Our PR24 Enhancement Strategies

Part 1: Resilient to the risk of drought and flood

October 2023

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Resilient to the risks of flood and drought

1 Overview

1.1 Overview

This document sets out the enhancement investments that we propose to make to help us achieve the ambitions set out in our Strategic Direction Statement. This specific section sets out investment to make the east of England resilient to the risks of drought and flooding. We have extended this aim to also reflect the need to adapt to climate change, broader hazards such as cyber security and risks to drinking water quality, consistently a top priority for our customers.

We've looked at how, across both water and water recycling, our proposed AMP8 investment can contribute to this ambition. Our enhancement proposals help to achieve this ambition through:

- Resilience to the risks of drought: through investments in interconnectors (section 2), supply-side improvements (section 3) , and strategic resource solutions (section 4)
- Resilience to the risks of flooding: through investments in storm overflows (section 5), increasing flow to full treatment (FFTs) and storm tanks (section 6), and reducing flooding risk at properties (section 7)
- Resilience to the risks from wider hazards such as climate change: through investments in water resilience (section 8), Odour and water recycling resilience (section 9), and security (section 10)
- Resilience to drinking water quality risks: through investments in addressing raw water deterioration (section 11), lead reduction (section 12) and improvements to taste, odour and colour (section 13)

1.1.1 Guide to our enhancement strategies

Each of the enhancement strategies aligns relates to costs presented in our data table submissions. The table below sets out how each section of our enhancement proposals presented in this document maps to enhancement cost tables.

Table 1 Our PR24 'Making the East of England resilient to the risk of flood and drought' Enhancement Strategies

Enhancement strategy	Costs data table references
Interconnectors (section 2)	CW3.50-CW3.52 (Interconnectors delivering benefits in 2025-2030) CW12.50-CW12.52 (Interconnectors delivering benefits in 2025-2030)
Supply-side improvements (section 3)	CW3.41-CW3.43 (Supply-side improvements delivering benefits in 2025-2030) CW3.53-CW3.55 (Supply demand balance improvements delivering benefits starting from 2031) CW12.41-CW12.43 (Supply-side improvements delivering benefits in 2025-2030) CW17.41-CW17.43 (Supply-side improvements delivering benefits in 2025-2030)
Strategic Resource Solutions (section 4)	CWW3.183-CWW3.184 (SROs)
Storm overflows (section 5)	Part of CWW3.16- CWW3.18 (Increase storm tank capacity at STWs - grey solution; (WINEP/NEP)) [£154.2m capex, £1.5m opex] CWW3.19-CWW3.21 (Increase storm system attenuation / treatment on a STW - green solution; (WINEP/NEP)) CWW3.22-CWW3.24 (Storage schemes to reduce spill frequency at CSOs etc - grey solution; (WINEP/NEP)) CWW3.31-CWW3.33 (Storm overflow - increase in combined sewer / trunk sewer capacity; (WINEP/NEP)) CWW3.34-CWW3.36 (Storm overflow - sustainable drainage / attenuation in the network; (WINEP/NEP)) CWW3.37-CWW3.39 (Storm overflow - source surface water separation; (WINEP/NEP))

Enhancement strategy	Costs data table references
	CWW3.43-CWW3.45 (Storm overflow - sewer flow management and control; (WINEP/NEP)) CWW3.46-CWW3.48 (Storm overflow - new / upgraded screens (WINEP/NEP)) CWW17.16- CWW17.18 (Increase storm tank capacity at STWs - grey solution; (WINEP/NEP)) CWW17.19-CWW17.21 (Increase storm system attenuation / treatment on a STW - green solution; (WINEP/NEP)) CWW17.31-CWW17.33 (Storm overflow - increase in combined sewer / trunk sewer capacity; (WINEP/NEP)) CWW17.34-CWW17.36 (Storm overflow - sustainable drainage / attenuation in the network; (WINEP/NEP))
Increasing FFTs and storm tanks (section 6)	CWW3.13-CWW3.15 (Increase flow to full treatment; (WINEP/NEP) Part of CWW3.16- CWW3.18 (Increase storm tank capacity at STWs - grey solution; (WINEP/NEP)) [£34.4m capex, £2.5m opex]
Reducing flooding risk for properties (section 7)	CWW3.156-CWW3.158 (Reduce flooding risk for properties)
Resilience (water) (section 8)	CW3.118-CW3.120 (Resilience)
Odour and resilience (water recycling) (section 9)	CWW3.165-CWW3.167 (Odour and other nuisance) CWW3.168-CWW1.170 (Resilience)
Security (water & water recycling - NIS & SEMD) (section 10)	CW3.121-CW3.123 (Security - SEMD) CW3.124-CW3.126 (Security - Cyber) CW3.138-CW3.139 (DWI ECAF) CWW3.171-CWW3.173 (Security - SEMD) CWW3.174-CW3.176 (Security - cyber)
Addressing raw water deterioration (section 11)	CW3.97-CW3.99 (Addressing raw water quality deterioration) CW3.132-CW3.133 (PFAS)
Lead reduction (section 12)	CW3.103-CW3.105 (Conditioning to reduce plumbosolvency for water quality) CW3.106-CW3.108 (Lead communication pipes replaced or relined) CW3.109-CW3.111 (External lead supply pipes replaced or relined) CW3.112-CW3.114 (Internal lead supply pipes replaced or relined) CW3.115-CW3.117 (Other lead reduction related activity)
Improvements to taste. odour and colour (section 13)	CW3.91-CW3.93 (Improvements to taste, odour and colour)

The structure of each individual enhancement strategy is aligned to Ofwat's enhancement criteria set out in chapter A1 of appendix 9 of the Final Methodology (Setting expenditure allowances). The table below sets out how each sub-heading maps across to the enhancement criteria. Our enhancement strategies should should be read alongside chapter 7 of our business plan which sets out an overview of how we have approached our enhancement investment plan overall.

Table 2 Enhancement strategy structure

Enhancement strategy sub-section heading	Enhancement assessment criteria
Delivering for the long term	**A1.1.1 Need for enhancement investment**
Investment context	a) Is there evidence that the proposed enhancement investment is required (ie there is a quantified problem requiring a step change in service levels)? This includes alignment agreed strategic planning framework or environmental programme where relevant.
Scale and timing	b) Is the scale and timing of the investment fully justified, and for statutory deliverables is this validated by appropriate sources (for example in an agreed strategic planning framework)?
Interaction with base expenditure	c) Does the proposed enhancement investment or any part of it overlap with activities to be delivered through base, and where applicable does the company identify the scale of any implicit allowance from base cost models?
Long term context (historic)	d) Does the need and/or proposed enhancement investment overlap or duplicate with activities or service levels already funded at previous price reviews (either base or enhancement)?
Long term context (future)	e) Is the need clearly identified in the context of a robust long-term delivery strategy within a defined core adaptive pathway?
Customer support	f) Where appropriate, is there evidence that customers support the need for investment (including both the scale and timing)?
Cost control	g) Is the investment driven by factors outside of management control? Is it clear that steps been taken to control costs and have potential cost savings (eg spend to save) been accounted for?
Unlocking greater value for customers, communities and the environment	**A1.1.2 Best option for customers**
Option consideration	a) Has the company considered an appropriate number of options over a range of intervention types (both traditional and non-traditional) to meet the identified need?
Cost-benefit analysis	b) Has a robust cost-benefit appraisal been undertaken to select the proposed option? Is there evidence that the proposed solution represents best value for customers, communities and the environment over the long term? Is third-party technical assurance of the analysis provided?
Environmental and social value	c) In the best value analysis, has the company fully considered the carbon impact (operational and embedded), natural capital and other benefits that the options can deliver? Has it relied on robustly calculated and trackable benefits when proposing a best value option over a least cost one?
Investment benefit	d) Has the impact (incremental improvement) of the proposed option on the identified need been quantified, including the impact on performance commitments where applicable?
Managing uncertainty	e) Have the uncertainties relating to costs and benefit delivery been explored and mitigated? Have flexible, lower risk and modular solutions been assessed - including where forecast option utilisation will be low?

Enhancement strategy sub-section heading	Enhancement assessment criteria
External funding	f) Has the scale of forecast third party funding to be secured (where appropriate) been shown to be reliable and appropriate to the activity and outcomes being proposed?
Direct procurement	g) Has the company appropriately considered the scheme to be delivered as Direct Procurement for Customers (DPC) where applicable?
Customer view	h) Where appropriate, have customer views informed the selection of the proposed solution, and have customers been provided sufficient information (including alternatives and its contribution to addressing the need) to have informed views?
Cost efficiency	**A1.1.3 Cost efficiency**
Developing costs	a) Is it clear how the company has arrived at its option costs? Is there supporting evidence on the calculations and key assumptions used and why these are appropriate?
Benchmarking	b) Is there evidence that the cost estimates are efficient (for example using similar scheme outturn data, industry and/or external cost benchmarking)? d) Is there compelling evidence that the additional costs identified are not included in our enhancement model approach? e) Is there compelling evidence that the allowances would, in the round, be insufficient to account for evidenced special factors without an enhancement model adjustment? f) Is there compelling econometric or engineering evidence that the factor(s) identified would be a material driver of costs?
Assurance	c) Does the company provide third party assurance for the robustness of the cost estimates?
Customer protection	**A1.1.4 Customer protection**
	a) Are customers protected (via a price control deliverable or performance commitment) if the investment is cancelled, delayed or reduced in scope? b) Does the protection cover all the benefits proposed to be delivered and funded (eg primary and wider benefits)? c) Does the company provide an explanation for how third-party funding or delivery arrangements will work for relevant investments, including how customers are protected against third-party funding risks?

Naturally, some of the information we highlight is relevant to more than one of these enhancement criteria, and so each enhancement investment should be read as a whole. In some sub-sections we go beyond the specific enhancement assessment criteria to provide additional relevant context where needed. For example, in some 'Long-term context (historic)' sections, we highlight not just the expenditure from previous price reviews, but also the activities and performance delivered in earlier AMPs.

2 Interconnectors

Overview

As set out in our Water Resources Management Plan, we face significant challenges in balancing supply and demand. In particular driven by licence caps and to support the environmental ambition to further reduce unsustainable abstraction from watercourses. Growth in our region also drives the need, but is offset by our demand management programme. This long term strategy to secure resilient water supplies for the region is adaptive, allowing us to respond to changing needs and pressures.

As part of this long term strategy we have looked to consider as wide a range of solutions as feasibly possible, before developing a plan which meets the needs of the supply demand balance, whilst providing best value for our customers, stakeholders and the environment. Drawing on our industry leading experience and vision in AMP7, we will continue our interconnector strategy by installing pipelines, an investment worth £534m. Our AMP7 experience has also led to us phasing some of the interconnectors into AMP9, a seven year delivery programme to reflect the complexities associated with these investments.

A summary of our planned interconnectors is shown in the table below, these will move water from areas in surplus to those in deficit, helping to secure a reliable supply of water across all areas of our region whilst limiting the need to take more water from the environment.

Table 3 PR24 interconnector schemes

Scheme	Capacity of interconnector (Ml/d)	Water available for use (WAFU) benefit (Ml/d)	AMP 8 Totex (£m)
CAM4 - Ruthamford South to Cambridge Water potable transfer	50	50	54.6
SWC8 - Cambridge Water to Cambs and West Suffolk	50		136
LNC25 - Lincolnshire East to Lincolnshire Central potable transfer	29	29	69.8
NBR6 - Fenland to Norfolk Bradenham potable transfer	45	45	104.3
NTB10 - Norfolk Bradenham to Norwich and the Broads potable transfer	20		82.4
NAY1 - Norwich and the Broads to Aylsham potable transfer	3		14.8
NEH3 - Suffolk Thetford to Norfolk East Harling potable transfer	5	5	20.3
NHL4 - Norfolk East Harling to Norfolk Harleston potable transfer	5		25.2
SUE24 - Suffolk Sudbury to East Suffolk potable transfer	10*	19	7.7
EXC3 - Essex South to Essex Central potable transfer	10	10	9.7
East Suffolk WRZ IPZ	7.81	-	7.6

Scheme	Capacity of interconnector (Ml/d)	Water available for use (WAFU) benefit (Ml/d)	AMP 8 Totex (£m)
Strategic Interconnector Hydraulic Model	-	-	1.8
	Total		534.2

*Please note our revised draft WRMP has reduced the capacity of SUE24 from 10 to 5MLD. This change came too late to adjust our PR24 totex and so as noted in table commentary for CW8 we will adjust this after our Draft Determination.

On benchmarking, we have used key sources of evidence to benchmark the costs of our interconnectors programme: scheme forecast outturn data, benchmarking of interconnectors delivered in AMP7, and external benchmarking of proposed costs for AMP8 (carried out by Arup). From this evidence, we have confidence that the costs we have estimated for our PR24 interconnector programme, are efficient based on the findings of benchmarking exercises by Arup.

Table 4 Investment Summary

PR24 costs (£m)	
Capex	532.6
Opex	1.5
Totex	534.1
Benchmarking	
Method	Scheme outturn costs Asset level cost comparison with other companies
Findings	In the process of our cost benchmarking activity, we identified opportunities to reduce the costs included in our plan. This removed £210m of interconnector costs. Final benchmarking found our costs to be efficient.
Customer Protection	
Price Control Deliverable	Water available for use (WAFU) in Water Resource Zones (WRZ)
Ofwat data table	
CW3.50-CW3.52	Interconnectors delivering benefits in 2025-2030
CW12.50 CW12.52	Interconnectors delivering benefits in 2025-2030

2.1 Delivering for the long term

2.1.1 Investment context

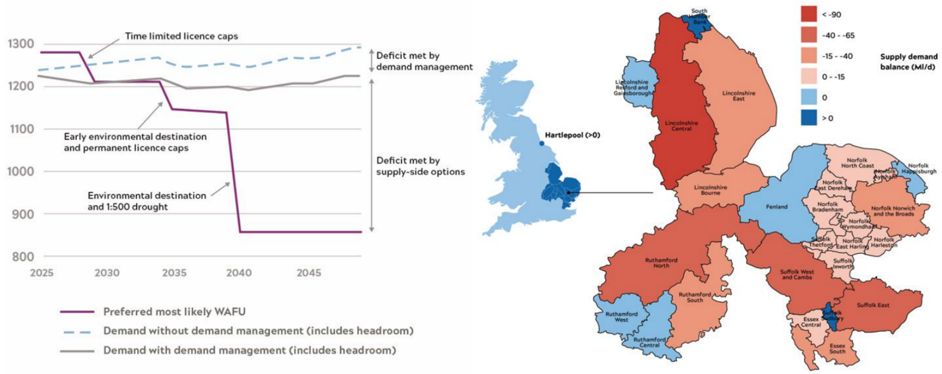
Our revised draft WRMP24 sets out how we will maintain a sustainable and secure supply of drinking water for our customers over the period of 2025 to 2050. This long-term view allows us to plan an affordable, sustainable pathway that provides benefit to our customers, society and the environment.

Our 25-year strategy has been driven by the challenges of growth, climate change, resilience to a 1 in 500 year drought, environmental destination, and licence capping. A summary of these challenges, with their forecasted impacts by 2050, is provided below:

- The implementation of further abstraction licence capping across our region (a 134 Ml/d reduction in water available for use). The reduction in Hartlepool is 7 Ml/d.
- Moving beyond statutory licence cap obligations to our environmental destination, further reducing the amount of water we take from sensitive environments. It is forecasted that this will reduce the amount of water we have to use by 241 Ml/d. There is no impact in Hartlepool.
- Achieving enhanced resilience to drought, building on our previous investments to become robust to an extreme 1 in 500 year drought; an impact of 70 Ml/d. There is no impact in Hartlepool.
- Adapting to climate change, and the impacts of the hotter, drier summers and warmer, wetter winters on our water resources. The expected impact is 10 Ml/d on top of the climate change impact. There is no impact in Hartlepool.
- We also expect an increased demand for water of 138 Ml/d by 2050, with our region's population forecasted to grow by 911,000 people.

