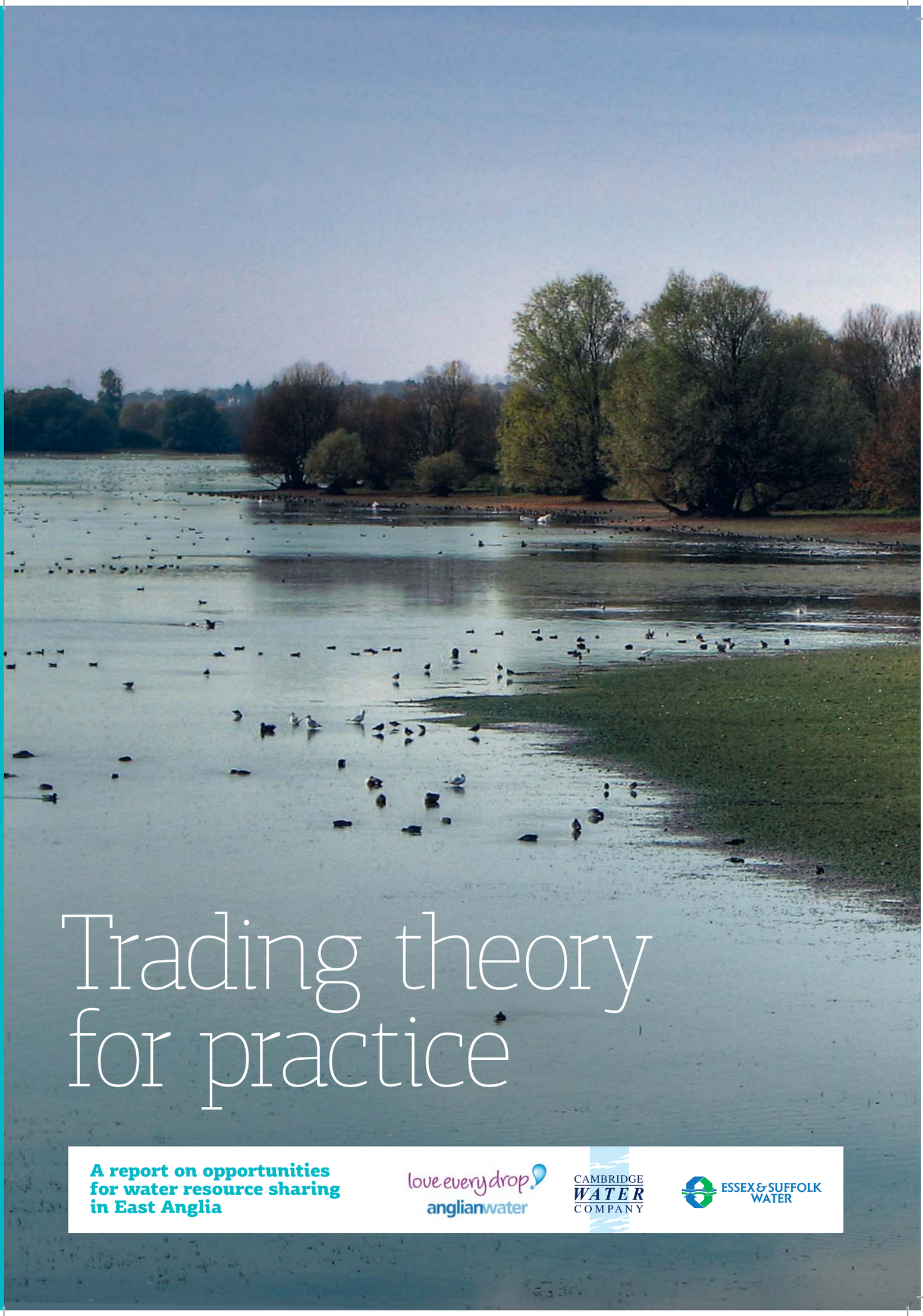


Trading theory for practice

A report on opportunities for water resource sharing in East Anglia

love every drop
anglianwater

CAMBRIDGE WATER COMPANY

ESSEX & SUFFOLK WATER

Water trading is a potential answer to one of the biggest challenges facing the future viability of our industry – water resource management.

Ofwat's paper *Valuing Water* addresses the nature of this challenge and in doing so has stimulated a very important and far-reaching debate.

Here, we contribute to that debate by presenting an evidence-based report, supported by detailed technical analysis. The conclusions are based on a case study, undertaken in close collaboration between our three water and wastewater companies that together serve over 6 million customers in eastern England.

Front cover:
Abberton Reservoir, Colchester, Essex

Looking to the future

At stake is the security of safe, constant supplies of water and wastewater services to every customer in our region. They will be looking to us for innovative and ideas-driven solutions, based on solid evidence and practical experience. And getting it right means more sustainable planning and operations too, with consequent benefits for the environment.

Valuing Water sets out a number of ideas for encouraging a greater level of water trading between companies. Its high level analysis suggests that companies may have been incentivised to invest in unnecessary capital spending, when water trading could have provided a more cost-effective solution.

Market reform

We see this in the context of the wider debate about market reform in the water industry. The proposed reform of upstream water resources, including abstraction, raw water distribution, treatment and treated water distribution, is likely to increase the role of trading in water resource planning, and so adds a further dimension to the debate.

Groundbreaking

With this in mind, Anglian Water, Essex and Suffolk Water (part of Northumbrian Water) and the Cambridge Water Company collaborated on a groundbreaking project on water resource sharing in the eastern part of East Anglia to see if this can really work.

Managing risk

This is of real significance given East Anglia is identified as one of the highest risk areas in the UK – being particularly vulnerable to the impacts of climate change as well as being the fastest growing region.

Given this we believe we can contribute a very helpful perspective.

Our starting point is that there is no significant surplus of water in this region, so major investment is required to help balance future supply and demand. This is being achieved over a 25 year planning horizon.

We set ourselves two primary goals:

1. **Establish whether sharing or trading of resources could result in enhanced benefits to customers and the environment; and**
2. **Determine whether the current industry structure and/or regulatory framework acts to constrain opportunities or an appetite for resource sharing.**

We share the ambition of Ofwat to achieve more flexible and efficient ways of meeting future challenges and we are pleased to share the results of our collaborative project to contribute towards this goal.

Peter Simpson
Managing Director
Anglian Water

Heidi Mottram
Chief Executive Officer
Northumbrian Water

Stephen Kay
Managing Director
Cambridge Water Company

Ensuring a safe future supply

Executive summary

Ofwat is currently working on a programme of market reform, including looking at options to increase the role of trading in the allocation of water resources. Through such measures, Ofwat is seeking a flexible and efficient means to mitigate future risks from climate change, growth and sustainability reductions.

Anglian Water, Cambridge Water Company and Essex and Suffolk Water have completed a joint planning exercise to test whether trading or sharing of water resources in East Anglia will lead to enhanced customer and environmental benefits.

The study has looked at current Water Resources Management Plans in Cambridgeshire, Essex, Suffolk and Norfolk. This area was selected as it is vulnerable to the effects of climate change, growth and future sustainability reductions and the limited surpluses available mean that investment to maintain the supply-demand balance is needed in the short, medium and long term.

Within the study area, significant volumes of water resource are already shared or traded. In the short to medium term, however, opportunities for increasing this will be limited to the following:

1. **A transfer from Essex and Suffolk Water into Norwich in 2025-30; and**
2. **A transfer from Cambridge Water Company into Bury St Edmunds, also in 2025-30.**

The combined capacity of these schemes is 6.3 Ml/d; this compares to 1,180 Ml/d of water available for use in the study area in 2034-35.

However, successful delivery of the transfers is subject to the outcome of the 2012 CAMS update, future sustainability reductions, climate change, and, for the Essex and Suffolk option, the feasibility of developing a cost-effective groundwater source in the Lowestoft area.

These are all significant uncertainties and, until resolved, the existing plans must be considered optimal.

The failure to identify other economic options reflects a lack of surplus resource in the study area and the cost of transferring the small amounts that are available over long distances. The potential for stranding assets and sensitivity to bulk supply charges are also identified as issues.

Challenges and long-term opportunities

The challenge of climate change will mean we need to find more innovative ways to ensure secure water resources in the future. Inter-company transfers while beneficial should not be seen as a universal solution, as transferring water long distances is expensive and technically complex with high carbon and environmental impacts. Investment in winter storage in impounding structures or below ground as part of aquifer recharge schemes will also be essential to mitigate against the impacts of climate change. The need for each company in the study area to invest in strategic storage and transfer capacity beyond 2035 means that there will be long-term opportunities to increase the volume of water that is shared or traded. To fully utilise these opportunities, the following improvements are needed in the way that water company activities are regulated:

- **The process for making sustainability reductions needs to be aligned with the water resource planning process;**
- **Inefficiencies and complexity in the current process for approving resource sharing need to removed, particularly for transfers between EA regions; and**
- **Opex efficiency assessments need to take into account the adverse effect of bulk transfer charges.**

The long lead time for delivery of strategic assets means that work on planning and development needs to start now. Optimising arrangements for trading the resource that will be created needs to be a key element of this work.

1

Setting the context

This report outlines the results of a collaborative project between Anglian Water, Cambridge Water Company and Essex and Suffolk Water to look at water resource sharing opportunities.

The project considers the benefits and barriers to companies trading water across traditional water company boundaries.

