nottinghamshire Secondary groundwater	Desalination	-	Generic option with insufficient detail to develop carry forward for IEA screening.
	Tidal Trent	Desalination	AWSHPL	Generic option description - superseded
	Hartlepool	Desalination	AWSHPL	There is no deficit in the Hartlepool area
	Secondary groundwater	Desalination	AWSHPL	There is no deficit in the Hartlepool area
	Hartlepool harbour (sea water)	Desalination	AWSFND	There is no deficit in the Hartlepool area
	Sea Water desalination Holkham area (North Norfolk Coast)	Desalination	AWSFND	Multiple environmental designations and also shares the same issues as Hunstanton
	Hunstanton	Desalination	-	Intake not feasible due to shallow nature of the wash. Abstraction form groundwater will also be limited due to the risk of GW intrusion and impacts on the wash
	River Nene	Desalination	-	Considered very difference with the Kings Lynn desalination, therefore it will be treated a sub option
	Sea Water Desalination along the coastline of The Wash	Desalination	-	Intake not feasible due to shallow nature of the wash. Abstraction form groundwater will also be limited due to the risk of GW intrusion and impacts on the wash
	Fenland Secondary Groundwater	Desalination	-	Generic option with insufficient detail to develop carry forward for IEA screening.
	Fenland River Outfalls	Desalination	AWSEXS	Superseded
	Brackish water desalination at the mouth of the river Stour	Desalination	-	Water quality review shows this would be considered a sea water desalination plant with a balancing tank to manage the variability. There is a very small industrialised area which could be considered but a number of challenging

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				aspects relating to environmental designation of the estuary (SSSI, RAMSAR, SPA). To reach the consistent water depth there is a large intertidal zone to cross
	Brackish water desalination on the North side of the Stour Estuary	Desalination	-	North side of the Stour Estuary carries multiple environmental designations and has no industrial infrastructure to suggest development would be allowed. Provides no benefit over DES-33a
	Brackish Water Desalination at Anderby Creek drainage channel	Desalination	-	Very small area where abstraction could take place opposite a holiday area and a with a number of other environmental designations. Likely to be a very small DO and not worth progressing.
	Covenham sea water desalination	Desalination	-	Rejected following review of high level. Too many overlapping environmentally designated sites. No infrastructure in immediate area suggests that this type of development will be successful.
	Louth Canal @ Teteny Lock	Desalination	-	Upstream of lock maximum chloride value is 68 mg/l, so this is fresh water and is not suitable for desalination.
	Trusthorpe Onsough Drain (Mablethorpe)	Desalination	-	Review of water quality data indicates the drains are freshwater and therefore not suitable for brackish desalination. Research indicates there may be a control point at Mablethorpe blocking saline influence into the drains. Additionally, the option would be abstracting downstream of the STW effluent discharge which could cause problems with customer acceptability. This option should be discounted as a brackish desalination option.
	Sandilands	Desalination	-	Very small area where abstraction could take place on a golf course and a with a number of other environmental designations. Likely to be a very small DO and not worth progressing.
	Skegness to Thedelthorpe (multiple options)	Desalination	-	Too many overlapping environmentally designated sites.
	Tidal Trent at Gainsborough	Desalination	AWSEXS	Superseded

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	Harwich desalination (seawater) 25 Ml/d	Desalination	AWSEXS	Offshore area comprises variable and highly undulating sand banks. Unlikely to be feasible to construct non-trenchless. Pipe lengths likely to be beyond that needed for cost effective/pragmatic operation.
	Harwich desalination (seawater) 50 Ml/d	Desalination	AWSEXS	Offshore area comprises variable and highly undulating sand banks. Unlikely to be feasible to construct non-trenchless. Pipe lengths likely to be beyond that needed for cost effective/pragmatic operation.
	Harwich desalination (seawater) 100 Ml/d	Desalination	AWSEXS	Offshore area comprises variable and highly undulating sand banks. Unlikely to be feasible to construct non-trenchless. Pipe lengths likely to be beyond that needed for cost effective/pragmatic operation.
	Desalination Barge moored at Harwich	Desalination	AWSEXS	Due to proximity of the harbours this is considered as a variation of other options
	Harwich floating desalination (sea water)	Desalination	-	The seabed conditions in this are not appropriate for a permanent mooring. There is a sand bank which suggests a current running parallel to the coast. It is also in close proximity to a shipping channel.
	Harwich Brackish Water desalination	Desalination	-	Water quality indicates that this is effectively sea water, as such it is covered under alternative option
	Frinton & Walton desalination (Sea Water)	Desalination	-	Adjacent to important bird area and constrained by special protection areas both near and offshore. Does not offer any advantages over other options in area
	Brackish water desalination between Harwich and Manningtree	Desalination	-	Rural area with a number of tourist locations would be challenging to consent - no benefits over other options
	West Mersea desalination (sea water)	Desalination	-	Intake / outfall needs to cross several km of seabed designated at SAC / SPA. Routing a pipeline off of the island would also need to cross several environmentally sensitive areas. No other benefits to select this location over other local options
	Jaywick (Sea Water)	Desalination	-	Need to cross large SPA area to site intake. No other benefits to select this location over other local options

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	Coastal desalination network (small scale)	Desalination	-	Generic option with insufficient detail to carry forward for IEA screening.
	Small scale desalination	Desalination	-	Generic option with insufficient detail to develop carry forward for IEA screening.
	Secondary groundwater	Desalination	-	Generic option with insufficient detail to develop carry forward for IEA screening.
	Secondary groundwater	Desalination	AWSNTB	Generic option with insufficient detail to develop carry forward for IEA screening.
	Whitlingham Trowse WRC to Heigham via river Wensum (with additional treatment at Heigham)	Water reuse	AWSNTB	Process calculations showed that the DO is severely constrained due to the 250Mg/l chloride limit at the discharge point. As such the DO is not considered feasible for development
	Whitlingham Trowse WRC to Heigham via river Wensum (no additional treatment at Heigham)	Water reuse	AWSRTN	Process calculations showed that the DO is severely constrained due to the 250Mg/l chloride limit at the discharge point. As such the DO is not considered feasible for development
	Great Billing (Northampton)	Water reuse	AWSRTN	Upstream of existing abstraction of Rutland water and as such no value in developing option further
	Corby	Water reuse	AWSRTS	Upstream of existing abstraction of Rutland water and as such no value in developing option further
	Huntingdon (Godmanchester) to Grafham Reservoir	Water reuse	AWSRTS	Process calculations showed that the DO is severely constrained due to the 250Mg/l chloride limit at the discharge point. As such the DO is not considered feasible for development
	Bedford	Water reuse	AWSRTS	Upstream of existing abstraction for Grafham water and as such no value in developing option further
	Cotton Valley (Milton Keynes)	Water reuse	AWSRTS	Upstream of existing abstraction for Grafham water and as such no value in developing option further
	Chalton	Water reuse	AWSRTS	Outside of WRE and AWS area and some distance from an appropriate water body for transfer

Option ID	Option Name	Option type	WRZ	Rejection reason
	Martson	Water reuse	AWSRTS	Screened out following discussion with WINEP team. This WRC is supporting river flows

love every drop

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