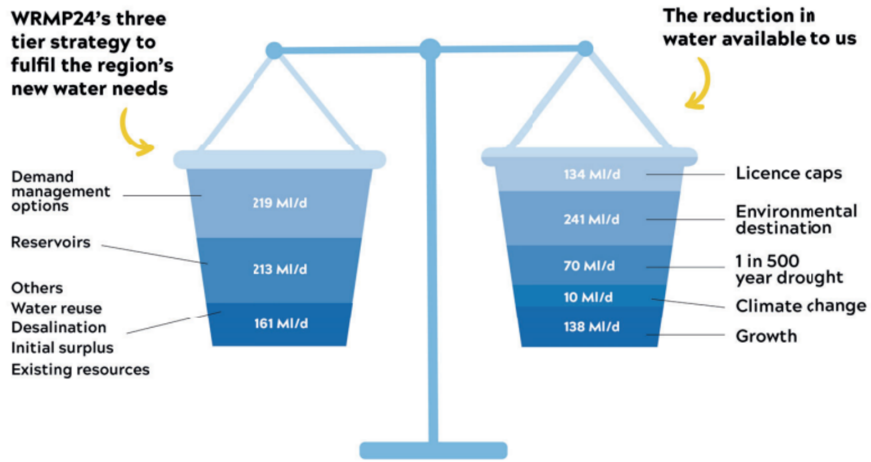
The impact of these challenges is shown in our supply demand balance, in Figure 1 below.

Figure 1 WRMP24 supply demand balance



This shows that without any action by 2050, we will experience a shortfall of 593 Ml/d; that's equivalent to approximately half the amount of water we put into our network currently.

Figure 2 Meeting our challenges for the WRMP24



To tackle this shortfall in water for the next 25 years, we have adopted a three-tiered strategy:

1. We will make the best use of our existing resources, building on our industry leading demand management and using any surplus water available.
2. The progression of the strategic resource options (SROs): the Fens and Lincolnshire reservoirs.
3. Planning for adaptive future resources, allowing us to remain flexible to changing circumstances, whilst ensuring we limit bill impacts to our customers by only investing in low regret solutions.

This strategy is central to this business plan, using demand management in AMP8 to reduce the shortfall in water available. However, even with the continuation of our industry-leading smart metering strategy, and its associated benefits (detailed in 'Enhancement Strategies 'Enabling sustainable economic growth'' section 2 'Metering') between 2025 and 2030, we will still have a deficit of 46 Ml/d by 2030, which will immediately become much larger as caps are applied to our permanent licences.

This means to fulfil our legal obligation, as a water undertaker, of providing water for domestic purposes, we must invest in interconnectors in AMP8. These interconnectors will allow us to unlock surplus in our WRZs (including that created through the AMP8 supply-side enhancements detailed in 3 Supply-side improvements) and move it to areas in deficit.

2.1.2 Scale and timing

Our WRMP is a 25 year adaptive plan, produced every five years and reviewed annually. It is developed by following the Water Resources Planning Guideline (WRPG), as well as other relevant guidance and legislation, ensuring it meets statutory requirements. Following the WRPG and WRMP Directions has also established a best value planning framework where we take into account the views of customers and stakeholders.

In developing the WRMP, we have worked with regulators, customers and stakeholders to appraise our supply-side options. This options appraisal process highlighted that we have limited new water supplies available to us as, operating in the driest region in England, there is hardly any surplus water which we can take from the environment. There are also limited opportunities to trade and share water resource with other water companies and sectors as abstraction reform and climate change considerations apply across all water resources.

This limited resource means that we must turn to supply-side options that are relatively new to the United Kingdom's water industry; these options have long-lead times due to the environmental investigations and design work that is needed.

This means for AMP8 we will build on our AMP7 strategy of utilising existing resource and moving it to where it is needed through interconnectors. These investments can be delivered within AMP8, ensuring our customers remain on resilient water supplies and allowing us the opportunity to develop new resources such as raw water reservoirs, water reuse and desalination.

This enhancement investment has been developed using our Economics of Balancing Supply and Demand model (EBSD), as well as our best value plan metrics. All of the proposed interconnectors, apart from NAY1 (section 2.2.2 sets out why NAY1 has been included in our plan), were selected as part of the least cost plan development.

We carefully considered if any of the interconnector investments could be phased to support the deliverability of our AMP8 plan, and requested Accelerated Infrastructure Development expenditure for CAM4 Ruthamford South to Cambridge Water and SWC8 Cambridge Water to Cambridge and West Suffolk. As this request was declined, we have phased the delivery of these mains so they are completed in the early part of AMP9. This will also spread some of the bill impact of these complex mains. We are currently in discussions with Ofwat, Defra and the EA (via letters and meetings) regarding the deliverability of interconnector schemes. We are currently proposing a 2032 delivery date for the Grafham to Rede section of the interconnectors programme, however this is dependent on environmental obligations matching this timing.

More significant phasing (i.e. by three years or more) in AMP9 would lead to a change in the supply-side solution set required in AMP8 and subsequently a requirement for the installation of larger mains than required. Phasing beyond that included in our plan would also create an unresolved deficit in AMP9. This would mean delaying licence capping but in some locations, this would not reduce the deficit. Therefore, the scale and timing of the interconnector investments represent the best value, low-regret solutions with optimal alignment with other supply and demand components of the WRMP.

2.1.3 Interaction with base expenditure

All of the interconnector investment relates to the installation of new assets that will deliver a step-change in the benefits that are required to ensure we continue to meet demand for water in our region in the face of climate change, environmental protection and growth. Similar to the treatment of interconnectors at PR19, no implicit allowance is made within the base models for this investment.

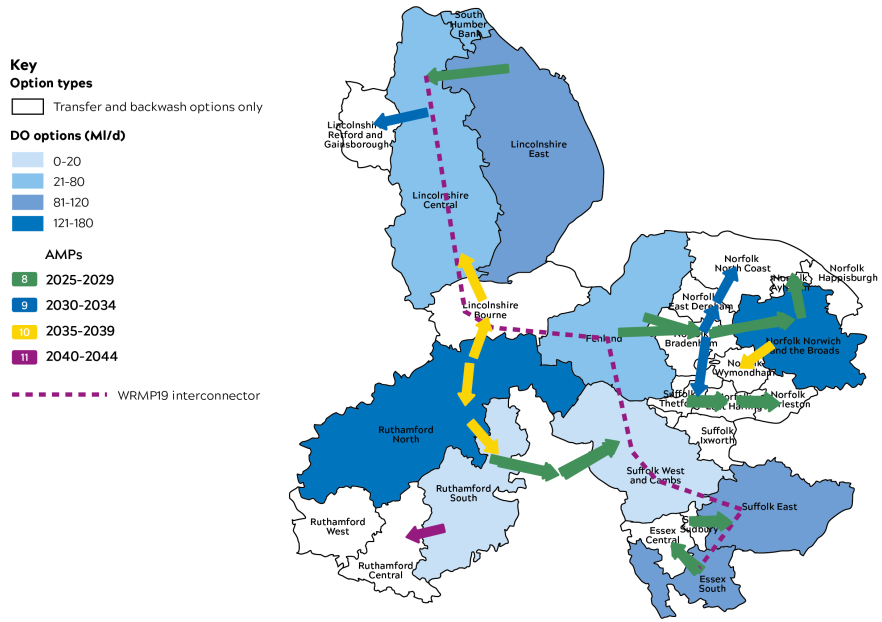
The costs to maintain the interconnector investments from previous AMPs are base costs and have not been included these in our proposed enhancement investments.

2.1.4 Long term context (historic)

Our Plan's interconnector programme builds on the investment included in the PR19 programme, expanding the interconnectivity of our region to allow further flexibility in the supply-side solutions available in future. The PR24 programme of investment is entirely distinct from the PR19 interconnector programme, with no overlap between the schemes for which an allowance was made at PR19 and what is required as part of our PR24 programme. The table below sets out the interconnectors allowed as part of our PR19 determination and those proposed as part of our PR24 programme.

Our PR24 enhancement investment programme only funds the schemes in the right-hand side column of the PR19 and PR24 interconnector schemes table There is no overlap with the schemes in the left hand column, which were funded at PR19. We show how we build on our PR19 investment and strategy in the figure below [1].

Figure 3 WRMP24 transfers



1 Note that some construction for CAM4 and SWC8 is in AMP9.

Table 5 PR19 and PR24 interconnector schemes

PR19	PR24
SLN6 -Central Lincolnshire WRZ to South Lincolnshire WRZ	CAM4 - Ruthamford South to Cambridge Water potable transfer
RTN27 - South Lincolnshire WRZ to North Ruthamford WRZ	SWC8 - Cambridge Water to Cambs and West Suffolk
SFN4 - North Ruthamford to South Fenland	LNC25 - Lincolnshire East to Lincolnshire Central potable transfer
NFN4 - South Fenland WRZ to North Fenland WRZ	NBR6 - Fenland to Norfolk Bradenham potable transfer
ELY9 - North Fenland WRZ to Ely WRZ	NTB10 - Norfolk Bradenham to Norwich and the Broads potable transfer
NWM6 - Ely WRZ to Newmarket WRZ	NAY1 - Norwich and the Broads to Aylsham potable transfer
CVY1 - Newmarket WRZ to Cheveley WRZ	NEH3 - Suffolk Thetford to Norfolk East Harling potable transfer
BHV5 - Newmarket WRZ to Bury Haverhill WRZ	NHL4 - Norfolk East Harling to Norfolk Harleston potable transfer
ESU8 - Bury Haverhill to East Suffolk WRZ	SUE24 - Suffolk Sudbury to East Suffolk potable transfer
SEX4 - East Suffolk to South Essex WRZ	EXC3 - Essex South to Essex Central potable transfer
HPB1 - Norwich& the Broads to Happisburgh WRZ	East Suffolk WRZ IPZ
NTM1 - Central Lincolnshire WRZ to Nottinghamshire WRZ	
BHV Intra RZ - Bury Haverhill to Haverhill PZ	
RTC2 - Ruthamford South WRZ to Ruthamford Central WRZ	
North Norfolk Rural WRZ - Diddlington PZ	
RTS Intra Ruthamford South WRZ - Woburn PZ	
NNR8 - Norwich & the Broads WRZ to North Norfolk Rural WRZ	
THT1 - Bury Haverhill WRZ to Ixworth WRZ, Ixworth WRZ to Thetford WRZ	
RTS Intra Ruthamford South WRZ -Meppershall PZ	
SHB2b - Transfer from Pyewipe to non-potable network	
Norwich & the Broads WRZ to North Norfolk Rural WRZ - E Ruston	

AMP7 Challenges

Cost and time pressures continue to materially affect the AMP 7 Strategic Interconnectors programme. We are currently forecasting an overspend of around £347m against the £563m totex allowance (adjusted to 22/23 price time basis). Both AMP7 and AMP8 interconnectors are once in a generational assets.

We have mitigated the impact of global supply chain issues, caused by Covid and conflict in Ukraine by purchasing 100% of the steel pipes required for the interconnector. These large diameter pipes are being laid at record rates, following delays from planning authorities. Our experience on the delivery of this strategic interconnector portfolio, tells us that in the development phase of these "once in a generation assets", there is a significant degree of interdependency between the current supply and distribution operation providing wholesome drinking water, and the very high volume of demand and flexibility required to get these assets into service.

As a result, we will need to work closely with the Environment Agency to mitigate the risk posed to our current and future portfolio of interconnectors which is likely to include abstraction licensing arrangements. This includes a need for licence flexibility on the transition between AMP7 and AMP8, reflecting the knock-on consequences from changes in the Environment Agency's abstraction policy published in November 2021, outcomes from WINEP investigations, impacts of the Covid pandemic on demand, delays to planning decisions from local planning authorities and the consequences of the war in Ukraine which has impacted our supply chain both in terms of volatility and imposed government sanctions.

Although the AMP7 delivery issues have presented significant challenges, we have not requested an enhancement allowance for any of the interconnectors that we received an enhancement allowance for at PR19.

2.1.5 Long term context (future)

Our core pathway for WRMP24 includes: the interconnectors that need to be delivered in AMP8 to connect WRZs to the WRMP19 interconnectors, the supply-side investments detailed in 3 Supply-side improvements, a water reuse scheme required in AMP9 with development started in AMP7 as part of the Accelerated Infrastructure Development programme, continued development of the Fens and Lincolnshire reservoirs, and our demand management strategy.

This core pathway has been tested, using the common reference scenarios, for robustness to future uncertainty through sensitivity and stress testing, as well as least worst regrets analysis. We also conducted modelling to generate alternatives, to add further robustness.

This testing showed us that:

- The AMP8 supply-side schemes remained the same, apart from a treatment works upgrade, when tested with Ofwat's basic low climate change scenario. We don't believe this scenario is an appropriate basis for planning, given the current level of greenhouse gas emissions and the evident change in climate. Our region once again recorded the UK's highest ever temperature last summer, and it is obvious to us as natural resource managers that higher temperatures, rising sea levels and more variable rainfall requires serious attention.
- If we use Office of National Statistics (ONS) projections for 2030 and beyond, our AMP8 investments remain the same apart from a treatment works upgrade. We strongly believe this scenario is not a sensible proposal for our company considering the East of England saw the highest growth in population in England between 2011 and 2021, an 8.3% increase (approximately 488,000 additional people). We are also experiencing a high amount of non-domestic requests, some of which we have had to decline due to lack of resource.
  This non-household and population growth in our region shows we need to continue with our planned investment in AMP8 and beyond; this is reinforced by the long lead times of our supply-side options that simply cannot be 'swapped in' if we experience higher levels of growth than planned for. For these reasons, we believe the ONS projection scenario is unrealistic and will create further expenditure in the long-term.
- Delaying drought resilience does not impact any of our core pathway.

We have detailed our adaptive pathways in the revised draft WRMP24 Section 11 [2] and revised draft WRMP24 Decision making technical supporting document, Section 10 [3] .

Our LTDS also sets out how we will achieve our SDS long-term ambition to make the East of England resilient to the risk of flood and drought. Our AMP8 interconnectors programme is captured within our Water Resources sub strategy, and is required to achieve our ambition in all tested scenarios. [4].

2.1.6 Customer support

The independently produced synthesis of our customer insight tells us that safe, clean water is a fundamental customer expectation, and customers expect us to not only maintain but improve and upgrade the current infrastructure. The scale and timing of our interconnectors investment is principally driven by the most

2 https://www.anglianwater.co.uk/siteassets/household/about-us/wrmp/rdwrmp24-main-report.pdf
3 https://www.anglianwater.co.uk/siteassets/household/about-us/wrmp/rdwrmp24-decision-making-technical-supporting-document.pdf
4 For more detail, please refer to Section 2.2.2 'Water Resources' in our LTDS

effective way to manage the supply-demand balance, and ensure that customers have a safe, clean reliable supply of water over the long-term as set out in our WRMP.

2.1.7 Cost control

The interconnector investments highlighted here are driven by the need to deliver a supply-demand balance for the WRMP24. The factors driving these deficits, such as licence cap reductions, climate change, the requirement to be resilient to a 1 in 500 year drought, and growth in our region are new factors which are out of our control. But, we have taken significant steps to control costs and provide the potential for further cost savings in our long term strategy through our policy decision modelling (see section 5.2 of our revised draft WRMP24 Decision Making report).

Installing new interconnectors deliver near term water resources but also creates an infrastructure which unlocks the potential for future water resources. We have built on our WRMP19 interconnector strategy for WRMP24, opening up the potential for better value options (in terms of costs, carbon, environmental and other wider impacts). This makes these PR24 interconnectors a low-regret investment as part of our LTDS core pathway, and an important spend to save investment over the long-term.