This is something that Ofwat has considered in its paper "A study on potential benefits of upstream markets in the water sector of England and Wales" (March 2010). In this, Ofwat estimates that the benefits of greater trading could be approximately £1,000m more than those delivered by capital investment projects proposed in water companies' Draft Water Resources Management Plans (WRMPs).

We share the ambition of Ofwat to achieve more flexible and efficient ways of meeting future challenges. This project has enabled us to explore these concepts in a real context to trade theory for practice.

It is particularly valuable in contributing to the current debate because it:

- **Targets a high risk area** – the project is focused in East Anglia, an area highlighted in the Ofwat report as likely to have the most significant savings from water trading;
- **Uses latest data** – several key changes were made to company Draft WRMPs used by Ofwat in their analysis; our research uses the final plans for the four companies in scope to give the latest position; and
- **Provides evidence** to assess the scale of likely benefits compared to costs to identify the most effective solutions.

2

Objective

The purpose of the project is to determine if resource trading can deliver enhanced customer and environmental benefits.

It was designed to:

- **Explore the practicalities and opportunities for water resource trading in East Anglia;**
- **Assess the scale of likely benefits compared to costs to identify most effective solutions;**
- **Explore whether, in light of the findings, changes to WRMPs should be recommended; and**
- **Identify potential barriers to increased levels of sharing or trading and how they could be overcome.**

The project focuses on whether resource trading can deliver enhanced customer and environmental benefits to an area that is vulnerable to climate change, growth and sustainability reductions.

Scope

The project approach is an appraisal of trading opportunities in the eastern parts of East Anglia.

This region is an ideal case study to test if trading is more cost-effective than schemes in Final WRMPs as it is very vulnerable to the effects of climate change and growth. There are only limited surpluses available and investment in measures to maintain the supply-demand balance is needed.

Pressures on water resources include:

- **Impact of climate change on water resource availability;**
- **Low rainfall;**
- **Limited surpluses available;**
- **Forecasts of significant population growth – up to a million new homes could be built in the next 25 years; and**
- **High probability that the EA will reduce available resources further because of the need to maintain sustainable levels of abstraction.**

Methodology

The study is based on the baseline forecasts and final planning solutions in the 2010 Water Resources Management Plans ("Final" WRMPs). These have been published for water companies in the study area and provide a realistic strategic plan for the east of our region that balances the needs of public water supply and the environment. The Water Resource Zones (WRZs) in the study area are given below:

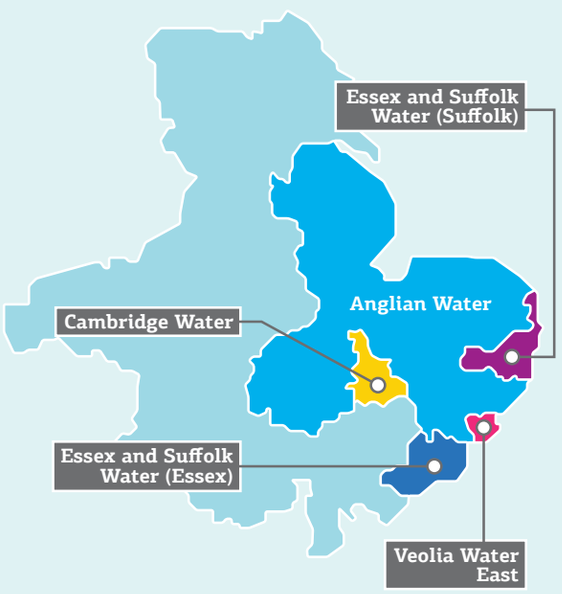
Table 1
Water Resource Zones in study area

COMPANY	WATER RESOURCE ZONE
Anglian Water	East Suffolk and Essex Cambridgeshire and West Suffolk Norfolk Rural Norwich and the Broads North Norfolk Coast Fenland
Essex and Suffolk Water	Essex Northern and Central (Northern/Central) Hartismere Blyth
Veolia Water East	Veolia Water East (single zone)
Cambridge Water Company	Cambridge (single zone)

Figure 1
Study area

The study area is shown in Figure 1. It includes areas supplied by Anglian Water (AW), Essex and Suffolk Water (ESW), Cambridge Water Company (CWC) and Veolia Water East (VWE) – Figure 2.

Figure 2
The water companies



In the study, unconstrained and feasible scheme options in the Final WRMPs were extended to include a series of new inter-company transfers. After screening the unconstrained options, the feasible options were evaluated using an Average Incremental Cost (AIC) assessment. This approach is based on the Anglian Water Final WRMP and 2009 price review Final Business Plan submission on supply-demand and is summarised in the box below right.

Step 1 – please see section 4

Understand original investment need and solutions

2034-35 supply-demand deficit forecast in Water Resources Management Plan

Water Resourcess Management Plan resource development schemes

Step 2 – please see section 5

Evaluate unconstrained options

Explore all possible inter-company transfers to assess which are technically and economically feasible

→ Non feasible inter-company transfers

Step 3 – please see section 6

Assessment of feasible inter-company transfers

Explore the feasible transfer options

Step 4 – please see section 7

Economic appraisal of feasible inter-company transfers

Assess which inter-company transfers are more cost-effective than original Water Resources Management Plan schemes

Step 5 – please see section 8

Interpretation and wider discussion

Explore the wider implications of results, benefits, barriers and future opportunities

Cost-benefit

The cost-benefit assessment takes into account benefits for both customers and the environment:

- **Customer benefits from reduced capital expenditure (capex) and operational expenditure (opex); and**
- **Environmental benefits through a reduction in the volume of licensed resource needed to maintain the supply-demand balance and carbon reductions.**

In completing the project, we have assumed that investment plans for AMP5 have been committed and will deliver the assumed benefits and that the current trading arrangements between Anglian Water and Veolia Water East will be extended where appropriate. Similarly, we have excluded the UKCP09 outputs, future sustainability reductions and bulk transfer charges. Additional details about exclusions from the scope are given in Appendix 1.

AIC methodology

The final planning solution is selected using the lowest average incremental cost (AIC) for the option or options that are needed to maintain the supply-demand balance. To compare AICs using the AW models, each option is assessed using the "water of benefit"; this is equivalent to the water generated by the scheme that is used and is different from the total supply capacity of the new scheme. AICs are calculated from the following:

$$\text{Average Incremental Cost (£/Ml)} = \frac{\text{NPV (capex + opex)}}{\text{NPV of water consumed}}$$

As part of the economic modelling, capex and opex estimates for selected schemes in the Final WRMPs were also updated, allowing for direct comparison of the existing resource development schemes and the new transfers. In all cases, the capex and opex estimates were generated using AW cost models with a price time base of 2007-08 and engineering scope sheets that were prepared for AW.

Investment need

The 2034-35 baseline supply-demand balances for WRZs in the study area are given in Figure 3, together with an equivalent map – Figure 4 – that shows the effect of delivering all of the schemes which are identified in the Water Resources Management Plans.

Details of supply-demand balance are summarised below and in Appendix 2:

Cambridge Water Company and Veolia Water East
The Cambridge Water Company and Veolia Water East WRZs are in surplus through the forecast period and as a consequence, no supply-side schemes are required by either company.

Anglian Water
To maintain the supply-demand balance, post AMP5 investment in resource development or transfers will be needed in all of the WRZs in the east of the AW region.

Essex and Suffolk Water (ESW)
Current deficits in the ESW Essex WRZ will be restored by the AMP5 Abberton scheme. This will deliver 64 Ml/d of additional water available for use (WAFU) and will result in the zone being in surplus from 2014-15 to 2034-35.

Of the remaining ESW WRZs, there is a surplus throughout the forecast period in the Suffolk Blyth WRZ, and minor deficits in the Suffolk Hartismere WRZ will be avoided using demand management measures. A 4.2 Ml/d deficit in the Suffolk Northern/Central WRZ will be avoided using a combination of demand management and the 5 Ml/d Lowestoft Groundwater scheme. Following delivery of these, there is forecast to be a nominal 2.5 Ml/d surplus in the WRZ in 2034-35.

Figure 3
Supply-demand balance 2034/5
No investment to restore deficits

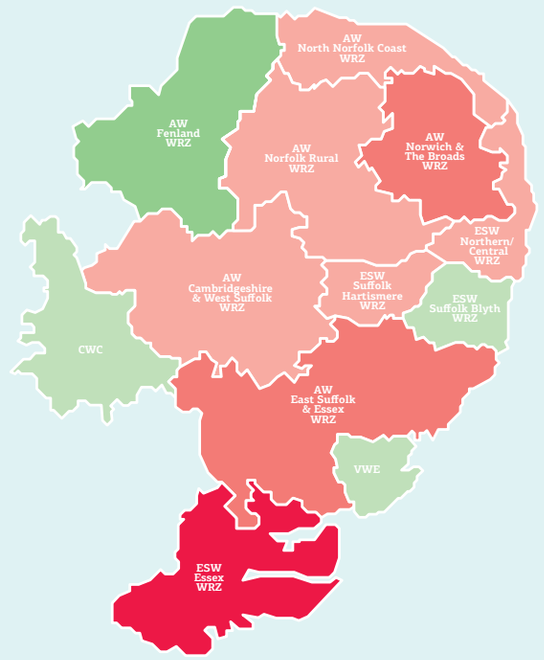
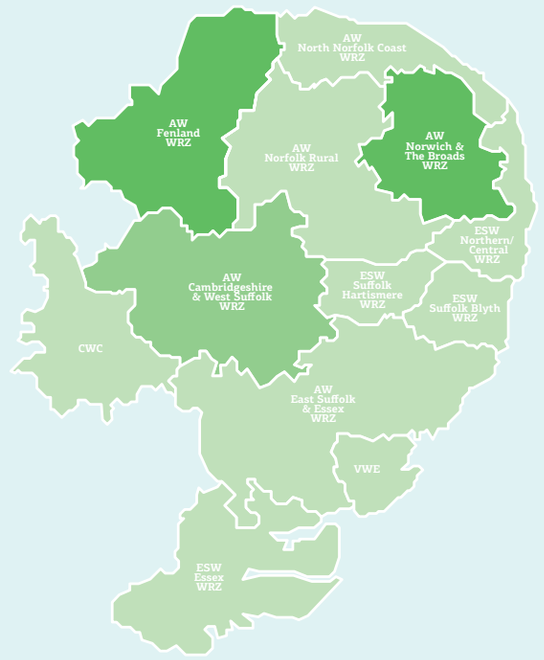


Figure 4
Supply-demand balance 2034/5
WRMP schemes delivered



Evaluation of unconstrained options

Unconstrained options for new inter-company transfers have been developed from the analysis and from discussion between AW, ESW and CWC about the infrastructure needed to deliver each option. Table 2, at the base of the page, sets out the unconstrained options.

No inter-company transfer options have been identified for deficits in the AW Fenland and Norfolk Rural WRZs. This reflects a combination of the following:

1. **Fenland WRZ: a lack of surplus resource in the adjacent company area (Cambridge Water Company) once other possible trades have been taken into account; and**
2. **Norfolk Rural WRZ: the availability of options to transfer resources over relatively short distances within the AW network.**

It has also been assumed that any VWE surpluses will be traded with AW, either to avoid deficits in the Colchester Planning Zone (PZ) or to support the supply-demand balance in PZs adjacent to Colchester. Details of the unconstrained options are illustrated on the page opposite (Figure 5).

Three of the unconstrained options fell out of the analysis at this stage as they entailed excessive cost or are likely to be environmentally unacceptable. These were:

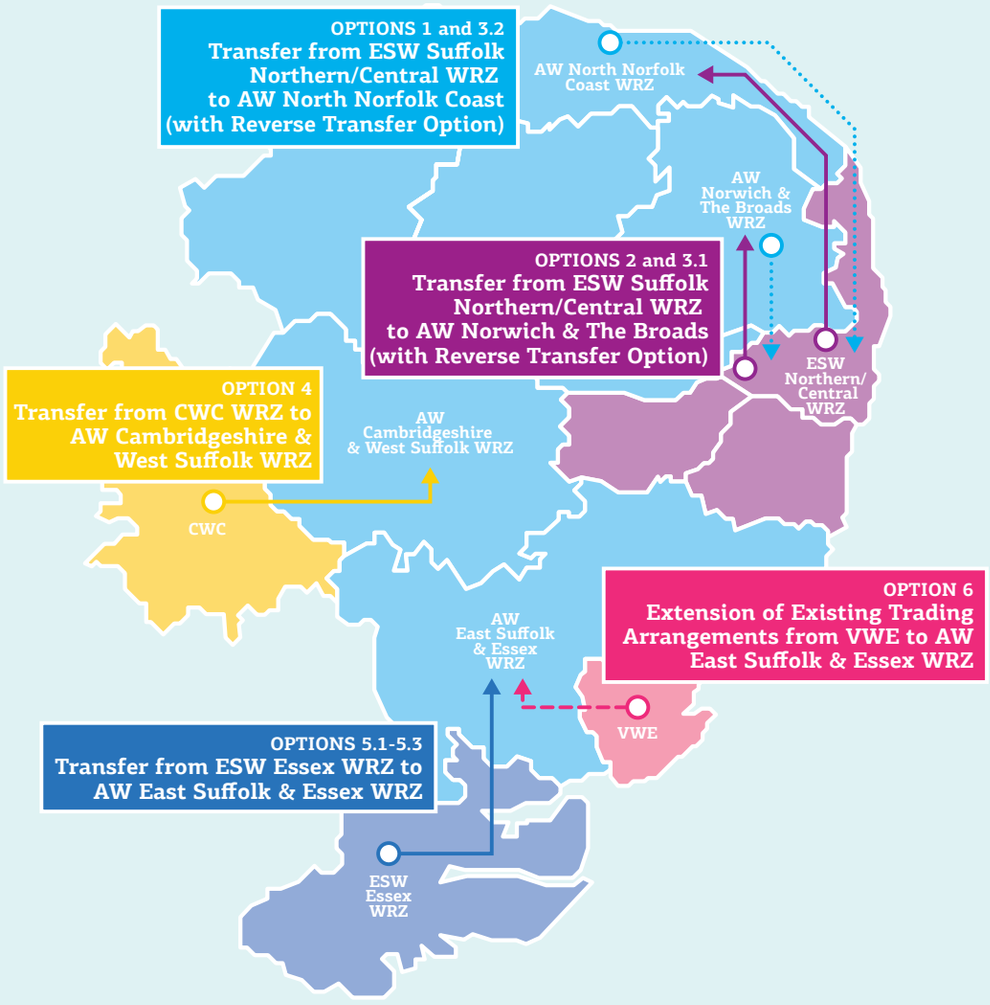
Option 1:
ESW transfer to AW North Norfolk Coast WRZ in AMP6 based upon an extension of the North Lowestoft Groundwater scheme. This option would involve a pipeline transfer from ESW Lound WTW across the environmentally sensitive Norfolk Broads to north-east Norfolk. There are significant difficulties of routing a pipeline through the Broads making this environmentally unacceptable and

Table 2
Unconstrained options

INTER-COMPANY TRANSFER OPTION REFERENCE	WATER RESOURCE ZONE WITH NEED	EXISTING WRMP SUPPLY-SIDE SCHEME (AMP)	NEW INTER-COMPANY TRANSFER OPTIONS	OUTLINE DETAILS
1	AW North Norfolk Coast	Secondary Groundwater Use (AMP6)	Transfer from ESW Suffolk Northern/ Central WRZ	Extension of 5Ml/d ESW North Lowestoft Groundwater scheme (AMP8) and transfer from ESW Lound WTW to service reservoir in the vicinity of Stalham (34km)
2	AW Norwich and the Broads	Norwich Effluent Reuse (AMP8)	Transfer from ESW Suffolk Northern/ Central WRZ	Extension of 5 Ml/d ESW North Lowestoft Groundwater scheme (AMP8) and transfer from ESW Lound WTW to AW Lakenham Service Reservoir, on the outskirts of Norwich (33km)
3.1	ESW Suffolk Northern and Central	North Lowestoft Groundwater (AMP8)	Transfer from AW Norwich and the Broads WRZ	Delivery of Norwich Effluent Reuse (AMP8) and transfer from AW Lakenham Service Reservoir to ESW Lound WTW (33km)
3.2			Transfer from AW North Norfolk Coast WRZ	Extension of Secondary Groundwater Use scheme (AMP6) or a new desalination plant sized to meet both AW and ESW needs and transfer from AW service reservoir in the vicinity of Stalham or Bacton to the ESW Lound WTW (34km (+12km for Bacton))
4	AW Cambridgeshire and West Suffolk	Groundwater Development (AMP8)	Transfer from CWC WRZ	Supply from CWC Thetford well-field. Transfer via connection to CWC Thetford-Cambridge main
5.1 5.2 5.3	AW East Suffolk and Essex	Cliff Quay Effluent Reuse (AMP6)	Transfer from ESW Essex WRZ	Using surplus from 64 Ml/d Abberton scheme (AMP5): • Abberton (I): treated water transfer from Colchester to Ipswich based on extension of Ardleigh WTW • Abberton (II): raw water transfer from Colchester to Ipswich based on extension of Alton WTW • Abberton (III): treated water transfer from Colchester to Ipswich based on bulk supply from ESW Layer de la Haye WTW
6	AW East Suffolk and Essex	–	–	A variation of the Ardleigh reservoir supply agreement

Figure 5

Unconstrained options



technically complex. There is also a timing issue since this option in AMP6 relies on an extension of the North Lowestoft Groundwater scheme which is currently proposed in AMP8. For these reasons this option has been discounted.