2.2 Unlocking greater value for customers, communities and the environment

2.2.1 Option consideration

We have considered an appropriate range of supply-side options across WRZs in our region, following the 8-stage framework set out in the UKWIR Guidance on decision making processes. For the development of feasible options, we developed an unconstrained options list by:

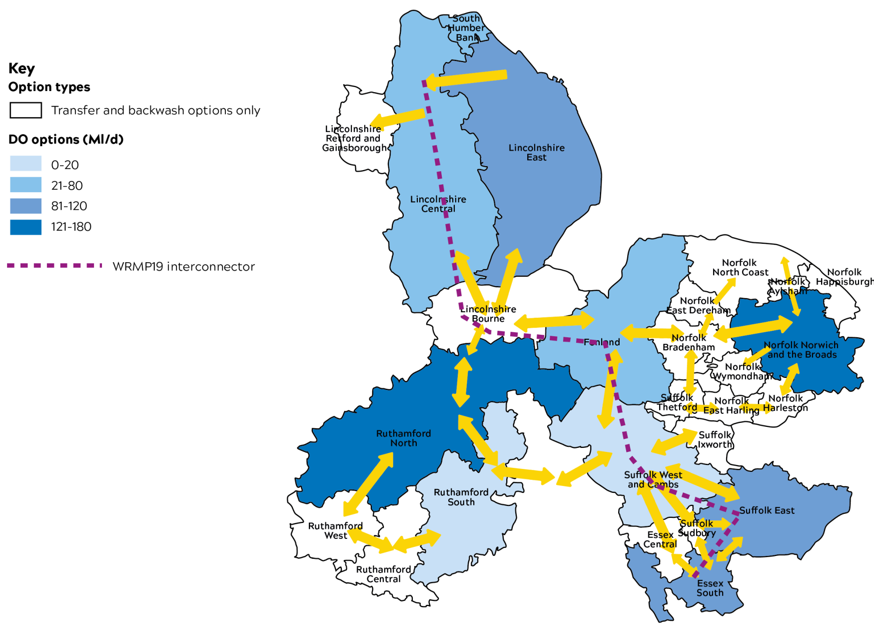
- Identifying all the options considered in the previous planning round, as well as any options identified since.
- Exploring options presented by regional groups, including regionally scaled and joint-company options. We also identified potential transfers from neighbouring water companies and engaged with third party options.
- Reviewing the Environment Agency's Catchment Abstraction Management Strategies (CAMS).

These unconstrained options were then subject to a coarse screening exercise, before progressing to feasible studies and fine screening. This process resulted in 1528 unconstrained options, of which 335 were internal interconnectors.

Interconnectors are important as they allow the benefits of supply-side options to be deployed to zones in deficit, ensuring that the investment modelling is not constrained to only developing supply-side options within the zones they are physically located.

In developing these interconnector options, we considered as wide a range of solutions as feasibly possible. We achieved this through evaluating the transfer options developed as part of WRMP19, with additional routes identified through workshops held with operational teams and the WRE options set. This resulted in an extensive list of interconnector options, which are available to view in the revised draft WRMP24 Supply-side option technical supporting document. The feasible interconnectors for WRMP24 can be seen in Figure 4 WRMP24 feasible interconnectors.

Figure 4 WRMP24 feasible interconnectors



Each of the interconnector options were assessed using a route optimisation tool developed by our consultants. This tool minimises the capex and totex of a transfer route and reflects the need to avoid key land uses and environmental constraints. It also evaluates topographical data along a route (OS tiles) and carries out hydraulic calculations, adjusting route outputs to minimise pumping costs by optimising the vertical profile of the transfer route. This is achieved 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 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 a Site of Special Scientific Interest (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.

To enable the flexibility of options to adapt to future uncertainty, the interconnectors have been sized to meet deficits across a set of plausible scenarios. The different capacities supplied by each option are set out in section 6 of our revised draft WRMP Supply-side options development technical supporting document. Our EBSD model includes a number of alternative capacities for each interconnector route to allow real choices to be made when developing our plan.

This process resulted in 1528 unconstrained options being reduced to 170 constrained options (of which 93 were internal interconnectors) that entered into our decision making processes. As highlighted in our draft WRMP24 consultation, these options provided nearly three times the amount of deployable output required by our region.

2.2.2 Cost-benefit appraisal

Our WRMP24 decision making looks beyond cost and seeks to deliver benefits to customers and society, as well as the environment, whilst listening and acting on the views of our customers and stakeholders. Our plan is assessed using our best value plan framework which is based on objectives that we would like our plan to achieve. These objectives are aligned to our strategic outcomes to customers and our Strategic Direction Statement.

We also develop a least cost plan which considers only cost and none of the other best value metrics. This provides a benchmark to compare our plan against. Further detail is available in the revised draft WRMP24 Decision Making technical supporting document.

In the least cost plan all the interconnectors in AMP8 are the same as the preferred plan, with the exception of NAY1 Aylsham 3Ml/d scheme which has been added to our Best Value Plan. The preferred plan includes backwash recovery options in our Norfolk Aylsham WRZ, which provides a small increase in deployable output at each of the works. However there is a risk, that upon implementation, they do not deliver the full assumed benefit. In the other water resource zones, secondary new supply-side options are required alongside the backwash recovery option, as the backwash options are not large enough to fully satisfy deficit. However in Norfolk Aylsham WRZ the inclusion of both backwash recovery options is adequate to satisfy the deficit.

Norfolk Aylsham is a small mainly isolated zone with a 14% increase in distribution input over 25 years, which is expected to be offset by our demand management portfolio. It is one of our most environmentally sensitive zones with a risk of future abstraction reductions due to Habitats Regulations. The Environment Agency have indicated the River Bure catchment, which passes through the Aylsham WRZ, will be subject to further assessment of the impacts of abstraction as part of the Broads Sustainable Abstraction Plan in between now and 2024. Therefore we have included a transfer from our Norfolk Norwich and the Broads water resource zone to Aylsham (NAY1) to provide a robust resilience supply which can be supported, in the future, by the more strategic resources of the Fens Reservoir and Bacton desalination.

We have used four levels of assurance throughout our WRMP24 and business planning process, this includes external assurance. The WRMP has progressed through internal governance, culminating in Board approval for both draft and revised draft WRMPs.

We have also included a sub-zonal scheme in our interconnector programme. This option does not provide a zonal supply demand balance benefit, as such, and therefore has not been included in our WRMP24. However this scheme is required to enable the transfer from the WRMP19 interconnectors to our Bramford Tye Reservoir, both located within our Suffolk East WRZ. This scheme is required in both our least cost and best value plans.

The following factors drive the need for this scheme:

- **The change from capping abstraction licences to recent actual peak to recent actual average.** The general configuration of Suffolk East WRZ comprises groundwater sources in the north of the zone, with Alton Water supplying the south of the zone, with network interconnectivity between the two. The WRMP19 interconnectors connect to the Alton Water system in the south of the WRZ.

  WRMP19 was planned on the basis of groundwater licences being capped to recent actual peak in 2024/25. Since WRMP19, following a change in policy from the Environment Agency, we must plan to cap our abstraction licences to recent actual average either on renewal (for time limited licences) or by 2030 for permanent licences; this has been reflected in WRMP24. This creates a further 4.25Ml/d (6.3%) reduction in the Deployable Output of Suffolk East (based on WRMP24 modelling), which is concentrated in the groundwater supplied portion of the WRZ. Our WRMP24 WRZ integrity assessment and problem characterisation were completed in September 2020, before this change occurred, so did not take this factor into account. If this information had been available, it would be likely that the Suffolk East WRZ would have been split into two separate WRZs, making this scheme an inter-zonal interconnector.

  In these changed circumstances, we have found that the existing intra-WRZ network within Suffolk East can no longer provide sufficient supporting supply to the northern area. This creates a requirement for additional connectivity from the strategic grid to the north of the WRZ via the proposed connection to Bramford Tye WR.

- **Reduced yield of Belstead WTW following saline intrusion.** We have reviewed the yield constraints within our groundwater system as part of WRMP24 development. Following this, we have had to reduce the yield of Belstead WTW in the Suffolk East WRZ because of saline intrusion issues. These have been caused by its proximity to the coast, and the only possible mitigation is to reduce abstraction.

  Though this issue hasn't reduced average deployable output for the Suffolk East WRZ, it creates additional pressure within the groundwater system during peak summer operation, and in the management of outage events. The Bramford Tye connection will provide additional resilience to alleviate these issues.

2.2.3 Environmental and social value

Our proposed enhancement spend was selected by following our WRMP24 best value decision making process. This process has been developed based on our regulatory requirements, and following consultation with our customers and stakeholders. It aligns with Ofwat's public value principles.

The best value plan metrics we have used within our decision making process include both option level benefits and impacts, and those that apply at the broader system level. For example, capital and operational carbon impacts, and the effect of options on natural capital and biodiversity apply at option level, whilst wider benefits such as the scale and timing of reducing abstraction from unsustainable sources apply at the overall system scale.

As part of our best value process, we have quantified the impact of a range of policy decisions, alternative plans and stress and sensitivity tests on our best value metrics. This has enabled us to transparently demonstrate the trade-offs inherent in selecting a best value plan for our water resources, as described in further detail within the revised draft WRMP24 Decision making technical supporting document.

Carbon

We developed capital and operational carbon impact estimates for each feasible option in tonnes of CO2 equivalent.

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 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.

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.

As described in our revised draft WRMP24 Decision making technical supporting document (Appendix D: Future Carbon Pathways) the delivery of our WRMP24 strategy will take place in the context of delivery of our company level net-zero strategy. In that section, we demonstrate that the true carbon impact of our plan is likely to be significantly reduced during the design, delivery and operation stages as part of our net-zero strategy.

Natural Capital

A Natural Capital Assessment (NCA), including the assessment of changes to Ecosystem Services (ESS), has been undertaken on our supply-side options within the constrained list.

The NCA process identified permanent changes in natural capital (habitat types) predicted to result from the options. The assessment of ESS included: carbon sequestration (climate regulation), natural hazard regulation, water purification, water regulation, air pollutant removal, recreation & amenity value, food production. The findings are presented in the Biodiversity net gain and natural capital assessment sub-report to the revised draft WRMP24 Environment Report, as well as feeding into that over-arching report's findings.

Biodiversity Net Gain

Biodiversity Net Gain (BNG) assessments have been undertaken on our supply-side options within the constrained list. This approach meets both the WRPG's requirements to consider biodiversity and habitats related ESS impacts and to assess net gain to biodiversity. The findings are presented in the Biodiversity net gain and natural capital assessment sub-report to the revised draft WRMP24 Environment Report, as well as feeding into that over-arching report's findings.

Summary

Table 6 High level overview of PR24 interconnector schemes, their carbon and wider impactssets out a top level summary of the carbon and wider impacts from the interconnector schemes included in our PR24 plan. The assessment and quantification of our wider options are presented in the WRMP supply-side option development report and are not included here for simplicity.

With the exception of the NAY1 Aylsham 3Ml/d scheme, all of the options in Table 6 High level overview of PR24 interconnector schemes, their carbon and wider impacts were selected in both our least cost and best value plans. The NAY1 Aylsham 3Ml/d scheme was selected in the best value plan as it aligns with our best value objectives (informed by customer and stakeholder preferences) to:

- provide a resilient, secure and wholesome supply of water to our customers,
- deliver long-term environmental improvement, and
- provide an opportunity to adapt to future scenarios.

The transfer provides a robust resilient supply to this zone, supported by the future strategic resources of Fens reservoir and Bacton desalination increasing resilience. See Section 9.2 of the revised draft WRMP24 Decision Making technical supporting document.

Table 6 High level overview of PR24 interconnector schemes, their carbon and wider impacts

Scheme	Operational carbon emissions under maximum utilisation scenario (tonnes CO2e per annum)	Embedded carbon emissions (tonnes CO2e)	Habitats units (required restoration)	Biodiversity net gain cost (£000)
CAM4 - Ruthamford South to Cambridge Water potable transfer	584.6	16956.9	19.5	586
SWC8 - Cambridge Water to Cambs and West Suffolk	2233.4	46708.5	41.5	1246
LNC25 - Lincolnshire East to Lincolnshire Central potable transfer	767.5	12666.6	72.7	2181
NBR6 - Fenland to Norfolk Bradenham potable transfer	1532.4	26215.5	67.5	2024
NTB10 - Norfolk Bradenham to Norwich and the Broads potable transfer	151.8	24292.2	37.7	1131
NAY1 - Norwich and the Broads to Aylsham potable transfer	139.1	2378.8	12.2	365

Scheme	Operational carbon emissions under maximum utilisation scenario (tonnes CO2e per annum)	Embedded carbon emissions (tonnes CO2e)	Habitats units (required restoration)	Biodiversity net gain cost (£000)
NEH3- Suffolk Thetford to Norfolk East Harling potable transfer	352.1	5751.3	24.1	724
NHL4 - Norfolk East Harling to Norfolk Harleston potable transfer	131.6	3814.4	17.0	511
SUE24 - Suffolk Sudbury to East Suffolk potable transfer	143.5	1721.4	3.6	108
EXC3 - Essex South to Essex Central potable transfer	53.4	2381.7	16.0	479
East Suffolk WRZ IPZ	N/A	1093.1	N/A	N/A

2.2.4 Investment benefits

The key benefit of the interconnectors investments is their impact on the water supplied in our region. Table 7 Benefits of the PR24 interconnectorssets out the expected benefit from each scheme expressed as the maximum transfer capacity from each scheme, this is not Water Available for Use (WAFU).

Table 7 Benefits of the PR24 interconnectors

<table>
<tr><th>Scheme</th><th>Capacity of interconnector (Ml/d)</th><th>Water available for use (WAFU) benefit (Ml/d)</th></tr>
<tr><td>CAM4 - Ruthamford South to Cambridge Water potable transfer</td><td>50</td><td rowspan="2">50</td></tr>
<tr><td>SWC8 - Cambridge Water to Cambs and West Suffolk</td><td>50</td></tr>
<tr><td>LNC25 - Lincolnshire East to Lincolnshire Central potable transfer</td><td>29.</td><td>29</td></tr>
<tr><td>NBR6 - Fenland to Norfolk Bradenham potable transfer</td><td>45</td><td rowspan="3">45</td></tr>
<tr><td>NTB10 - Norfolk Bradenham to Norwich and the Broads potable transfer</td><td>20</td></tr>
<tr><td>NAY1 - Norwich and the Broads to Aylsham potable transfer</td><td>3</td></tr>
<tr><td>NEH3 - Suffolk Thetford to Norfolk East Harling potable transfer</td><td>5</td><td rowspan="2">5</td></tr>
<tr><td>NHL4 - Norfolk East Harling to Norfolk Harleston potable transfer</td><td>5</td></tr>
<tr><td>SUE24 - Suffolk Sudbury to East Suffolk potable transfer</td><td>10*</td><td>19</td></tr>
<tr><td>EXC3 - Essex South to Essex Central potable transfer</td><td>10</td><td>10</td></tr>
<tr><td>East Suffolk WRZ IPZ</td><td>7.81</td><td>-</td></tr>
</table>

*Note as explained above the capacity of this interconnector changed in our revised draft WRMP.

2.2.5 Managing uncertainty

The capacity of the interconnectors is determined by the WRMP24 supply demand balance needs over the 25 year planning period. They are then tested, using the common reference scenarios, for robustness to future uncertainty through sensitivity and stress testing, as well as least worst regrets analysis. We also conducted modelling to generate alternatives, to add further robustness. It is not possible to provide modular solutions to interconnectors.

We have compiled an adaptive version of our preferred WRMP plan, which includes a number of adaptive pathways, including some for delivery risks associated with our AMP8 investments. This is shown in Table 8 PR24 interconnector schemes, their risks and mitigations.