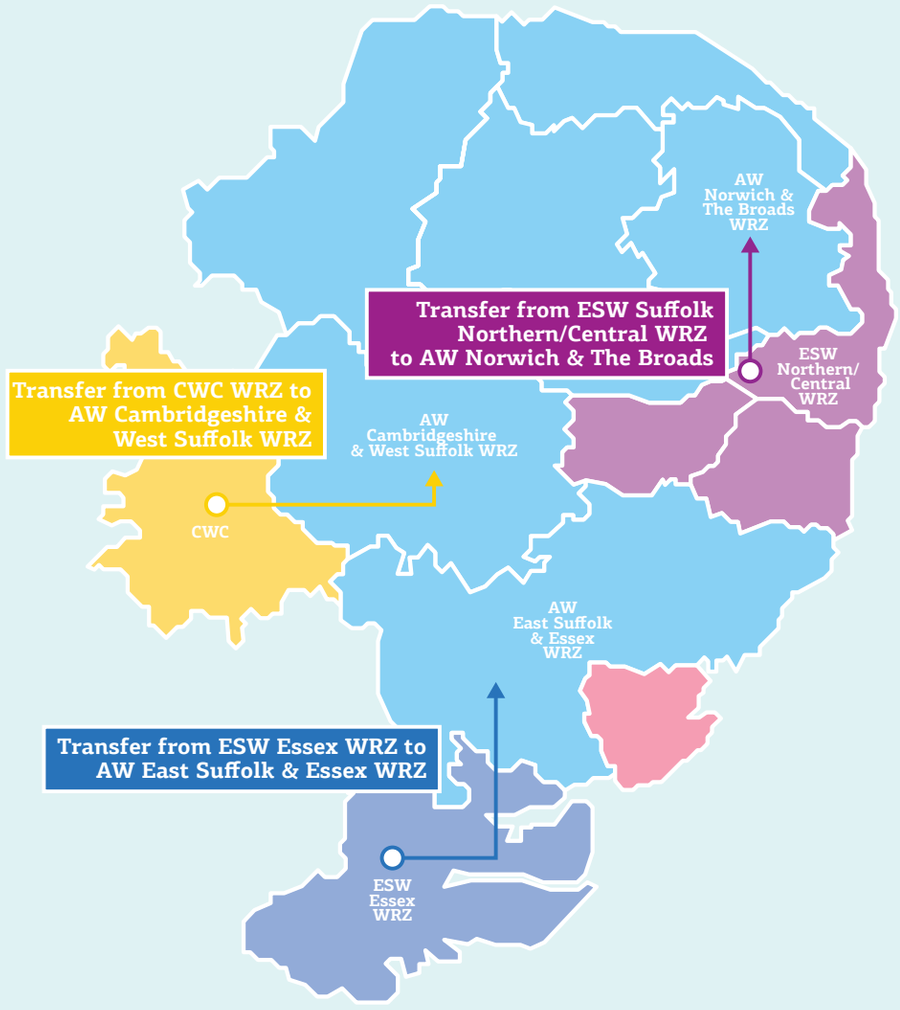
Option 3.1:
AW transfer to ESW Suffolk Northern/Central WRZ in AMP8 based on extension of Norwich Reuse scheme. This option involves a transfer from Norwich to the ESW water treatment works (WTW) at Lound. Since the capex requirement for this (approximately £10m) is twice the ESW capex estimate for the North Lowestoft Groundwater scheme (approximately £4m), the scheme is not economically feasible.

Option 3.2:
AW transfer to ESW Suffolk Northern/Central WRZ in AMP8 based on extension of the Secondary Groundwater Use or the (Bacton) desalination schemes. This option would involve a pipeline transfer from north-east Norfolk across the Norfolk Broads to the ESW Lound WTW. Given capex requirements similar to those of the transfer from Norwich, the difficulties of routing a pipeline through the Broads and the gap between delivery of the Secondary Groundwater Use scheme (AMP6) and the need in the ESW Suffolk Northern/Central WRZ (AMP8), this option is not considered to be economically feasible or environmentally acceptable.

Feasible options

Having assessed the unconstrained options to rule out those which were excessively expensive or likely to be environmentally unacceptable, five options which were feasible remained. Figure 6 summarises these transfer options. We discuss these below exploring economic modelling completed for each and detailed schematics of the transfer scheme options.

Figure 6
Feasible options



Options 5.1, 5.2 and 5.3: ESW Essex WRZ to AW East Suffolk and Essex WRZ Transfers

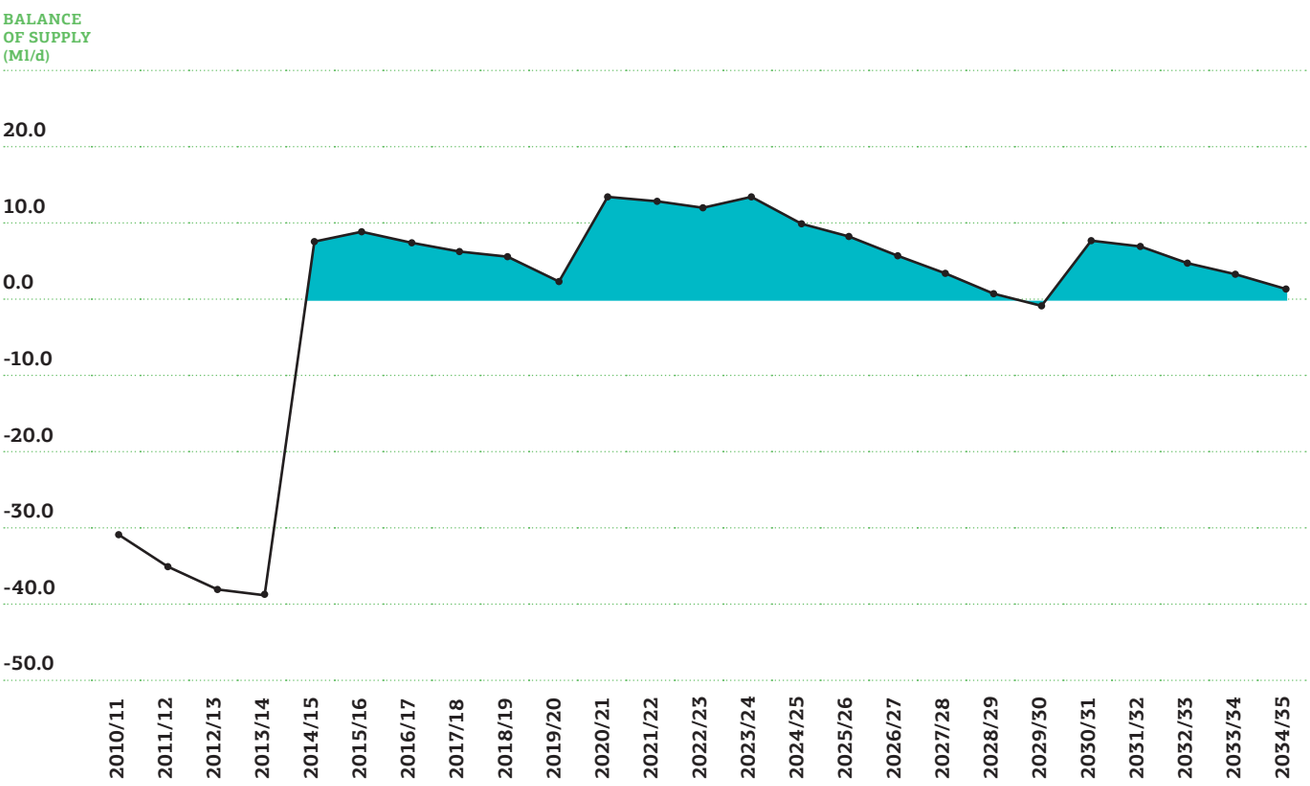
The three Abberton options are based on the surplus from the ESW (AMP5) Abberton scheme. This is most recently defined in the "Additional Information Supporting the Full Abberton Scheme" Final Report that was submitted by ESW to Defra, Ofwat and the EA. From this, the surplus is variable and declines, reflecting growth in demand in the WRZ and a series of target headroom adjustments that have been agreed between ESW and the EA. The maximum amount available to transfer to AW is marginally in excess of 10 Ml/d; however, for much of the forecast period, an amount significantly less than this is available (see Graph 1 below).

Outline details of the engineering required for the three Abberton options are set out overleaf in Figure 7. The associated capex and opex requirements are given in Table 3 opposite. In each case, the water generated by the scheme is required to support the supply-demand balances in the AW Ipswich and Colchester PZs.

Table 3
Scheme Cost Data (ESW transfers to AW East Suffolk and Essex WRZ)

SUB-OPTION	CAPEX REQUIREMENT (£M)	OPEX REQUIREMENT (£M/A)
Abberton I	36.028	0.647
Abberton II	48.395	0.800
Abberton III	20.046	1.806

Graph 1
Surplus from Abberton Scheme available to transfer to AW



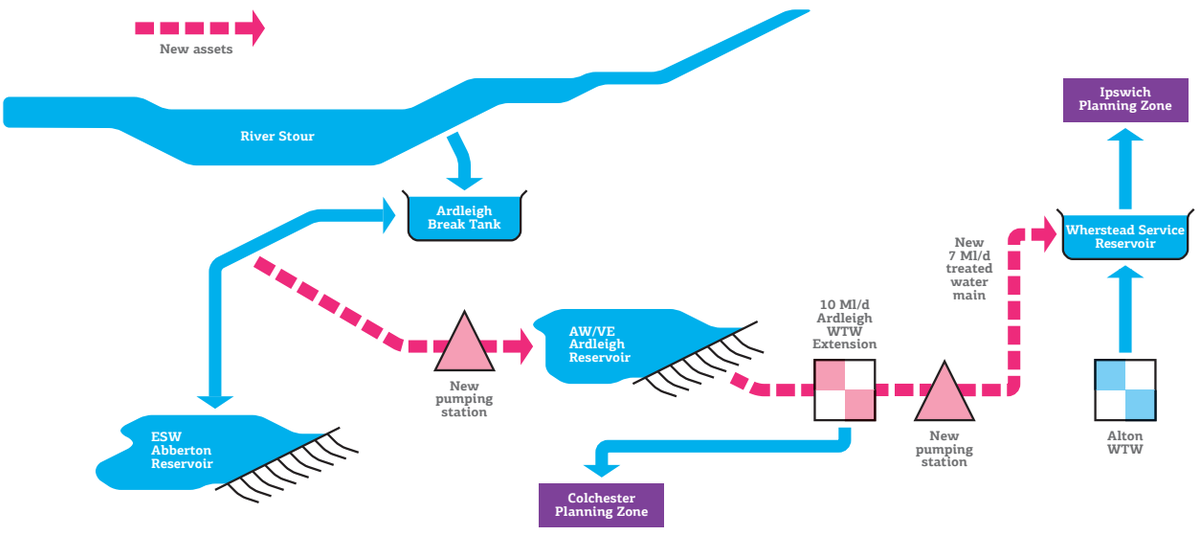
In the economic modelling, the Abberton (I) and (II) options were compared to updated costs for a 20 Ml/d Cliff Quay Effluent Reuse scheme. The capex and opex requirements for this are £54.786m and £0.937m/a respectively. The Abberton (II) option combines most of the elements of the Cliff Quay scheme and the Alton-Horkesley transfer scheme that is referred to in the WRMP and so this option was compared against the combined costs of the two AW schemes. The capex and opex requirements for this are £65.473m and £0.997m/a respectively.