For these adaptive pathways it is not possible to satisfy all deficits, due to the time needed to deliver alternative options. The adjustment to abstraction reductions, in these pathways, is the difference in the supply demand balance that is needed to ensure customers can receive a secure supply of water, ahead of new sources being commissioned.

Table 8 PR24 interconnector schemes, their risks and mitigations

Scheme	Delivery risk	Risk mitigations
CAM4 - Ruthamford South to Cambridge Water potable transfer	The CAM4 (along with SWC8) interconnector connects our Ruthamford South WRZ to Suffolk West and Cambs WRZs via Cambridge Water; this will be complex to design and construct. The total route is 75km of 900mm and 1000mm diameter steel pipeline. It involves crossing the River Great Ouse, the A14, a National Grid gas pipeline and the East coast mainline. Any modifications to the pipeline route during delivery could have an impact on both capex and opex costs and the time to implement the solution. Detailed consultation with Highways England, Environment Agency, Local Authorities and land owners could impact the costs and the time to implement the solution	Ruthamford South WRZ to Cambridge Water (CAM4) and Cambridge Water to Suffolk West & Cambs WRZ (SWC8) are needed to transfer surplus resource in Ruthamford eastwards to meet caps to time limited licence in 2030. In the preferred plan all new resource options available in AMP8 are selected to meet the licence caps. No alternative options are available to make up the shortfall if the interconnectors are delayed. We would investigate the feasibility of increasing demand management, in particular further leakage reduction. This may not be adequate to meet the full shortfall, but if it was assessed as cost effective, it could reduce it. Therefore, the delay creates a residual deficit which would require an adjustment to the licence caps.
SWC8 - Cambridge Water to Cambs and West Suffolk	The SWC8 (along with CAM4) interconnector connects our Ruthamford South WRZ to Suffolk West and Cambs WRZs via Cambridge Water; this will be complex to design and construct. The total route is 75km of 900mm and 1000mm diameter steel pipeline. It involves crossing the River Great Ouse, the A14, a National Grid gas pipeline and the East coast mainline. Any modifications to the pipeline route during delivery could have an impact on both capex and opex costs and the time to implement the solution. Detailed consultation with Highways England, Environment Agency, Local Authorities and land owners could impact the costs and the time to implement the solution.	Ruthamford South WRZ to Cambridge Water (CAM4) and Cambridge Water to Suffolk West & Cambs WRZ (SWC8) are needed to transfer surplus resource in Ruthamford eastwards to meet caps to time limited licence in 2030. In the preferred plan all new resource options available in AMP8 are selected to meet the licence caps. No alternative options are available to make up the shortfall if the interconnectors are delayed. We would investigate the feasibility of increasing demand management, in particular further leakage reduction. This may not be adequate to meet the full shortfall, but if it was assessed as cost effective, it could reduce it. Therefore, the delay creates a residual deficit which would require an adjustment to the licence caps.
LNC25 - Lincolnshire East to Lincolnshire Central potable transfer	A new interconnector that will expand WRMP19 network, enabling us to transfer resource from Lincolnshire East to Lincolnshire Central. The transfer will be quite complex to design as it consists 19 km of 800mm steel main. The route will involve a number of complex crossings including inluding the A15 and A180 highways, overhead pilon National Grid and two railway lines.	The interconnector into Lincolnshire Central is required to distribute resource from North Lincolnshire groundwater and surface water enhancements into our strategic grid. There are no alternatives to this option as it is required to deliver the benefit of other enhancements.
NBR6 - Fenland to Norfolk Bradenham potable transfer	There are two interconnectors which extend our WRMP19 interconnector network to Norfolk (NBR6, NTB10). These will be complex to design and construct as they require approx. 80km of 900mm steel and 603mm Ductile Iron pipeline. The route involves crossing a National grid gas pipeline and the A47 and there is a high risk of archaeological finds.	The interconnectors to Norfolk are required to meet time limited licence caps in 2030, but also to enable the closure of two of our sources from 2030 in relation to The Broads SAC review. No alternative options are available to make up the shortfall if the interconnectors are delayed, although it should be noted that there is uncertainty regarding The Broads SAC review that will only be resolved in 2024. We would investigate the feasibility of increasing demand management, in particular further leakage reduction. This may not be adequate to meet the full shortfall but if it was assessed as cost effective, it could reduce it. Therefore the delay creates a residual deficit which would require an adjustment to the licence caps.

Scheme	Delivery risk	Risk mitigations
NTB10 - Norfolk Bradenham to Norwich and the Broads potable transfer	As above	As above
NAY1 - Norwich and the Broads to Aylsham potable transfer	A continuation of the interconnector grid into Norfolk. This will consist a 13.5 km, 246mm polyethylene pipeline. The route will involve a river crossing, the Bure Valley railway (narrow gauge nostalgia/leisure), a National Grid gas pipeline, authorised landfill and an ancient monument. Any modifications to the pipeline route during delivery could have an impact on both capex and opex costs and the time to implement the solution. Detailed consultation with Highways England, Environment Agency, Local Authorities and land owners could impact the costs and the time to implement the solution.	Delivery of the backwash recovery options within the Norfolk Aylsham WRZ (NAY4, NAY5) will reduce the risk of requiring an adjustment to the licence caps if the delivery of NAY1 was delayed.
NEH3 - Suffolk Thetford to Norfolk East Harling potable transfer	A continuation of the interconnector grid into Norfolk. This will consist a 19.6 km, 311mm polyethylene pipeline. The route will involve a river crossing, National Grid overhead power, several livestock farms and directional drilling of several highway crossings. Any modifications to the pipeline route during delivery could have an impact on both capex and opex costs and the time to implement the solution. Detailed consultation with Highways England, Environment Agency, Local Authorities and land owners could impact the costs and the time to implement the solution.	No alternative options are available to make up the shortfall if the interconnector is delayed. Therefore, a delay would create a residual deficit that would require an adjustment to the licence caps.
NHL4 - Norfolk East Harling to Norfolk Harleston potable transfer	A continuation of the interconnector grid into Norfolk. This will consist a 25.8 km, 315mm polyethylene pipeline. The route will involve river crossings, National Grid including a main gas transmission line, several livestock farms and directional drilling of several highway crossings. Any modifications to the pipeline route during delivery could have an impact on both capex and opex costs and the time to implement the solution. Detailed consultation with Highways England, Environment Agency, Local Authorities and land owners could impact the costs and the time to implement the solution.	Delivery of the backwash recovery option (NHL7) within the Norfolk Harleston WRZ will reduce the risk of requiring an adjustment to the licence caps if the delivery of NHL4 was delayed.
SUE24 - Suffolk Sudbury to East Suffolk potable transfer	Transfer from Sudbury into Suffolk East. The pipeline is 6.1 km, 350 mm polyethylene. Mostly crossing agricultural land.	Delivery of the backwash recovery (SUE25) and the Suffolk East groundwater enhancement (SUE23) schemes within the Suffolk East WRZ will reduce the risk of requiring an adjustment to the licence caps if the delivery of SUE24 was delayed.

Scheme	Delivery risk	Risk mitigations
EXC3 - Essex South to Essex Central potable transfer	Transfer from Essex South to Essex Central. The pipeline is 7.8 km, 409 mm polyethylene. Mostly crossing agricultural land but will involve a river crossing, overhead power lines and passes close to an airfield.	Delivery of the backwash recovery option (EXC7) within the Essex South WRZ will reduce the risk of requiring an adjustment to the licence caps if the delivery of EXC3 was delayed.
East Suffolk WRZ IPZ	Intra RZ transfer of 7.5 km, 395 mm polyethylene pipe. The pipeline will require a river crossing, 2 National Grid overhead power line crossings and several minor road crossings.	In AMP8 all new resource options that are vailable are selected to meet the licence caps. No alternative option is available if this interconnector is delayed. We would investigate the feasibility of increasing demand management, in particular further leakage reduction. This may not be adequate to meet the full shortfall but if it was assessed as cost effective, it could reduce it. Therefore the delay creates a residual deficit which would require an adjustment to the licence caps.

As we have seen in AMP7, there is a significant degree of cost uncertainty that we are exposed to as part in the installation of interconnecting pipes within our region. In AMP7 we have seen a significant degree of cost increase due to factors outside of management control, most notably global supply chain issues and knock on impacts of the war in Ukraine. These cost increases are unlikely to reverse as we move into AMP8.

The scale of this major infrastructure programme also presents a risk in terms of deliverability. The increase in costs seen in AMP7 and the increase in competition for resources across the water sector with the significant increase in the size of capital programmes at PR24 are likely to present greater challenges when negotiating costs and timescales with suppliers. We have therefore reviewed the scale of the overall interconnector programme and, following their unsuccessful request for inclusion in the Ofwat supported AID programme, we have brought the two of the largest schemes CAM4 and SWC8 forward to try and mitigate the delivery risk. Early enabling work for these interconnectors will commence in AMP7 as part of our transition programme, and will continue into AMP9 to mitigate these deliverability risks.

We have long established strategic delivery alliances in place and have started discussions on procurement with suppliers. We have also applied learning from the delivery challenges, such as programme management, liaison with local planning authorities and negotiation with land owners, from our AMP7 interconnector programme into our PR24 programme. The costs that we have included in our plan for the interconnector programme build in the current view of the costs to deliver a major interconnector programme. Whilst this is larger as a unit rate than at PR19, our cost benchmarking has shown that our cost assumptions are efficient compared to the costs of similar schemes currently being delivered (see benchmarking section).

As set out above and in our WRMP, our options appraisal process ensures that we optimise the pipeline capacity of our interconnectors, striking the right balance between over-utilisation (and the need to return to sites to install larger pipelines again in future) and under-utilisation (and the greater costs associated with installing larger capacity pipes than necessary) to give a least regret and highly adaptive solution. It is important to keep in mind that any modifications to pipeline routes or capacity could have an impact on the costs and timelines of delivering the solution and have knock on impacts on the supply and demand solutions to be included within the WRMP.

There is additional cost and delivery uncertainty associated with the detailed consultation we will need to undertake with stakeholders such as Highways England, the Environment Agency, local authorities and land owners. We will apply the learning from the delivery of our AMP7 interconnectors in managing the uncertainty associated with these factors.

2.2.6 External funding

We have considered the opportunities for third-party funding for interconnector schemes. We have an opportunity to temporarily assist Cambridge Water via CAM4 and are engaging with Cambridge Water on this.

2.2.7 Direct procurement

We have applied the DPC criteria against each of our interconnectors to assess suitability for delivery through DPC. Table 9 High level overview of gated process to determine DPC eligibility illustrates the gated process we have followed to determine which interconnectors should be assumed to be delivered through DPC.

Table 9 High level overview of gated process to determine DPC eligibility

<table>
<tr><th></th><th>CAM4 Cambs Water 50MLD Supply</th><th>SWC8 Suffolk West 50MLD Supply</th><th>East Suffolk WRZ IPZ</th><th>NAY1 Aylsham 3MLD Supply</th><th>NBR6 Bradenham 45MLD Supply</th><th>NHL4 Harleston 5MLD Supply</th><th>NTB10 Norfolk Broads 20MLD Supply</th><th>LNC25 Irby to Elsham 29Ml/d Transfer</th><th>FND22b Marham 13.6MLD Transfer</th><th>FND22a Marham WTW - WRMP24 Return to Service PR24</th><th>NEH3 E Harling 5Ml/d Supply</th><th>EXC3 Essex Central 10MLD Supply</th><th>SUE24 Suffolk East 10MLD Supply</th></tr>
<tr><td>WLC criteria (>£200m?)</td><td>151.7</td><td>465.2</td><td>9.6</td><td>39.7</td><td>277.6</td><td>48.7</td><td>99.5</td><td>182.4</td><td>62.5</td><td>59.5</td><td>40.9</td><td>20.2</td><td>27.6</td></tr>
<tr><td>Discreteness</td><td colspan="2">These two transfers make up the Grafham to Bury St. Edmunds transfer.

Whilst above the size threshold, the project must be delivered within constrained timescales. It is unlikely that the risk of delivery within the required timescales for the project can be effectively transferred or mitigated contractually.

Further, the future use case for the transfer is uncertain and has the potential to be significantly impacted by other projects and sources of supply. This is likely to be challenging to transfer or mitigate contractually.</td><td colspan="11">None of the transfers except Bradenham pass the size test.

There are several factors which, considered together, indicate that the transfers are not discrete on an individual or combined basis.

• AWS' experience in the delivery of its AMP7 transfer programme has shown the need for and benefit of retaining flexibility in the design process to accommodate changes arising from (inter alia) consenting challenges across the route of extended transfers. Where changes are required in one area, the construction approach and programme can be adapted to accommodate, for example by changing the route of the project in one area without delaying the construction of other successfully consented areas. This is particularly important given that the AMP8 transfer programme is required in order to comply with the WFD by 2030. Under a DPC model a fully consented scope would be required across the entire DPC scope prior to the start of construction, and would therefore likely result in a longer overall delivery timeline and potentially the compromise of delivery against regulatory requirements.
• Decisions taken for the route and connection points of one transfer could have a material impact on decisions made in respect of other interconnected / downstream assets. If delivered in-house AWS has the opportunity to explore and identify routes and connection points across the programme which could result in increases in operational efficiency and interconnectivity. It can also reduce long-term operating costs (e.g. by selecting routes which take advantage of local geography to utilise gravity-fed flows instead of pumping). If projects were to be tendered without consideration across the programme, synergies may be lost which could reduce the resultant value for money for customers.
• All the assets considered involve potable water. Whilst AWS acknowledges that water quality issues are not a reason not to pursue DPC, the practical complexity of identifying the cause of a water quality issue in a wide and heavily interconnected network would likely result in significant risk pricing from bidders if the risk were transferred to the market, and/or a significant residual exposure for AWS in the event that the risk remained with AWS as Appointee.
• As the transfer programme evolves and additional transfers are introduced in future AMPs, the use case of each transfer is likely to evolve over time. Entering into a CAP would reduce flexibility and could impact future performance.
For these reasons, neither the construction nor operations and maintenance risks can be effectively transferred to the market, meaning the internal transfers are assessed as ineligible for DPC. The flexibility benefit in the delivery of the overall programme is also much greater where AWS is the sole entity responsible for delivering the assets and bringing them into service.</td></tr>
<tr><td>Suitable for DPC?</td><td colspan="2">No</td><td colspan="11">No</td></tr>
</table>

Based on these criteria, we have assumed within our plan that none of the interconnectors will be delivered through DPC.

2.2.8 Customer view

Our customer engagement synthesis report sets out details of our customer engagement and findings, and the revised draft WRMP24 Customer and stakeholder engagement technical supporting document details how this has been used for the development of WRMP24.

In line with our customer engagement strategy, we have aimed for engagement to be meaningful, impactful and able to help us make better business decisions. Recognising that the core, non-negotiable, requirement of WRMP24 is to ensure a safe, resilient water supply, we developed key engagement questions that customers could shape our response to. For example, the prioritisation of supply-side and demand management options and the level of environmental destination that should be achieved.

Our engagement on supply-side and demand management options found that there is a strong view to 'get your house in order' first, with many customers highlighting the need to fix leaks. Whilst we have taken this view into our considerations, demand management alone will not ensure a resilient water supply which is why we also require supply-side investments, and consequently interconnectors to distribute the water, in AMP8.

When discussing supply-side options, water reuse and reservoirs were highlighted as being preferred supply-side options. Reservoirs are seen as a familiar, tried and tested option which are environmentally friendly and an attractive community asset. They also like the fact it's cheaper and that it seems counter intuitive to emit more carbon by using desalination and water reuse when our climate challenges have been exacerbated by carbon emissions. Transfers were less preferred.

This feedback has helped us shape our AMP8 strategy. Whilst we recognise that our customers prefer supply-side options such as reservoirs, these simply cannot be delivered into service in AMP8. Instead, we will use transfers to utilise existing water in our network, as well as installing new equipment at our treatment works so it can treat the existing water available to us. This strategy, of utilising existing resource and moving it to areas in deficit, will allow us the time to develop the Fens and Lincolnshire reservoirs. We have engaged with customers through multiple channels to allow us to cross check findings and get a full understanding of customer preferences.

2.3 Cost efficiency

2.3.1 Developing costs

The development of the interconnectors costs in our plan follows our cost efficiency 'double lock' approach set out in chapter 7 of our business. plan. Through this approach we have ensured that are costs are efficient in their bottom-up build up, and this is cross-checked through external benchmark approaches. This section sets out how we have ensured cost efficiency of our interconnectors through step one of our double lock approach.

We have taken a robust approach to developing our interconnector costs, building on our experience from delivering our AMP7 strategic interconnector programme and other similar schemes into the bottom-up development of costs (before external cost benchmarking challenges are applied in step 2 of our 'double-lock' approach). The detail of the cost development approach is set out below, along with a breakdown of costs we provide in table CW3.

Cost Estimation Methodology

We follow a common cost development methodology across our enhancement investments in a three phase process:

1. Establish cost and carbon models
2. Input the cost drivers into the model (including location specific factors)
3. Data validation, internal challenge and assurance.

In phase 2, we derived our total cost estimation for each interconnector scheme by gathering location based data which influences the cost estimates for each scheme. For interconnectors, this included:

- The proposed interconnector route ;
- Hydraulics parameters to meet the minimum delivery pressure i.e velocity and head losses gradients;
- Topography and surface types (i.e roads, field, verge);
- Number of crossings to major infrastructures (e.g. railways, rivers, and ditches);
- Construction techniques and applicable Materials;
- Operability and connection to existing assets and;
- Assessment of construction constraints such as SSSI areas.

We have incorporated the experience gained in AMP7 from the delivery of WRMP programme, to take into account lessons learnt from the efficiency strategy implemented. For instance, when the selected water main route needs to cross multiple infrastructure obstacles, further assessment has been taken into account to determine the most suitable construction technique in the estimation, e.g. where there is a river crossing with a depth up to 6m, directional drilling has been used rather than micro-tunnelling.

We have considered programme-level efficiencies by applying overhead assumptions to the interconnectors programme as whole rather than as individual schemes. This takes into account the cost efficiency achieved by the standardisation of designs and products and maximising quality through the digital rehearsal and off site assembly.

When assessing the interconnector projects, in addition to the asset to be included in the scope, material suitability to the ground condition , pressure rating, longevity and sustainability have all been considered, including their impacts on the construction costs, assembly and carbon impact.

We conducted a thorough suitability study for different pipe materials. Plastic (HHPE, MDPE, etc), lined ductile iron and steel, are all materials that have different characteristics and suitability in different environments. For pipes greater than 700mm internal diameter, materials such as lined ductile iron and steel are more favourable than plastic (HPPE). This is due to factors such as fitting constraints as at this large size, some fittings and fitting types are unavailable/unsuitable.

The difference in rate for similar pipe diameters is driven (in addition to the material chosen) to the number and type of crossings that have been calculated in the proposed optimised route. For example, the most optimal route for CAM4 required more crossings under railways sections with construction space constraint that required to estimate the use of microtunnelling rather than directional drilling.

Table 10 Interconnector schemes, scope and costssummarises the scope designed to each project and the capital and operational cost forecast to incurred in AMP8 for the interconnectors options proposed. Each option has been assessed using the route optimisation tool to minimises the capex and totex of a transfer route and avoid key land uses and environmental constraints. For example, a feature that implies either a very high cost such as a lake, or an area to be avoided such as a Site of Special Scientific Interest (SSSI), will not be crossed by the pipeline unless there is no reasonable alternative.

Table 10 Interconnector schemes, scope and costs

	Investment Name	Scope	Water Main Length (km)	Dia (mm)	Flow (MLD)	Reservoirs (m3)	Pumping Stations Total kW	Capital Cost AMP7 £k	Capital Cost AMP8 £k	Capital Cost AMP9 £k	OPEX Cost £k (25-30)	Pipe Cost only £/metre
I034310	SWC8 Suffolk West 50MLD Supply	*Water mains and fittings *Chlorine disinfection *Reservoir *Two Pumping Stations in network; 123.3 kW and 2396 kW *Site Ancillaries (access road, fences, landscaping, telemetry)	54.44	1000	50	25,000	2,519	3,910	132,088	58,285		2,901
I034335	NHL4 Harleston 5MLD Supply	*Water mains and fittings *Reservoir *Two Pumping Stations in network; 80 kW and 30 kW *Site Ancillaries (access road, fences, landscaping, telemetry)	25.9	311	5	2,000	110		25,113		62	752

	Investment Name	Scope	Water Main Length (km)	Dia (mm)	Flow (MLD)	Reservoirs (m3)	Pumping Stations Total kW	Capital Cost AMP7 £k	Capital Cost AMP8 £k	Capital Cost AMP9 £k	OPEX Cost £k (25-30)	Pipe Cost only £/metre
I041287	NEH3 E Harling 5Ml/d Supply	*Water mains and fittings *Reservoir * Pumping Stations in network *Site Ancillaries (access road, fences, landscaping, telemetry)	19.7	311	5	2,000	146		20,196		60	758
I040016	LNC25 Irby to Elsham 29Ml/d Transfer	*Water mains and fittings *Two Pumping Stations ; 1480 kW and 10 kW *Site Ancillaries (access road, fences, landscaping, telemetry)	19.7	800	29		1,490		69,434		350	2,937
I034316	NAY1 Aylsham 3MLD Supply	*Water mains and fittings *Reservoir *Two Pumping Stations in network; 83 kW and 74 kW *Site Ancillaries (access road, fences, landscaping, telemetry)	13.7	246	3	1,500	83		14,723		64	600
I034318	NBR6 Bradenham 45MLD Supply	*Water mains and fittings *Interconnector balancing Reservoir (when applicable see Reservoir column) *Pumping Stations in network (when applicable see Pumping Station column) *Site Ancillaries (access road, fences, landscaping, telemetry)	35.85	900	50	9,000	1,730		103,647		680	2,451
I034308	CAM4 Cambs Water 50MLD Supply		20.87	900	50	12,500	660	2,620	51,948	23,386	-	3,039
I034337	NTB10 Norfolk Broads 20MLD Supply		47.6	603	20	1,500			82,361		75	1,669
I041291	EXC3 Essex Central 10MLD Supply	*Water mains and fittings *Interconnector balancing Reservoir (when applicable see Reservoir column) *Pumping Stations in network (when applicable see Pumping Station column) *Site Ancillaries (access road, fences, landscaping, telemetry)	7.8	409	10		60		9,668		26	1,008
I041327	SUE24 Suffolk East 10MLD Supply		6.1	352	10		162		7,520		226	850
I030103	East Suffolk WRZ IPZ		7.5	395	7.81				7,555		3	968
I040780	Strategic Interconnector Hydraulic model	Modelling							1804			
		Total	**259**		**240**	**53,500**	**7,015**	**6,530**	**526,058**	**81,671**	**1,545**	

For the total interconnector programme 85% of costs are on pipes, 8% on reservoirs, 6% pumping Stations and 1% on other process and ancillaries installation.

2.3.2 Benchmarking

Given the scale of the investment that the interconnectors programme represents and the significant volatility in costs seen in AMP7, we have applied significant focus on the benchmarking of costs for our PR24 interconnector programme using multiple different sources. We have partnered with Arup to seek and apply external benchmarks against the costs we have developed as there is limited directly comparable data from Ofwat data sources (owing both to no other company having a similar interconnector scheme on the scale of Anglian's in AMP7, and to location factors having a significant impact on costs).

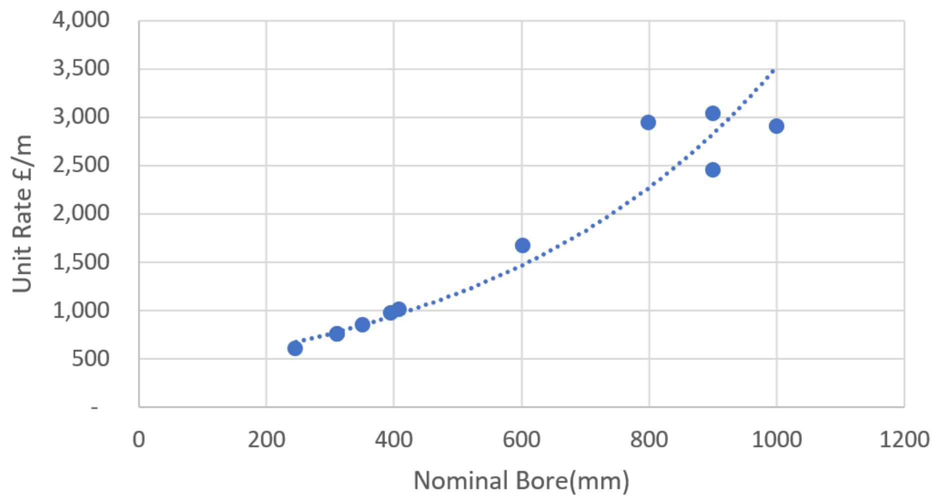
The three key sources of evidence that have been used to ensure to costs that we put forward are efficient are:

- Scheme forecast outturn data - largely from the AMP7 interconnector programme, this ensures that a form of benchmarking is built into our cost estimation process from the start
- Benchmarking of interconnectors delivered in AMP7 against external benchmarks - this ensures that the scheme outturn data we use in our cost estimation process is efficient compared to similar schemes delivered at a similar time (timing is particularly important given the steep increase in costs seen within AMP7)
- Benchmarking of the proposed costs for AMP8 - this provides a cross check to ensure that the costs we include in our PR24 plan are efficient.

Scheme forecast outturn data

We have built outturn costs into our interconnector programme. This builds in cost efficiency inherently into the build up of costs.. The below figure shows the pipeline direct cost unit rate for each of the interconnectors projects.

Figure 5 Interconnectors unit rate



Benchmarking of interconnectors delivered in AMP7

We have worked with Arup to compare our AMP7 top-level interconnector forecast outturn unit rate costs against similar unit rate costs available to Arup in its cost library. The interconnector costs have been assessed based on the unit costs drawn from pipe length, diameter and pipe material type. The overall findings are shown in the two figures below.

Figure 6 Overall benchmarking of isolated pipe rates - HPPE

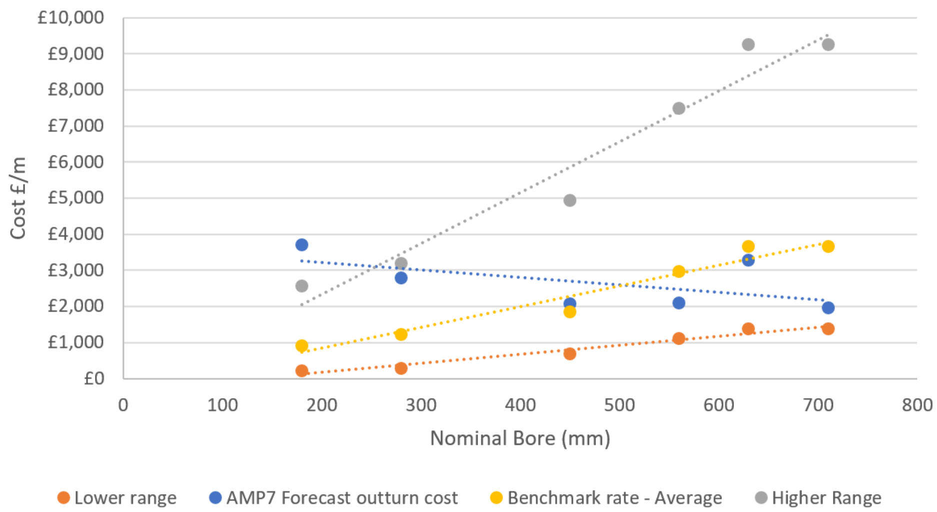
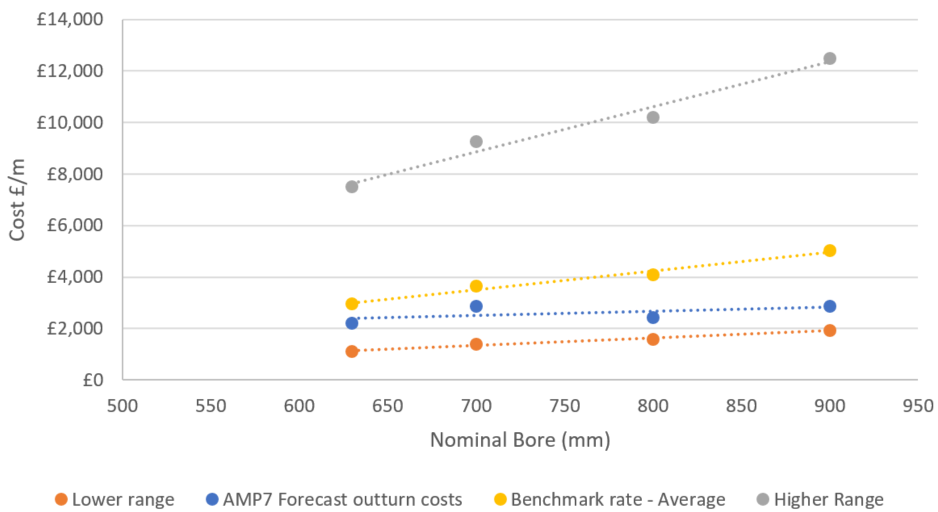


Figure 7 Overall benchmarking of isolated pipe rates - steel



This shows that that the scheme forecast outturn costs (blue dashed line) are typically at or below the benchmark rates. The benchmarking showed that section of the small diameter HPPE pipeline showed as an outlier of the benchmark. We considered whether this was due to inefficiency or other factors and found the deviation in costs is due to these being very short length (less than 2 km) and due to the number of obstacles and crossings that those pipes are subject to. These sections of pipe represent 1% of the overall programme length and so do not significantly influence the efficiency findings of our interconnector programme. Based on these findings, we considered there was robust evidence to conclude that our AMP7 interconnector delivery has been cons efficient relative to the benchmarks.

Benchmarking of AMP8 interconnectors

The use of AMP7 scheme outturn data and the benchmarking of this give us high confidence that efficient cost estimations have informed the costs included in our plan. To further cross-check this, we have taken a sample of five of our interconnectors which are representative of the costs of the full interconnector programme. Benchmarking was carried out by Arup using comparator projects as the benchmark rate. The benchmarking considered the overall scheme costs, detailed benchmarks of the individual components of the scheme and on-costs.

Figure 8 Benchmarking of interconnectorssummarises the findings reached by Arup in its benchmarking analysis.

Figure 8 Benchmarking of interconnectors

Overall, unit rates for Supply side schemes for key cost contributors are within expected benchmark range.