The £1.806m/a opex requirement for the Abberton III option assumes costs for supplying Ipswich with water from Ardleigh WTW (£0.647m/a) and a contribution to a 10 Ml/d extension of the ESW Layer de la Haye WTW. Supplies from this works into Colchester allow for an equivalent amount to be pumped from Ardleigh WTW to Ipswich.

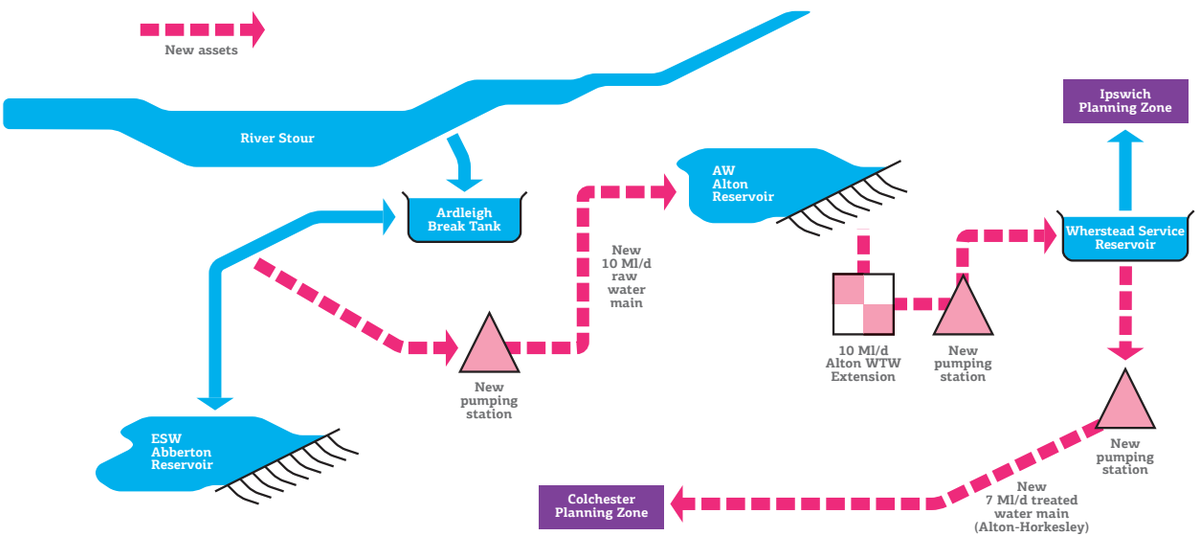
Figure 7

Abberton options for ESW transfers to AW East Suffolk and Essex WRZ

Option 1

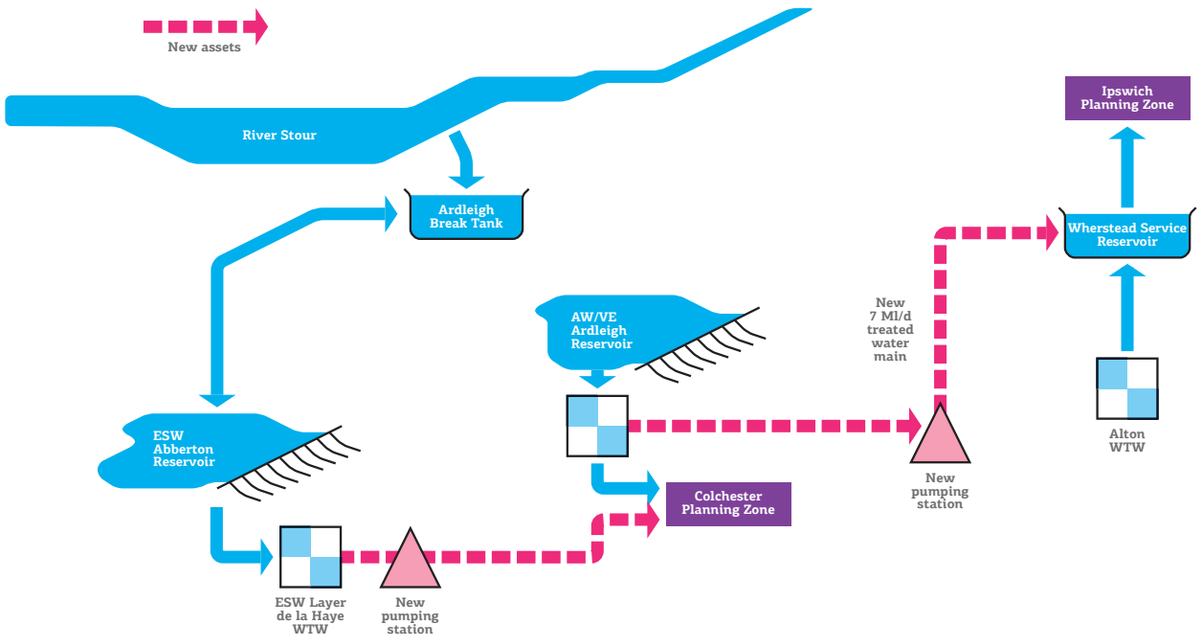


Option 2



Swan and cygnets feed on the River Stour

Option 3

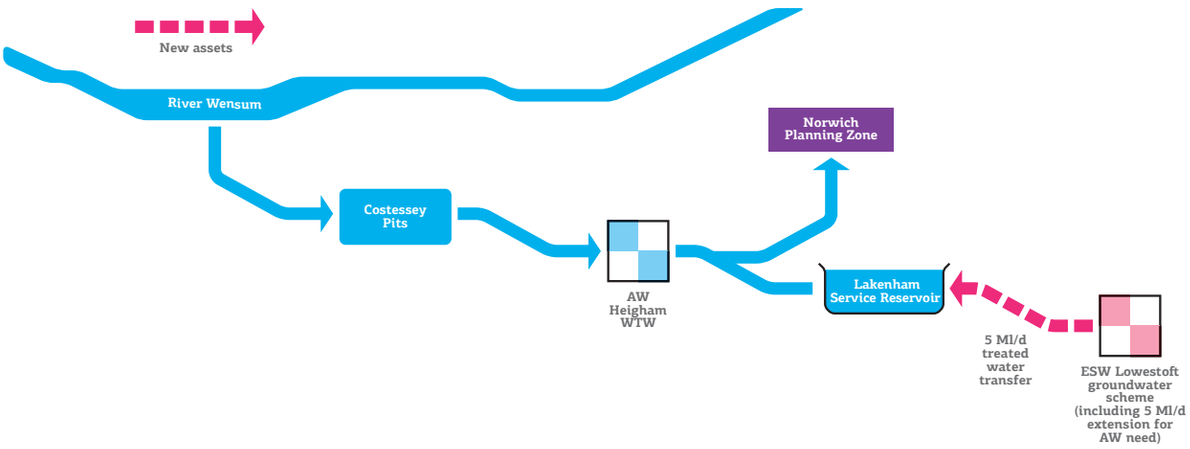


Option 2: ESW Transfer to AW Norwich and the Broads WRZ

To meet AMP8 needs in the AW Norwich and the Broads WRZ, the capacity of the ESW North Lowestoft Groundwater scheme would have to be increased to 7.5 Ml/d, with 5 Ml/d of this available to transfer to Norwich. The capex and opex requirements for the engineering required are estimated to £20.910m and £0.205m/a respectively. Outline details are given below.

In the economic modelling, the ESW transfer option was compared to updated costs for a nominal 10 Ml/d Norwich Reuse scheme. The capex and opex requirements for this are £47.246m and £0.650m/a respectively; 10 Ml/d is comparable in size to the combined output of the other post-AMP5 schemes for Norwich and so allows for comparison of these with both the reuse scheme and the ESW transfer.

Figure 8
ESW Transfer to AW Norwich and the Broads WRZ




Alton Water reservoir near Ipswich, Suffolk

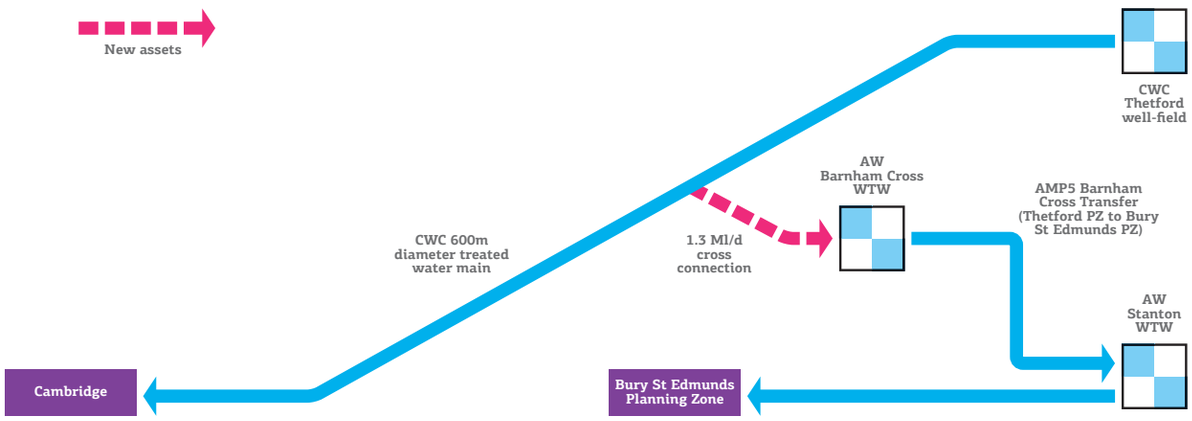
Option 4: CWC Transfer to AW Cambridgeshire and West Suffolk WRZ

To meet AMP8 needs in the AW Cambridgeshire and West Suffolk WRZ, the transfer from the CWC Thetford to Cambridge main would have to be approximately 1.3 Ml/d. This is equivalent to the surplus in the Cambridge WRZ at the end of the forecast period.

The capex and opex for a cross-connection between the AW and CWC systems are £0.481m and £0.027m/a respectively. Outline details of the engineering required are given below.

In the economic modelling, the CWC transfer option was compared to updated costs for a 1.3 Ml/d groundwater development in the vicinity of Stanton WTW. This allowed for direct comparison of the two options. The capex and opex for the Stanton option are £2.329m an £0.027m/a respectively.

Figure 9
CWC Transfer to AW Cambridgeshire and West Suffolk WRZ



7

Results of economic appraisal

Economic appraisal of the feasible options was conducted to assess which were more cost-effective than schemes in Final WRMPs. The results of this modelling are summarised in Table 4, opposite. Based on this analysis, two options were identified as acceptable alternatives, these are discussed below and illustrated on Figure 10. All three Abberton options were rejected as being less cost-effective than schemes in Final WRMPs.

Accepted alternatives

Only two of the five new inter-company transfer options are more cost-effective than schemes in the Final WRMPs. These are shown in Figure 10 and are:

- **ESW to AW Norwich and the Broads transfer, which is more cost-effective than the proposed AW (AMP8) Norwich reuse scheme; and**
- **CWC to AW Cambridgeshire and West Suffolk transfer, which is more cost-effective than the proposed AW (AMP8) GOGS South Groundwater Development.**

However, delivery of these schemes depends on existing groundwater resources being available in AMP8 and in the case of the ESW transfer, the ability to develop groundwater in the Lowestoft area cost-effectively. The CAMS update planned for 2012, outcomes from the EA "Restoring Sustainable Abstraction" (RSA) programme and hydrogeological conditions near Lowestoft may not be consistent with these assumptions.

Rejected alternatives

None of the ESW to AW East Suffolk and Essex transfers were cost-effective relative to the AW (AMP6) Cliff Quay reuse scheme or, for Abberton (II), a combination of this and the Alton-Horkesley link.

The high AICs for the Abberton options reflect a combination of the variable and declining surplus from the ESW (AMP5) Abberton scheme as well as high capex and opex requirements for each of three sub-options.

The effect of the variable and declining surplus is to reduce the scheme capacity, meaning that the comparatively large investments deliver relatively little benefit. This differs from the Cliff Quay scheme which, although more expensive, generates a far higher yield.

It is also noteworthy that, at the end of the forecast period some of the assets created by these schemes would be stranded, since there will no longer be a surplus to trade with AW. These include:

- **Abberton (I): 10 Ml/d Ardleigh WTW extension;**
- **Abberton (II): 10 Ml/d raw water transfer main between Ardleigh Reservoir and Alton Water; and**
- **Abberton (III): 10 Ml/d treated water transfer main from Layer de la Haye WTW into Colchester and pumping station on the Ardleigh-Alton treated water transfer main.**

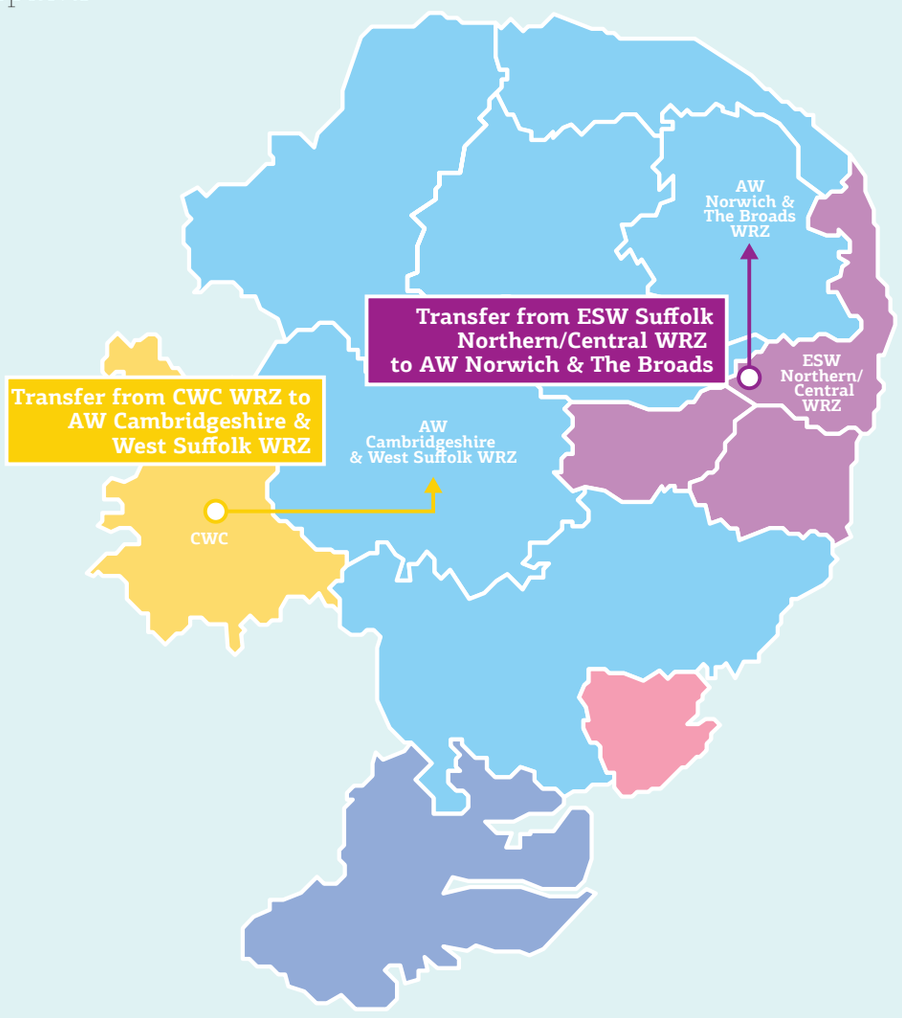
Table 4

Results of economic modelling

OPTION	AIC (£/Ml)	SELECTED	EXISTING WRMP OPTION
Abberton I ESW transfer to AW East Suffolk and Essex	3,306	No	Cliff Quay Effluent Reuse
Abberton II ESW transfer to AW East Suffolk and Essex	3,234	No	Cliff Quay Effluent Reuse and Alton-Horkesley Link
Abberton III ESW transfer to AW East Suffolk and Essex	3,506	No	Cliff Quay Effluent Reuse
ESW Transfer to AW Norwich and the Broads	649	Yes	Norwich Effluent Reuse
CWC Transfer to AW Cambridgeshire and West Suffolk	101	Yes	GOGS South Groundwater Development

Figure 10

Cost-effective options



Discussion

Our analysis of these results has considered a number of dimensions including customer and environmental benefits, sensitivity to scheme costs and bulk transfer charges, barriers to sharing or trading resources, and future opportunities for trading or sharing resources.

Customer and environmental benefits

As well as some small water resource savings, the two cost-effective options offered wider customer and environmental benefits. We anticipate they will offer capex savings, carbon savings and reduced impact on sites of conservation interest.

Overall, the capacity of the two new transfers is 6.3 Ml/d. This compares to a total WAFU (Water Available For Use) in the study area in 2034-35 of approximately 1,180 Ml/d.

Assuming delivery of the two transfers is possible, we anticipate the following customer and environmental benefits:

- **Customer benefits. Savings from replacement of the AW Norwich Reuse and Stanton Groundwater schemes will be:**
  – capex £28.184m
  – opex £445k/a.