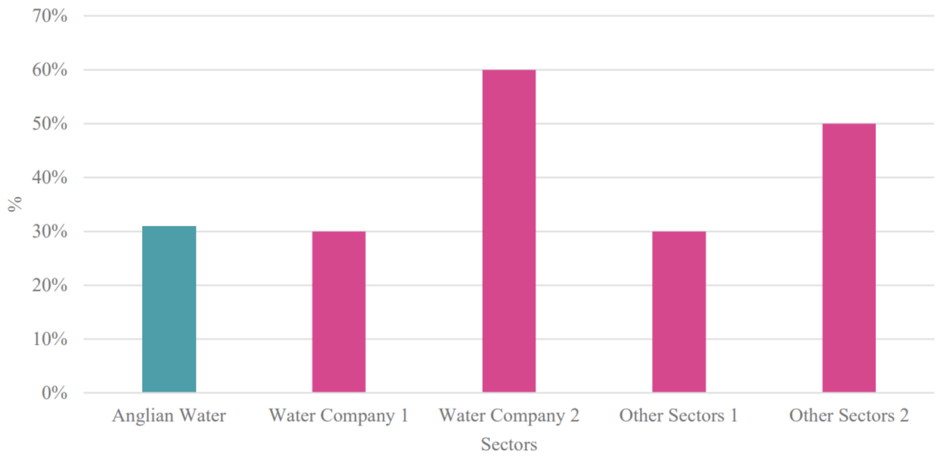
Scheme	Scheme Capital cost (£)	% of the total Capital Cost	Summary of Findings	Benchmark RAG	Data Confidence RAG
CAM4 - BCTTW_138.Fwd.50MLD with 6 hrs storage	94,507,245.28	34%	Overall, the Anglian rate for the high level benchmark rate falls within the expected range. The Water Mains rates are all lower than benchmark rates, but Supply rate is higher and therefore, counteracts one another. The main area to highlight is the micro tunnelling rate which is much lower than the benchmark rate. This item is the second highest contributor and therefore likely to have material impact to the overall CAPEX. Below benchmark rates, may be due to efficiency, but may also be pure underestimation. Supply rate is also an area highlighted as it is 161% higher than benchmark rate and contributes to 9% of the overall scheme construction cost. Further investigation would be beneficial. Maximum Water Capacity is a small cost contributor but would also benefit from further investigation if this were to become a larger cost contributor as the Anglian rate is 182% lower than the benchmark.		
NAY1 BCTTW_62	14,507,958.32	5%	For this scheme, Anglian Water's overall high level rate is higher than the benchmark rate and out of the expected range. This is approximately 43% more than the upper end benchmark rate. The rates for Water Main and Micro tunnelling are the only rates close to the benchmark rates. At 5% of the overall Capex contribution for the five schemes reviewed, an Amber status has been given despite 43% higher than upper end of the benchmark rate.		
NBR6 BCTTW_59.Fwd 3	57,321,730.60	21%	The Anglian high level rate is lower than the benchmark rate. Anglian rates are therefore very efficient, however, risk of underestimating remains. Water Main rate is lower than the benchmark rate and outside the expected range. Below benchmark rates, may be due to efficiency, but may also be pure underestimation. Water Main #2 is outside the expected range, but small cost contributor and therefore unlikely to have significant material impact on the overall CAPEX. Supply costs might require further investigation as it seems Anglian figures include more elements.		
NTB10 BCTTW_60.Fwd 2	43,696,463.43	16%	The overall Anglian high level rate is low compared to the benchmark rate and is outside the expected range. All rates for Water Mains are lower than the benchmark rates and are therefore likely to have significant material impact on the overall CAPEX. The lower the benchmarked rates may be as a result of above average efficiency, however, it could also possibly be due to pure underestimation of the realistic costs for this scheme. Therefore, we have given an Amber status.		
SWC8 BCTTW_140.Fwd.50MLD with re-chlorination	66,268,548.09	24%	Overall, the Anglian Water rate is within the expected benchmark rate range. The highest cost contributor rate is lower than the benchmark range which may be as a result of above average efficiency. Water Main #2 and #4 rates are close to benchmark rates. Supply costs might require further investigation as it seems Anglian figures include more elements.		

The purpose of this benchmarking was to understand the reasonableness of our cost estimates, including whether they appear to be over- or under-estimates compared to the benchmarks. Therefore two schemes (NBR6 and NTB10) have a benchmark RAG of amber, not because of a risk of inefficiency, but because of a risk that we have underestimated costs. Whilst this is a risk, we consider our costs in the round to strike the right balance of efficiency and deliverability. Figure 8 Benchmarking of interconnectorsshows that overall our capital costs are in-line with the benchmarks, two schemes appear low compared to the benchmark rate and one smaller scheme (NAY1) appears to be higher than the benchmarked rate.

These benchmarked costs relate to the direct capital costs of the schemes. Because of how different companies may apportion direct costs and on-costs we considered it was possible that our efficiency relative to the benchmarks could potentially be attributed to higher indirect on-costs which are not reflected in these tables. We therefore undertook further benchmarking of our on-costs.

Arup concluded that our on-cost percentage is within the expected range (and towards the lower end) for comparable costs for other water companies and other sectors. This is shown in the chart below.

Figure 9 On cost comparison



In light of the evidence, we have confidence that the costs we have estimated for our PR24 interconnector programme present an efficient rate.

We have used the analysis of unit rate to benchmark the overall AMP8 unit rate calculated at each scheme in the programme, this can be seen in the two below figures.

Figure 10 AMP8 interconnectors and overall benchmarking of isolated pipe rates - HPPE

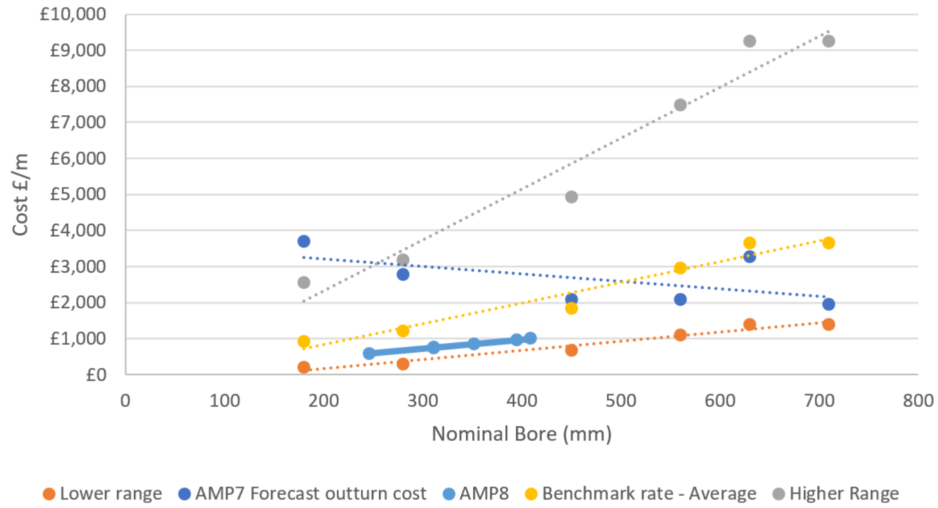
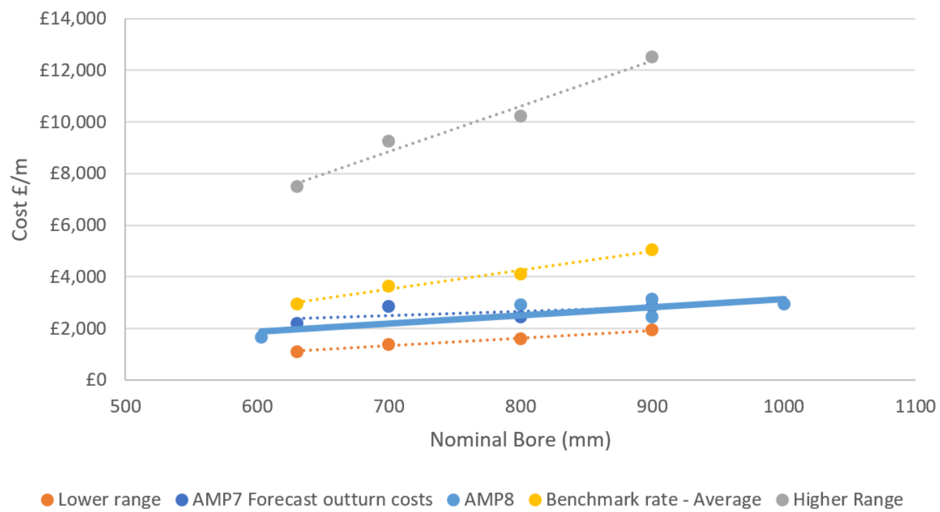


Figure 11 AMP8 interconnectors and overall benchmarking of isolated pipe rates - Steel



2.3.3 Assurance

Our cost estimation approach has been assured by an independent third party (Jacobs) and the cost benchmarking we have used to validate our costs has been carried out independently by Arup.

2.4 Customer protection

Customers are protected in the event of a cancellation, delay or reduction in scope of this investment through the 'Water Available for Use (WAFU) in WRZ' Price Control Deliverable.

At PR19, our Final Determination included a performance commitment for the interconnector programme that was output based (MLD of capacity delivered by each interconnector). This has caused issues in the deliverability of that programme. We have therefore developed the Water Available for Use (WAFU) in WRZs PCD as more a outcomes focused customer protection measure that supports the delivery of best value options to achieve that outcome. Although there is no net WAFU benefit from interconnectors, they do provide a benefit to receiving WRZs which this PCD is designed to reflect.

This PCD has two payment rates defined:

- The non-delivery payment rate applies if the company has not started the investment and has no plan to deliver it at the date agreed
- The late delivery payment applies if the company has substantially made progress on the delivery of the investment but has not completed it by the date agreed

By focussing the PCD on the benefits the investment is intended to deliver, customers are protected against the non- or under-delivery of this investment.

For more detail , please refer to the appendix 'Price Control Deliverables' ANX ANH37

3 Supply-side improvements

Overview

- A key component of our three tier strategy for revised draft WRMP24 is to utilise our existing resource. Alongside our extensive demand management programme, this will see us invest in supply-side enhancements.
- These supply-side improvements include the relocation of abstractions that are due to cease, enhancements to treatment works to allow them to operate at lower abstraction licence rates, backwash recovery schemes and the additions of new processes to allow variable water quality to be treated. These options are shown in Table 11 PR24 supply-side enhancements
- All of these enhancements will increase our water available for use (WAFU), allowing us time to develop our strategic resource options (detailed separately in 4 Strategic Resource Solutions).
- We will also continue to develop our desalination options, building on our WRMP19 work, so that we are able to move to an adaptive pathway, if required.
- Where possible, we have benchmarked our infra and non-infra costs. For non-infra assets, our benchmarked costs are below the industry WRC TR61.

Table 11 PR24 supply-side enhancements

Scheme	Description	WAFU benefit (Ml/d)	AMP8 Totex £m
Marham abstraction relocation (FND22a & FND22b)	This is the relocation of our River Nar abstraction point. The need for this investment is driven by our existing abstraction becoming unfeasible due to a Hands-Off Flow (HoF) condition that will be implemented in 2025. FND22 will result in the abstraction point being moved to another area of the Nar, or close by. A new intake and raw water transfer will be required to the existing Marham water treatment works, which will also need an upgrade to its treatment processes.	7.9*[a]	48.1
Suffolk West & Cambs groundwater relocation (SWC13)	Our current abstraction (both location and volume) is unsustainable due to its environmental impact. SWC13 relocates part of the existing abstraction licence to a new location. The investment includes a new borehole and transfer to the existing treatment works.	2.6	8.8
Lincolnshire Central surface water enhancement (LNC30)	Water is currently abstracted from the River Trent; it is of variable quality and does not get opportunity to blend in the small raw water reservoir. As a result, the existing treatment processes can only reliably treat 13 Ml/d. This investment will enhance our existing treatment process by adding additional filtration capacity and an ion exchange process to aid Total Organic Carbon (TOC) removal. This will allow the treatment works to achieve its full output of 20 Ml/d.	3.2	28.1

Scheme	Description	WAFU benefit (Ml/d)	AMP8 Totex £m
Ruthamford South surface water enhancement (RTS21)	Ruthamford South WTW abstracts water directly from the River Great Ouse. Treated water is distributed into Ruthamford South WRZ. The water in the river is of variable quality with no significant storage or opportunities for raw water blending. As a result, the existing treatment processes cannot reliably treat the full licensed volume of 27 Ml/d. This investment will enhance the existing treatment process by adding pre-treatment and nitrate removal. This will enable the treatment works to achieve its full output of 25.7 Ml/d.	9.5*	33
Lincolnshire East surface water enhancement (LNE12)	We will invest in new flow monitoring stations on the River Great Eau, Tetney Lock and the River Tud to monitor flow and maximise our abstractions. We will also enhance the control system and pumping station at the River Great Eau. These surface water abstractions, combined with treatment enhancements at the surface water works, will allow us to maximise our abstractions and treatment to 60 Ml/d.	13*	56.6
Lincolnshire East groundwater enhancement (LNE11)	Lincolnshire East WRZ will gain extra deployable output with planned investment allowing us to maximise abstraction from existing borehole assets.	7.5	18.5
Suffolk East groundwater enhancement (SUE23)	Following on from WINEP investigations, we have agreed with the Environment Agency that we can continue to operate our groundwater at Suffolk East WTW at a lower flow than we do currently. Due to the current operation of the site, investment will be required to run at the much lower flow of 1.7 Ml/d.	1.7	5.7
Lincolnshire Retford and Gainsborough groundwater enhancement (LNN3)	We will make the best use of our existing resource in Lincolnshire, Retford and Gainsborough WRZ by installing granular activated carbon adsorption filters (GAC) so we can treat hydrocarbons in the raw water, allowing us to increase our deployable output. We will also increase the booster pump capacity at the site so we can distribute this additional water.	0.72	5.6
Backwash recovery schemes	There are thirteen backwash recovery schemes: EXC7, EXS7, FND26, LNE3, NAY4, NAY5, NBR9, NED3, NHL7, NNC5, NNC6, SUE25 and SUT6. These will take water previously lost to sewer or the environment and return to the head of the WTW, increasing deployable output.	4.1	7
Colchester reuse (ESX19)	This scheme will intercept the final treated water effluent before it is discharged into the Colne Estuary, diverting it to an advanced treatment process known as a water reuse plant. The water from this water reuse plant will be transferred through a new main and discharged into Ardleigh Reservoir where it will mix with river waters before being abstracted and treated at the water treatment works onsite. The investment also includes a demonstration centre.	11.4*	32.8
Adaptive planning	We will invest in increasing our understanding of desalination so we can move to alternative adaptive pathway if the need arises. We will focus on determining preferable location, investigating brine management techniques and new technologies and then testing these with a demonstration centre.	N/A	12.1

Scheme	Description	WAFU benefit (Ml/d)	AMP8 Totex £m
	Total	47.92	256.4

a The WAFU benefit of the * options varies relative to the drought resilience scenario. The WAFU presented in the table is relative to 1:200. The WAFU benefit will change in 2039/40 when drought resilience to 1:500 occurs. Some options benefits will increase and others decrease depending on the type of option.

Table 12 Investment Summary

PR24 costs (£m)	
Capex	252.6
Opex	3.8
Totex	256.4
Benchmarking	
Method	Scheme outturn costs Industry cost models from TR61 Asset level cost comparison with other companies
Findings	Benchmarking findings Our costs for both infrastructure and non-infrastructure assets were found to be below the industry benchmarks.
Customer Protection	
Price Control Deliverable	Water available for use (WAFU) in Water Resource Zones (WRZ)
Ofwat data table	
CW3.41-CW3.43	Supply-side improvements delivering benefits in 2025-2030
CW3.53-CW3.55	Supply demand balance improvements delivering benefits starting from 2031
CW12.41-CW12.43	Supply-side improvements delivering benefits in 2025-2030
CW17.41-CW17.43	Supply-side improvements delivering benefits in 2025-2030

3.1 Delivering for the long term

3.1.1 Investment context

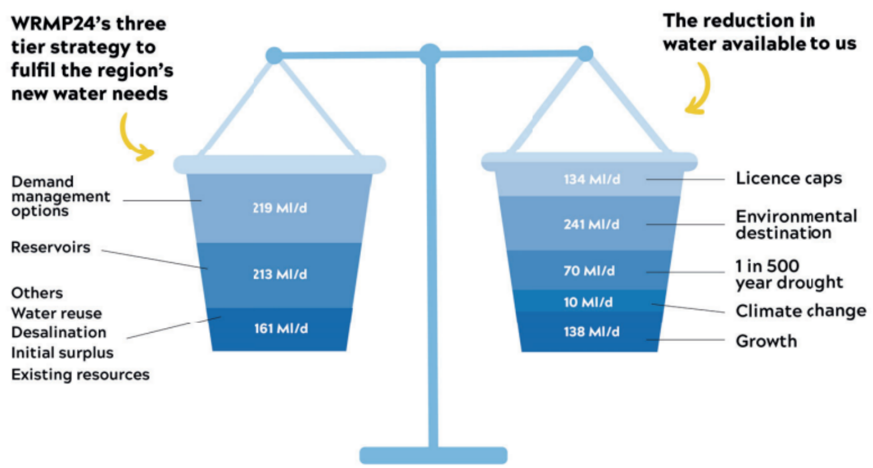
Our revised draft WRMP24 sets out how we will maintain a sustainable and secure supply of drinking water for our customers over the period of 2025 to 2050. This long-term view allows us to plan an affordable, sustainable pathway that provides benefit to our customers, society and the environment.