  This assessment excludes the effect of bulk transfer charges which vary from underlying economic costs.
- **Environmental benefits. These comprise the following:**
  – Substitution of 1.3 Ml/d abstraction from a potentially scarce groundwater resource in the vicinity of Stanton with an increase in output from the existing Thetford well-field.
  – Carbon benefits equivalent to approximately 1,000t CO2e embodied carbon and 1,200t CO2e operational carbon per year. These savings arise principally from replacement of the AW Norwich Reuse scheme.
- **Local improvements in supply-system resilience for customers in the Thetford, Stanton, Bury St Edmunds and Norwich PZs.**

There are unlikely to be significant environmental benefits from replacement of the Norwich reuse scheme, since this relies on the capture and use of sewage treatment works discharge to tidal waters in the River Wensum.

It is important to note that the two transfers are not required until AMP8 (2025-30) and the feasibility of delivering them is subject to significant uncertainty. This includes whether or not sustainability reductions on the Wensum or in the Thetford well-field will result in the need for additional resource development or strategic transfers.

Scheme costs

Our work has enabled us to compare costs of water transfers based on robust engineering assessments with figures assumed in previous published high-level analyses performed by both Ofwat and Severn Trent Water. We calculate unit costs of transporting water that were substantially higher, in some cases by two or three times, than the unit costs that Ofwat's modelling appears to assume for schemes of a similar scale. Our unit costs are also substantially higher, by several times, than the 20p/Ml unit cost quoted by Severn Trent Water. However the derivation of this figure is not clear, particularly what scale of transfer has been assumed.

Our work therefore casts some doubt on the cost benefit analyses and suggests the importance of developing a more robust evidence base in relation to costs.

The projects will deliver carbon savings as well as customer and commercial benefits.

Sensitivity to scheme costs and bulk transfer charges

We conducted a series of sensitivity analyses to confirm that the results of the economic modelling were robust. These are summarised in Table 5 and show:

1. **The CWC – AW Cambridgeshire and West Suffolk option displays some sensitivity to bulk transfer charges; and**
2. **Selection of the ESW – AW Norwich and the Broads WRZ transfer is relatively insensitive to bulk transfer charges but potentially sensitive to assumptions about the minimum size of an effluent reuse scheme that could be developed in Norwich.**

The sensitivity to bulk transfer charges is something that will be important to consider further if trading opportunities are to be realised.

All else equal, trading should result in bulk transfer charges at which both trading parties would be willing to trade. These will fall somewhere between the cost of the transfer scheme to the exporter and the next cheapest alternative for the importer. Any factor, regulatory or otherwise, which causes the bulk charge to be set at level outside this range is likely to result in a sub-optimal decision. How bulk transfer charges are set is therefore important.

In our case study, switching of the CWC transfer and Stanton Groundwater options occurs at a tariff of between 20p/m^3 and 30p/m^3. As the current bulk supply tariff for CWC is 61p/m^3, charges for the transfer are likely to be a factor affecting the feasibility of this option.

Barriers to sharing or trading resources

Within the study area, significant volumes of resource are already either shared or traded. These are shown in Table 6 on page 17 and include up to 573 Ml/d of raw water and up to 68 Ml/d of treated water.

Collaborative planning has also been used in delivery of assets such as the CWC Thetford aqueduct to maximise benefits for customers supplied by different water companies.

These transfers have been achieved with few barriers to sharing or trading between water companies.

In completing the project, however, it has become apparent that future opportunities for sharing or trading water in the study area are likely to be limited by:

1. **A lack of surplus resource and the economics of transferring the small volumes that are available over long distances; and**
2. **Uncertainty about the impact of the EA 2012 CAMS update and Restoring Sustainable Abstraction (RSA) programme on deployable output. The effect of this is to leave companies not knowing whether they have surplus resources that could be shared or will need new resources, which could be developed cooperatively.**

Table 5
Results of sensitivity analysis

SCHEME	ASSESSED SENSITIVITY	EFFECT INVESTIGATED	RESULT
ESW – AW Norwich and the Broads WRZ transfer	Assumption that capex and opex for transfer is split in proportion to the ESW and AW need (2.5 Ml/d and 5 Ml/d respectively)	Whether use of capex and opex estimates for the full 7.5 Ml/d option result in the inter-company transfer being deselected	No change in scheme selection
	Assumption that Norwich Reuse scheme will deliver 10 Ml/d	Whether use of nominal capex and opex estimates for a 5 Ml/d Norwich reuse option result in the inter-company transfer being deselected	Scheme selection changed
	Bulk transfer charge (additional scheme opex)	Bulk transfer charge at which inter-company transfer is deselected in favour of existing WRMP scheme	Approximately 50p/m^3
CWC – AW Cambridgeshire and West Suffolk WRZ transfer	Bulk transfer charge (additional scheme opex)	Bulk transfer charge at which inter-company transfer is deselected in favour of existing WRMP scheme	Between 20p/m^3 and 30p/m^3

Difficulties with the RSA programme arise from several areas including classification of a large volume of sustainability reductions in our region as "potential", the length of time it takes to confirm whether or not these are needed, and the lack of alignment between the RSA programme and the WRMP process.

These uncertainties mean that companies are not able to identify the optimal solutions for managing the change that is needed. This problem is exacerbated by disagreement between Ofwat and the EA about the treatment of climate change effects.

Discussions between AW, ESW and CWC also identified other potential regulatory barriers to the sharing or trading resources. These include:

- **The EA process for approving the development and use of shared resources. This is cumbersome and time-consuming and additional complexity arises where the transfer involves movement of resources from one EA region to another, for example between the Thames/Southern Region and the Eastern Region; and**
- **The impact of bulk transfer charges on the opex efficiency assessment for the company receiving the transfer.**

Table 6
Examples where companies obtain water from "out-of area" sources

	Ml/d
CWC supplies to Cambridge from the Thetford well-field, which is located in the AW supply area	25
CWC supplies to the AW Cambridgeshire and West Suffolk WRZ, using the CWC Thetford aqueduct at Swaffham Prior	3
ESW supplies to the ESW Essex WRZ from the Abberton Reservoir, which is supported by the Ely-Ouse to Essex Transfer Scheme (EOETS) and the Great Ouse Groundwater Scheme (GOGS), both of which are operated by the EA using resources available in the AW supply area	455
VWE supplies to the AW East Suffolk and Essex WRZ, which are obtained from the jointly managed Ardleigh Reservoir	25
Bulk supplies that are traded between ESW and AW in the Tiptree PZ	2
Thames Water supplies to the ESW Essex WRZ, using an interconnection at Chigwell	118
AW supplies from the Great Bardfield source, which is located in the ESW supply area	13
Total	**641**

Future opportunities for trading or sharing resources

The WRMPs for AW, ESW and CWC all show the need to develop new resources at the end of the forecast period. Current plans suggest there are no surplus resources in the study area for direct abstraction under low flows, it is likely the supply-demand balance will be maintained using demand management in combination with wastewater reuse, winter storage, groundwater storage and transfers. In this scenario, most of the recycled wastewater will be pumped into rivers to support or increase reservoir yields.

The development of integrated storage and transfer systems in the study area offers many opportunities for the sharing or trading of resources and for designing market-type arrangements that promote flexible and efficient ways to mitigate the risk from climate change, growth and sustainability reductions. Several options are available, including:

- **A winter storage reservoir in central East Anglia that is filled using the surplus resources of the River Trent. This scheme would transfer water from the north and west of our region to resource-limited demand centres in the south and east. Through trading of the resource stored in the reservoir, water companies, farmers and the environment could all benefit from the development;**
- **Wastewater recycling, such as that used to support the ESW Hanningfield reservoir or that proposed in the AW WRMP for Ipswich and Norwich. Schemes of this type would see the development of resources in proximity to the major demand centres in the south and east, with potential carbon and opex benefits. Storage of the recycled water in the reservoirs in the study area (Langham, Hanningfield, Abberton, Ardleigh and Alton) and the development of inter-connecting assets could be used to drive an increase in resource trading; and**
- **Aquifer Storage and Recovery. The development of underground storage could generate resources that are available at a local scale for trading or sharing. These could be used to mitigate the effects of climate change and growth.**

Since delivery of large infrastructure projects, such as a winter storage reservoir, may take up to 20 years, detailed evaluation of the options for maintaining the long-term supply-demand balance is a priority. Given the current debate, this work needs to encompass arrangements for the sharing or trading of the resources that become available, including with the agricultural and environmental sectors.

Emperor dragonfly

Conclusions

In collaborating on this groundbreaking project, we have explored the practical implications of water trading as a potential answer to one of the biggest challenges facing the future of water resource management. Key conclusions are made below.

1 The most significant constraints to sharing water resources in East Anglia are physical and cost related rather than due to any artificial regulatory or legislative barriers. Our work suggests that the costs of water transfers may be substantially higher than assumed in previous high-level analysis and suggests the need for a more robust evidence base.

2 The relatively small volumes of surplus water available, and the cost of transferring these long distances, would not offer a cost-effective or environmentally sustainable solution, even when taking into account displacement.

3 Whether or not optimal water transfers will take place depends on the prices charged for the bulk water transferred. If bulk prices are restricted from moving to the price that would be struck between willing trading partners, for regulatory or any other reasons, then sub-optimal outcomes are likely.

4 Further obstacles to trading, and hindrances to long-term planning, are caused by uncertainty as to the water available. More precisely this is in relation to the process for determining definitive sustainability reductions under the EA's ongoing Restoring Sustainable Abstraction programme. This results in companies being unsure of their future deployable output and thereby not knowing whether they have surplus resources (which could be shared) or will need to develop new resources (which could be developed cooperatively).