Our 25-year strategy has been driven by the challenges of growth, climate change, resilience to a 1 in 500 year drought, environmental destination, and licence capping. A summary of these challenges, with their forecasted impacts by 2050, is provided below:

- The implementation of further abstraction licence capping across the Anglian region (a 134 Ml/d reduction in water available for use). The reduction in Hartlepool is 7 Ml/d.
- Moving beyond statutory licence cap obligations to our environmental destination, further reducing the amount of water we take from sensitive environments. It is forecasted that this will reduce the amount of water we have to use by 241 Ml/d. There is no impact in Hartlepool.
- Achieving enhanced resilience to drought, building on our previous investments to become robust to an extreme 1 in 500 year drought; an impact of 70 Ml/d. There is no impact in Hartlepool.
- Adapting to climate change, and the impacts of the hotter, drier summers and warmer, wetter winters on our water resources. The expected impact is 10 Ml/d on top of the climate change impact. There is no impact in Hartlepool.
- We also expect an increased demand for water of 138 Ml/d by 2050, with our region's population forecasted to grow by 911,000 people.

The impact of these challenges is shown in our supply demand balance, in Figure 13 WRMP24 Supply Demand balance This shows that without any action by 2050, we will experience a shortfall of 593 Ml/d; that's equivalent to approximately half the amount of water we put into our network currently.

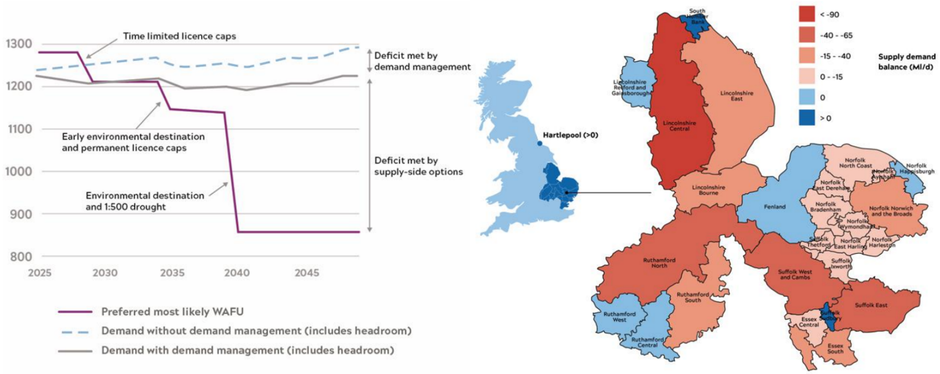
Figure 12 Meeting our challenges for WRMP24



To tackle this shortfall in water for the next 25 years, we have adopted a three-tiered strategy:

1. We will make the best use of our existing resources, building on our industry leading demand management and using any surplus water available.
2. The progression of the strategic resource options (SROs): the Fens and Lincolnshire reservoirs.
3. Planned for adaptive future resources, allowing us to remain flexible to changing circumstances, whilst ensuring we limit bill impacts to our customers by only investing in low regret solutions.

Figure 13 WRMP24 Supply Demand balance



This strategy is central to this business plan, using demand management in AMP8 to reduce the shortfall in water available. However, even with the continuation of our industry-leading smart metering strategy, and its associated benefits between 2025 and 2030 (detailed in 'Enhancement Strategy 'Enabling sustainable economic and housing growth' Section 2 'Metering'), we will still have a deficit of 46 Ml/d by 2030, which will immediately become much larger as caps are applied to our permanent licences.

This means to fulfil our legal obligation, as a water undertaker, of providing water for domestic purposes, we must invest in supply-side solutions in AMP8. These supply-side improvements include investments at water treatment works, either increasing capacity or securing additional output, to secure the flows needed to feed the 2 Interconnectors We have also considered the development of solutions which are only required under adaptive pathways, and the potential for schemes to be delivered through direct procurement for customers (DPC). Fens and Lincolnshire reservoirs are discussed in 4 Strategic Resource Solutions

3.1.2 Scale and timing

Our WRMP is a 25 year adaptive plan, produced every five years and reviewed annually. It is developed by following the Water Resources Planning Guideline (WRPG), as well as other relevant guidance and legislation, so it meets statutory requirements. By following the WRPG and WRMP Directions, we have established a best value planning framework that takes into account the views of customers and stakeholders.

In developing the WRMP, we have worked with regulators, customers and stakeholders to appraise our supply-side options. This options appraisal process highlighted that we have limited new water supplies available to us as, operating in the driest region in England, there is minimal surplus water we can take from the environment. There are also limited opportunities to trade and share water resource with other water companies and sectors, as abstraction reform and climate change considerations apply across all water resources.

This limited resource means that we must turn to supply-side options that are relatively new to the United Kingdom's water industry; these have long-lead times due to the environmental investigations and design work that is needed. This means for AMP8 we build on our AMP7 strategy of utilising existing resource; these investments can be delivered within AMP8, ensuring our customers remain on resilient water supplies, allowing us opportunity to develop new resources such as raw water reservoirs, water reuse and desalination.

This proposed enhancement spend, detailed in this section, has been developed using our Economics of Balancing Supply and Demand (EBSD) model, as well as our best value plan metrics. The majority of the proposed investments were selected as part of the least cost plan development, apart from some backwash recovery schemes. The latter investments are best value, as they will allow us to maximise opportunities to use water efficiently and for one isolated Water Resource Zone (WRZ) it will also provide a small element of additional capacity which will go a small way to dealing with the additional licence constraints that the Environment Agency has indicated we are likely to be facing in north east Norfolk.

In addition to this, we have considered adaptive low-regret investments that will support us in the early development of major new options, such as desalination, which may need to be deployed as part of an adaptive pathway.

3.1.3 Interaction with base expenditure

The supply-side options that we have considered all deliver a step-change in benefits; this will ensure we can continue to meet demand for water in our region in the face of climate change, environmental protection and growth. We have considered the costs to maintain the supply-side enhancement investments from previous AMPs to be base costs and have not included any of these in our proposed enhancement investments.

As an example of our enhancement investment, the sites identified for backwash water recovery schemes were originally designed to discharge water into the environment or sewer. Our enhancement investments will introduce the assets needed to create a new mode of operation the backwash water will be reused through the process, creating less waste. This will be achieved by enhancement investments such as tank upgrades, online monitoring, control systems, pipelines and pumps. This will ensure that the backwash water cannot be contaminated, the settled water is of a treatable standard, and can be delivered to the correct place. Without this investment, a deployable output benefit will not be achieved.

3.1.4 Long term context (historic)

Our WRMP24 builds on previous WRMPs. Table 13 Funded PR19 supply-side schemes and overlap/duplication with PR24 enhancement shows the PR19 supply-side schemes (not including interconnectors) and considers if there is overlap or duplication with PR24 enhancement investment.

Table 13 Funded PR19 supply-side schemes and overlap/duplication with PR24 enhancement

Scheme	Status	Overlap or duplication with PR24 enhancement investment?
SHB2a-Pyewipe Water Reuse for Non-potable use - treatment	Scheme stopped and replaced with the North Lincolnshire Alternate Strategy	None - the North Lincolnshire Alternate Strategy as discussed with Ofwat in Jan 2022 set out a 2 AMP programme of investments in the groundwater sources in the area. We are progressing the AMP7 investments as planned and have included the AMP8 investments in our PR24 Plan as they were selected in the WRMP24 scenario modelling.
ELY9 North Fenland WRZ to Ely WRZ Non infra only	In progress as part of our AMP7 programme	None
RTS Intra RZ - Meppershall PZ Non infra only	In progress as part of our AMP7 programme	None
Elsham DPC development	Scheme stopped and replaced with the North Lincolnshire Alternate Strategy	None
Long-term enhancement (development of strategic regional schemes)	In progress	None

3.1.5 Long term context (future)

Our core pathway for WRMP24 includes: the transfers that need to be delivered in AMP8 to connect WRZs to the WRMP19 interconnectors, the supply-side investments detailed in this section, a water reuse scheme required in AMP9 with development started in AMP7 as part of the Accelerated Infrastructure Development programme, continued development of the Fens and Lincolnshire reservoirs, and our demand management strategy.

This core pathway has been tested, using the common reference scenarios, for robustness to future uncertainty through sensitivity and stress testing, as well as least worst regrets analysis. We also conducted modelling to generate alternatives, to add further robustness.

This testing showed us that:

- The AMP8 supply-side schemes remained the same, apart from a treatment works upgrade, when tested with Ofwat's basic low climate change scenario. We don't believe this scenario is an appropriate basis for planning, given the current level of greenhouse gas emissions and the evident change in climate. Our region once again recorded the UK's highest ever temperature last summer, and it is obvious to us as natural resource managers that higher temperatures, rising sea levels and more variable rainfall requires serious attention.
- If we use Office of National Statistics (ONS) projections for 2030 and beyond, our AMP8 investments remain the same apart from a treatment works upgrade. We strongly believe this scenario is not a sensible proposal for our Company considering the East of England saw the highest growth in population in England between 2011 and 2021, an 8.3% increase (approximately 488,000 additional people). We are also experiencing a high amount of non-domestic requests, some of which we have had to decline due to lack of resource.
- This non-household growth and the population growth in our region shows we need to continue with our planned investment in AMP8 and beyond; this is reinforced by the long lead times of our supply-side options that simply cannot be 'swapped in' if we experience higher levels of growth than planned for. For these reasons, we believe the ONS projection scenario is unrealistic and will create further expenditure in the long-term.
- Delaying drought resilience does not impact any of our core pathway.

We have detailed our adaptive pathways in the revised draft WRMP24 Main report Section 11 and revised draft WRMP24 Decision making technical supporting document, Section 10.

Our LTDS also sets out how we will achieve our SDS long-term ambition to make the East of England resilient to the risk of flood and drought. Our AMP8 supply-side programme is captured within our Water Resources sub strategy, and forms a low-regret investment as it is required to meet our ambition in all tested scenarios. For more detail, please refer to Section 2.2.2 'Water Resources' in our LTDS.

3.1.6 Customer support

The independently produced synthesis of our customer insight (submitted as an appendix to our PR24 business plan) tells us that safe, clean water is a fundamental customer expectation, and customers expect us to not only maintain but improve and upgrade the current infrastructure. The scale and timing of our supply-side improvements investment, alongside our interconnector, strategic resource solutions, and demand-side measures have been designed to ensure that this customer need is met.

3.1.7 Cost control

The supply-side investments detailed here are driven by the need to deliver a supply-demand balance for the WRMP24. The factors driving these deficits, such as licence cap reductions, climate change, the requirement to be resilient to a 1 in 500 year drought, and growth in our region are out of our control. But, we have taken significant steps to control costs and provide the potential for further cost savings in our long term strategy, through our policy decision modelling (see Section 5 of our revised draft WRMP24 Decision Making technical supporting document report).

A key example of this cost control is the interconnector programme which began in AMP7 and formed the bulk of our supply-demand enhancement at PR19. This investment, by increasing our ability to transfer water between different parts of our region, has increased the supply-side opportunities available to us, as we are not limited to those that are located close to or within areas at risk of deficit. We have built on this for WRMP24, opening up the potential for better value options (in terms of costs, carbon, environmental and other wider impacts).

Investing in drought resilience is a ‘spend to save’ investment as it will help support our environmental ambitions in part through avoiding the expenditure associated with drought permits, and alternative supplies.

3.2 Unlocking greater value for customers, communities and the environment

3.2.1 Option consideration

We have considered an appropriate range of supply-side options across WRZs in our region, following the 8-stage framework set out in the UKWIR Guidance on decision making processes. We developed an unconstrained options list by:

- Identifying all the options considered in the previous planning round, as well as any options identified since.
- Exploring options presented by regional groups, including regionally scaled and joint-company options. We also identified potential transfers from neighbouring water companies and engaged with third party options.
- Reviewing the Environment Agency's Catchment Abstraction Management Strategies (CAMS).

These options were then subject to a coarse screening exercise, before progressing to feasible studies and fine screening. The breakdown of options by screening process is shown below in Table 14 Unconstrained option types for WRMP24.

Table 14 Unconstrained option types for WRMP24

	Aquifer recharge/Aquifer storage recovery	Catchment management	Desalination	Drought permits/orders	External potable bulk supply/transfer	External raw water bulk supply transfer	Groundwater enhancement	Internal potable transfer	Internal raw water transfer	International import	Licence trading	New groundwater	New reservoir	New surface water	New technology	Rainwater harvesting	Surface water enhancement	Water reuse	Water treatment works capacity increase	Water treatment works loss recovery	Total
Unconstrained	43	33	114	8	1	37	103	335	10	12	178	94	115	114	43	18	4	145	19	102	1528
Feasible	2	0	22	4	0	0	4	113	1	3	2	0	14	1	0	0	4	16	0	13	199
Constrained	2	0	18	3	0	0	4	93	1	3	1	0	12	1	0	0	3	16	0	13	170

This process resulted in 1528 unconstrained options being reduced to 170 constrained options which entered into our decision making processes. As highlighted in our draft WRMP24 consultation, these options provided nearly three times the amount of deployable output required by our region.

We provide a brief summary of the constrained option types considered for WRMP24 below, with further information available in our revised draft WRMP24 Supply-side options development technical supporting document.

Aquifer storage and recovery (ASR) is a technique used to replenish and store groundwater in aquifers for subsequent abstraction and supply. We don't currently operate ASR in our region, and there are limited examples of its use in the UK. The earliest delivery date of the ASR options is 2032.

Backwash recovery involves cleaning filter backwash water and returning it to the head of a water treatment works to be treated again, rather than discharged to the environment or sewer. The amounts associated with such returns are generally small, with their benefits localised to the WRZ. The earliest delivery date for these options is 2027 to 2030.

Bulk/intra company transfers of treated water move surplus water between WRZs. The transfer routes were developed using a specialist tool and internal workshops. The earliest deliverable date for transfers is 2028 to 2030.

We also explored **conjunctive use** which describes when we share resource between us and other companies. For instance, there could be an instance where a power company possesses a consumptive abstraction licence that is not being fully utilised. In this circumstance, there could be the opportunity to purchase the unused volume of these licences, abstract and treat it, to support our own supply needs. The earliest deliverable date for these options is 2030.

An investigation was undertaken to determine where **desalination** (the process of removing salt from water, then treating it and conditioning it to make safe, drinking water) is viable in our region. This evaluation encompassed 500km of coastline, including estuaries. Some of these desalination options contained a conjunctive use element, for instance, discussing possibilities to share outfall structures with energy producers. The earliest deliverable date for desalination is 2032 to 2035.

We also included **drought permits** in our constrained option set. These permits secure additional water resources by modifying or suspending conditions on an abstraction licence. An application is reviewed and determined by the Environment Agency. The delivery dates of these are dependent on the monitoring requirements, and approval, by the Environment Agency.