5 Our analysis supports the view that current Water Resources Management Plans are robust and provide a sound basis for planning.

6 Nevertheless, we believe that there may be more opportunities for water trading in the longer term. During this case study we have identified fewer than expected schemes where sharing or trading options might offer a benefit relative to current company plans. These relate to long-term plans – schemes scheduled for the period 2025-2030 – rather than anything more imminent.

7 By looking at a very real and practical issue in East Anglia we have discovered that the scope for economic trading in the short-term may be less than had previously been assumed. However there may be long-term opportunities and it's absolutely essential that any further consideration of water trading is rooted in real and practical case studies and disincentives to trade are avoided.

8 When we look further ahead and consider the extended planning horizon – beyond 2035 – a raft of solutions will need to be developed to meet future needs. It is possible that we will need to look at bringing water from further afield and there will then be opportunities to develop sharing or trading options. These are likely to involve the delivery of strategic storage (reservoir storage and groundwater storage) and strategic infrastructure, and the use of this to mitigate growth, climate change and sustainability reduction risks. Continuing cross-company collaboration and joint working with the EA seems the best route to plan for this.

Positive next steps

We believe collaborative working will be essential between all parties involved and that there are several key areas to consider in taking positive next steps.

1 We would encourage further collaborative work in other regions to consider the long-term resource position extending beyond the horizon of WRMPs and the potential prospects for trading. Further detailed empirical work is required to test assumptions and challenge theories.

2 We are pleased that Ofwat has identified the equalisation of opex and capex incentives in order to remove disincentives to trading. The price paid by the receiving company for water transfers, which becomes an operating cost for the purpose of price setting and comparative efficiency under current arrangements, could prove to be a barrier to trading and hence drive sub-optimal investment.

3 We are committed to making meaningful progress on developing our strategic plans for 2035 and beyond. To achieve this we are keen to work with the Environment Agency and government on addressing the scale of uncertainty in sustainability reductions in abstraction rights. There is an urgent need to pick up the pace of progress on this, and a statement of government policy would greatly assist this process.

4 In this region we already have a track-record of collaborative working and resource trading across water companies. It is our intention that this will continue and will play a role in providing solutions for the challenges we face in the extended planning horizon.

5 Consequently, we do not believe enforced trading is the answer and would welcome the removal of barriers to water trading and the introduction of incentives to encourage it.

6 The possible scale and scope of investment required to transfer water into the East Anglian region in the longer term will raise many complex social, environmental, political and economic issues. In our view a cooperative approach involving water companies working in partnership with government may be very well suited to meeting this challenge. An analogy may be drawn to the situation in the energy sector where the demands of energy security require government to set a clear policy framework and to work collaboratively with the industry and its regulator to achieve the desired policy goals. Increasing the role of market forces in delivering strategic investment of substantial scale over a long period will require careful thought.

This project has provided detailed evidence on the practicalities of water trading in one of the fastest growing areas in the UK which is also most vulnerable to the impacts of climate change. We hope it will provide a valuable contribution to the wide ranging debate around meeting the challenges of future water resource management.

Glossary and abbreviations

	DEFINITION
Baseline forecast	A supply-demand balance forecast that assumes no additional investment in options to reduce demand or increase supply beyond our existing level of activity.
Catchment abstraction management strategies (CAMS)	CAMS is the vehicle for reviewing time-limited licences, determining whether they should be renewed and on what terms. It assesses how much water is reliably available on a catchment by catchment basis. CAMS was developed by the EA following the government's decision to apply more control on how much water is taken from our water sources.
Deficit	When available water resources are less than total demand plus target headroom requirements.
Restoring Sustainable Abstraction (RSA)	RSA is a programme of work that identifies, investigates and solves environmental risks or problems caused by unsustainable licensed water abstraction throughout England and Wales.
Water available for use (WAFU)	The value calculated by deducting allowable outages and planning allowances from deployable output.
Water resource zone (WRZ)	EA Definition: "The largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which all customers experience the same risk of supply failure from a resource shortfall."
Water resources management plan (WRMP)	This is closely related to the Ofwat Periodic Review process and also operates on a similar five yearly cycle of review. It is the key regulatory submission to Defra and the EA, setting out our detailed current and forecast water resources needs and investment proposals. By amendment to the Water Act 2003, this is now a statutory document, open to public consultation, and requires the approval of the Secretary of State. More focus is placed on the environmental impact of the business plan, and the WRMP is accompanied by a Strategic Environmental Assessment (SEA) report.

OTHER ABBREVIATIONS	
£/Ml	Pounds per megalitre
AMP	Asset Management Plan
AW	Anglian Water
CWC	Cambridge Water Company
ESW	Essex & Suffolk Water
GOGS	Great Ouse Groundwater Scheme
EOETS	Ely-Ouse to Essex Transfer Scheme
VWE	Veolia Water East (Formerly Tendring Hundred Water Services)
WTW	Water Treatment Works
WWTW	Wastewater Treatment Works

Appendix 1: Exclusions

Excluded from the project scope were the following:

1. AMP5 schemes: the study assumes that agreed investment plans for AMP5 have been committed and will deliver the assumed benefits (Ml/d).
2. Northern, western and south western parts of the AW supply area: these are excluded because:
   a. Thames Water has yet to publish its Final WRMP and, as a consequence, there is significant uncertainty about needs and opportunities in the Thames and Veolia Water Central (VWC) areas that adjoin AW, CWC and ESW;
   b. There is significant uncertainty about the scale of future sustainability reductions in the VWC supply area; and
   c. The supply-demand balance in the Lincolnshire WRZs is secured by AMP5 schemes.
3. Explicit consideration of VWE needs and related opportunities: this reflects co-participation in the Ardleigh Reservoir Committee and current arrangements for trading the resources of Ardleigh Reservoir. It is assumed that, when required, these will be used to deliver the VWE-AW East Suffolk and Essex WRZ transfer that is identified in the recent Ofwat study.
4. Bulk transfer charges: this follows from the assumption that the study area is a single supply region with no internal cost-boundaries. Tariff charges have been used, however, to assess the sensitivity of the modelling outcomes.
5. Future sustainability reductions: the potential exists for significant sustainability reductions in the study area in AMP6 and beyond. However, these have yet to be confirmed and so have been excluded from the study. Of significance is the following:
   a. 29 Ml/d reduction in abstraction from the River Wensum at Costessey Pits, near Norwich. This is scheduled to be determined in AMP6 and, in combination with an equivalent 20 Ml/d reduction in AMP5, would drive a complete re-evaluation of our supply strategy for the Norwich and the Broads WRZ. Since options for restoring the resulting deficit would include sub-regional transfers, this will also lead to a re-evaluation of the supply-demand strategies for the AW Fenland, Norfolk Rural and North Norfolk Coast WRZs and, potentially, the ESW Suffolk Northern/Central WRZ; and
   b. Possible reductions in output from the CWC Thetford well-field.
6. Climate change impacts using UKCP09 outputs, including the WAFU reductions in the study area that are described in the Final WRMPs.

Appendix 2: Baseline Forecast Supply-Demand Data

Table 7
Cambridge Water Company investment need and WRMP schemes

WATER RESOURCE ZONE	DRY YEAR ANNUAL AVERAGE BASELINE SUPPLY-DEMAND BALANCE (2034-35 – Ml/d)	POST AMP5 SUPPLY-SIDE SCHEMES (AMP)	COMMENT
Cambridge Water Company	1.36	n/a	n/a
Veolia Water East	2.44	n/a	n/a

Table 8
Anglian Water investment need and WRMP schemes (eastern region)

WATER RESOURCE ZONE	DRY YEAR ANNUAL AVERAGE BASELINE SUPPLY-DEMAND BALANCE (2034-35 – Ml/d)	POST AMP5 SUPPLY-SIDE SCHEMES (AMP)	COMMENT
Fenland	5.26	Stoke Ferry Extension (AMP7)	Selected to avoid local deficits in the Feltwell PZ
North Norfolk Coast	-3.75	Secondary Groundwater Use (AMP6)	Local deficits supported by transfers
Norwich and the Broads	-7.78	Norwich Urban Source (AMP6)	Schemes needed for the Norwich PZ
		Mousehold WTW Extension (AMP7)	
		Norwich Reuse (AMP8)	
Norfolk Rural	-3.25	Norwich Transfer (AMP8)	
Cambridgeshire and West Suffolk	-2.58	Groundwater development (AMP8)	Local deficits supported by transfers
East Suffolk and Essex	-30.44	Cliff Quay Effluent Reuse (AMP6)	Local deficits supported by transfers

Table 9
Essex and Suffolk Water investment need and WRMP schemes

WATER RESOURCE ZONE	DRY YEAR ANNUAL AVERAGE BASELINE SUPPLY-DEMAND BALANCE (2034-35 – Ml/d)	POST AMP5 SUPPLY-SIDE SCHEMES (AMP)	COMMENT
Essex	-63.52		AMP5 Abberton scheme will deliver 64 Ml/d WAFU on completion
Suffolk Northern/Central	-4.19	North Lowestoft Groundwater	Delivery of the scheme results in a ~2.5 Ml/d surplus at the end of the forecast period
Suffolk Blyth	1.75		
Suffolk Hartismere	-0.33		Deficit avoided using demand management

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