Groundwater sources have also been developed. As previously discussed, our options for taking any additional water from the ground are limited with many of our sources being subject to licence caps or complete cessation of licence. We have reviewed these, as well as CAMS, and believe there are some options which could yield a small deployable output benefit. These groundwater options are available between 2027 and 2030.

The Fens and Lincolnshire reservoirs are currently being developed through the Regulators' Alliance for Progressing Infrastructure Development (RAPID). These are examples of **new reservoirs**, and are discussed in 4 Strategic Resource Solutions It is expected that the earliest delivery date for these options are 2036 to 2046.

Sea tankering, the importing of water from countries outside of the UK, has been explored.

As well as groundwater, we have reviewed the availability of **surface water**. This review, and liaison with the Environment Agency, has determined surplus water for the Fens and Lincolnshire reservoirs and the relocation of the River Nar abstraction. The earliest delivery date for new surface water (excluding the new reservoirs) is 2030.

There are also instances where our existing treatment works cannot treat the water due to water quality issues, such as rising nitrate level. We have reviewed our works, their available water and the constraints associated with them, to determine where enhancement investment could be utilised for **water quality schemes** to increase deployable output. The earliest delivery dates for these options is 2027 to 2030.

Water reuse options have been developed. This involves the advanced treatment of final effluent before returning it to the environment. It is then abstracted and treated to a drinking water standard at one of our water treatment works. We assessed the suitability of our Water Recycling Centres for water reuse against criteria designed to ensure that any options were cost effective and did not deprive sensitive environments of vital flow. The earliest delivery date for water reuse is 2032 to 2035.

Consultation responses to the draft WRMP24 highlighted the need to continue developing supply-side options so they could be used for adaptive pathways. The risks of desalination and water reuse, and their long lead times, were also highlighted as an area we need to keep developing. For AMP7, our **adaptive planning** programme has developed Aquifer Storage Recharge, Fens Reservoir, Colchester Reuse and our understanding of desalination; two of these schemes have now gone to delivery.

For AMP8, we have developed 2 options for desalination and water reuse schemes:

- Option 1 - 4 sites (desalination and water reuse)
- Option 2 - 2 desalination sites

The adaptive programme for AMP8 will aim to continue the works completed in AMP7- progressing our knowledge of desalination, the best locations for it on our coastline (in terms of water quality and impact to the environment), as well as exploring waste and treatment technologies. This will culminate in a demonstration centre which will aid with customer engagement. This upfront work and investment will reduce the amount of lead time for a new desalination plant, if a trigger point is reached.

3.2.2 Cost-benefit appraisal

Our WRMP24 decision making looks beyond cost and seeks to deliver benefits to customers and society, as well as the environment, whilst listening and acting on the views of our customers and stakeholders. Our plan is assessed using our best value plan framework which is based on the objectives we would like our plan to achieve. These objectives are aligned to our strategic outcomes to customers and Strategic Direction Statement.

We develop a least cost plan which considers only cost and none of the other best value metrics. This provides a benchmark to compare our plan against. Further detail is available in the revised draft WRMP24 Decision Making technical supporting document.

In this least cost plan all the supply-side options in AMP8 are the same as the preferred plan, with the exception of the backwash recovery schemes. The preferred plan has 13 backwash schemes providing a DO benefit of 4.1Ml/d whereas the least cost plan has 3 (EXC7, NAY5, SUT6) providing a benefit of 0.45Ml/d.

We have used four levels of assurance throughout our WRMP24 and business planning process, this includes external assurance. The WRMP has progressed through internal governance, culminating in Board approval for both draft and revised draft WRMPs.

3.2.3 Environmental and social value

Our proposed enhancement spend was selected by following our WRMP24 best value decision making process. This process has been developed based on our regulatory requirements, and following consultation with our customers and stakeholders. It aligns with Ofwat's public value principles.

The best value plan metrics we have used within our decision making process include both option level benefits and impacts, and those that apply at the broader system level. For example, capital and operational carbon impacts, and the effect of options on natural capital and biodiversity apply at option level, whilst wider benefits such as the scale and timing of reducing abstraction from unsustainable sources apply at the overall system scale.

As part of our best value process, we have quantified the impact of a range of policy decisions, alternative plans and stress and sensitivity tests on our best value metrics. This has enabled us to transparently demonstrate the trade-offs inherent in selecting a best value plan for our water resources, as described in further detail within the revised draft WRMP24 decision making technical supporting document.

Carbon

We developed capital and operational carbon impact estimates for each feasible option in tonnes of CO2 equivalent.

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 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.

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.

As described in our revised draft WRMP24 decision making technical supporting document (Appendix D: Future Carbon Pathways) the delivery of our WRMP24 strategy will take place in the context of delivery of our company level net-zero strategy. In that section, we demonstrate that the true carbon impact of our plan is likely to be significantly reduced during the design, delivery and operation stages as part of our net-zero strategy.

Natural Capital

Natural Capital Assessment (NCA), including the assessment of changes to Ecosystem Services (ESS), has been undertaken on the supply-side options within the constrained list.

The NCA process identified permanent changes in natural capital (habitat types) predicted to result from the options. The assessment of ESS included: carbon sequestration (climate regulation), natural hazard regulation, water purification, water regulation, air pollutant removal, recreation & amenity value, food production. The findings are presented in the Biodiversity net gain and natural capital assessment sub-report to the revised draft WRMP24 Environment Report, as well as feeding into that over-arching report's findings.

Biodiversity Net Gain

Biodiversity Net Gain (BNG) assessments have been undertaken on the supply-side options within the constrained list. This approach meets both the WRPG's requirements to consider biodiversity and habitats related ESS impacts and to assess net gain to biodiversity. The findings are presented in the Biodiversity net gain and natural capital assessment sub-report to the revised draft WRMP24 Environment Report, as well as feeding into that over-arching report's findings

Summary

Table 15 Top level summary of carbon and wider impacts of the supply-side schemes in Our Plan sets out a top level summary of the carbon and wider impacts from the schemes included in our PR24 plan. The assessment and quantification of our wider options are presented in the WRMP supply-side option development report and are not included here for simplicity.

With the exception of the backwash recovery schemes, all of the options in Table 15 Top level summary of carbon and wider impacts of the supply-side schemes in Our Plan were selected in both our least cost and best value plans. The recirculation schemes were selected in the best value plan as they align with our best value objective (informed by customer and stakeholder preferences) to optimise our available resource by maximising all opportunities to use water efficiently.

Table 15 Top level summary of carbon and wider impacts of the supply-side schemes in Our Plan

Scheme	Operational carbon emissions under maximum utilisation scenario (tonnes CO2e per annum)	Embedded carbon emissions (tonnes CO2e)	Habitats units (required restoration)	Biodiversity net gain cost (£000)
Marham abstraction relocation (FND22)	430	6589	7.9	236
New groundwater - Suffolk West and Cambs (SWC13)	48	1214	0	0
Lincolnshire Central surface water enhancement (LNC30)	244	4943	0.0	0
Ruthamford South surface water enhancement (RTS21)	488	3909	0.0	0
Lincolnshire East surface water enhancement (LNE12)	283	15055	0.0	0
Lincolnshire East groundwater enhancement (LNE11)	343	2745	0.9	26
Suffolk East groundwater enhancement (SUE23)	177	1023	6.2	185
Recirculation schemes	15	1666	0.0	0
Colchester reuse (ESX19)	271	14713	35.0	1050
Adaptive planning	N/A			

3.2.4 Investment benefits

The key benefit of the supply-side investments is their impact on the water supplied in our region. Table 16 The benefit expected from the supply-side schemessets out the expected benefit from each scheme expressed as the additional water available for use from each supply scheme, relative to the 1 in 200 year drought resilience. It should be noted that the Colchester reuse and adaptive planning schemes are intended to deliver benefits to supply after 2030. We do not expect any of these investments to have an impact on performance commitments.

Table 16 The benefit expected from the supply-side schemes

Scheme	Additional water available for use (WAFU)[a] Ml/d (relative to 1:200 drought)
Marham abstraction relocation (FND22)	7.9*
New groundwater - Suffolk west and Cambs (SWC13)	2.6
Lincolnshire central surface water enhancement (LNC30)	3.2
Ruthamford south surface water enhancement (RTS21)	9.5*
Lincolnshire east surface water enhancement (LNE12)	13*
Lincolnshire east groundwater enhancement (LNE11)	7.5
Suffolk east groundwater enhancement (SUE23)	1.7
Lincolnshire Retford and Gainsborough groundwater enhancement (LNN3)	0.72
Recirculation schemes	4.1
Colchester reuse (ESX19)	11.4*
Adaptive planning	N/A

a The WAFU benefit of the options denoted by a * varies relative to the drought resilience scenario. The WAFU presented in the table is relative to 1:200. The WAFU benefit will change in 2039/40 when drought resilience to 1:500 occurs. Some options benefits will increase and others decrease depending on the type of option.

3.2.5 Managing uncertainty

The scale of the deficit by 2030 and into AMP9 means that all supply side options available are required to satisfy the deficit. This prevents the development of modular solutions for the options needed in AMP8, however in subsequent planning periods modular solutions maybe appropriate for future options required from AMP10 onwards.

We have compiled an adaptive version of our preferred WRMP plan, shown in Table 17 Managing uncertainty in our AMP8 supply-side schemes, which includes a number of adaptive pathways, including some for delivery risks associated with our AMP8 investments.

For these adaptive pathways it is not possible to satisfy all deficits, due to the time needed to deliver alternative options. The adjustment to abstraction reductions, in these pathways, is the difference in the supply demand balance that is needed to ensure customers can receive a secure supply of water, ahead of new sources being commissioned.

Table 17 Managing uncertainty in our AMP8 supply-side schemes

Scheme	Cost and benefit uncertainties	Mitigations
Marham abstraction relocation	The relocation of the abstraction point for our Marham water treatment works to another location on, or near, the River Nar is subject to ongoing flow monitoring to confirm the feasibility of this option. If this option is not available an alternative desalination option is required to meet deficits caused by abstraction licence caps.	Ongoing engagement with Environment Agency and Natural England to secure supply. Follow adaptive pathway to switch to desalination via adaptive planning programme
New groundwater - Suffolk west and cambs	The Suffolk West & Cambs WRZ groundwater option requires a new borehole to be relocated to allow us to continue using the licence. The ongoing investigations may show an impact to the headwaters and the option could be deemed unfeasible.	Following liaison with the Environment Agency we are conducting studies to establish the impact on the headwaters. We do not have an option to replace it with, which leaves a residual deficit between 2030-2032. Follow adaptive pathway - that shows that an adjustment to the licence caps is required. The option is small, and after 2032 the other options within the plan can make up the shortfall until 2040 when the desalination plants are required; at this stage we would need to increase the Norfolk desalination capacity from 25Ml/d to 28Ml/d.
Lincolnshire central surface water enhancement	The raw water quality is more variable and complex to treat than assumed impacting the deployable output benefit of the option.	Abstraction is from an existing raw water source where we already collect water quality data. We will use this data for the design of the new treatment assets.
Ruthamford south surface water enhancement	The raw water quality is more variable and complex to treat than assumed impacting the deployable output benefit of the option.	Abstraction is from an existing raw water source where we already collect water quality data. We will use this data for the design of the new treatment assets.
Lincolnshire east surface water enhancement	The raw water quality is more variable and complex to treat than assumed impacting the deployable output benefit of the option.	Abstraction is from an existing raw water source where we already collect water quality data. We will use this data for the design of the new treatment assets.
Lincolnshire east groundwater enhancement	The raw water quality is more variable and complex to treat than assumed impacting the deployable output benefit of the option.	Abstraction is from an existing raw water source where we already collect water quality data. We will use this data for the design of the new treatment assets.
Suffolk east groundwater enhancement	Changes to abstraction licence differ from the assumptions used. The raw water quality is more variable and complex to treat than assumed impacting the deployable output benefit of the option.	Following on from WINEP investigations, we have agreed with the Environment Agency the changes to the licence.

Scheme	Cost and benefit uncertainties	Mitigations
		Abstraction is from an existing raw water source where we already collect water quality data. We will use this data for the design of the new treatment assets.
Backwash recovery schemes	The benefits to water resource zone deployable output are less than assumed.	The deployable output benefits from the backwash recovery options are small. In all WRZs with backwash recovery schemes the plan contains other options (interconnectors supported by new supply-side options) to meet deficits if the benefits are less than assumed. However, due to the timing to deliver the other supply-side options (e.g. desalination), in some WRZs we would be unable to meet the full licence caps impacts if the backwash recovery schemes had lower benefits in the short term, even with the transfer options.
Colchester reuse	The final treated water effluent quality and/or quantity is different from assumed.	We have existing data for the quality and quantity of the effluent from our water recycling centre.
Adaptive planning	More unforeseen uncertainty occurs and we need to develop additional schemes other than those planned in the adaptive planning programme	Adaptive planning assessment, set out in Section 10 of the Decision Making report, has been used to identify the schemes to be included in the Adaptive Planning programme.

3.2.6 External funding

We have worked in collaboration with other water companies and third parties to develop a common understanding of water resource planning issues and to identify cost-effective options for sharing available resources, including transfers and trading.

3.2.7 Direct procurement

We have considered whether each of the schemes in our WRMP supply-side programme could be suitable for delivery through DPC, through considering the size and discreteness of each scheme to understand whether it would be appropriate for delivery through DPC.

Our assessment, shown in Table 18 Suitability of schemes for DPC, has identified that, post the AID elements of demonstration centre and transfer main, the Colchester reuse project, a new water reuse plant with a capacity of 15Ml/D, would be DPC by default based on its whole life totex. Further, our early assessment has identified no significant reasons why most construction, operations and maintenance risks cannot be transferred or mitigated. As such, the project is eligible for and will be progressed under DPC; the scope of this is yet to be determined.

Table 18 Suitability of schemes for DPC

Scheme	Size test	Discreteness test	Potentially suitable for DPC?
Marham abstraction relocation	Did not pass	Did not pass	No
New groundwater - Suffolk west and cambs	Did not pass	Did not pass	No
Lincolnshire central surface water enhancement	Did not pass	Did not pass	No
Ruthamford south surface water enhancement	Did not pass	Did not pass	No
Lincolnshire east surface water enhancement	Did not pass	Did not pass	No
Lincolnshire east groundwater enhancement	Did not pass	Did not pass	No
Suffolk east groundwater enhancement	Did not pass	Did not pass	No
Recirculation schemes	Did not pass	Did not pass	No

Scheme	Size test	Discreteness test	Potentially suitable for DPC?
Colchester water reuse	Passed - £297.7m whole life totex	Passed	Yes
Adaptive planning	Did not pass	Did not pass	No

3.2.8 Customer view

Our customer engagement synthesis report sets out details of our customer engagement and findings, and the revised draft WRMP24 Customer and stakeholder engagement technical supporting document details how this has been used for the development of WRMP24.

In line with our customer engagement strategy, we have aimed for engagement to be meaningful, impactful and able to help us make better business decisions. Recognising that the core, non-negotiable, requirement of WRMP24 is to ensure a safe, resilient water supply, we developed key engagement questions that customers could shape our response to. For example, the prioritisation of supply-side and demand management options and the level of environmental destination that should be achieved.

Our engagement on supply-side and demand management options found that there is a strong view to 'get your house in order' first, with many customers highlighting the need to fix leaks. Whilst we have taken this view into our considerations, demand management alone will not ensure a resilient water supply which is why we also require supply-side investments in AMP8.

When discussing supply-side options, water reuse and reservoirs were highlighted as being preferred supply-side options. Reservoirs are seen as a familiar, tried and tested option which are environmentally friendly and an attractive community asset. They also like the fact it's cheaper and that it seems counter intuitive to emit more carbon by using desalination and water reuse when our climate challenges have been exacerbated by carbon emissions. Transfers were less preferred.

This feedback has helped us shape our AMP8 strategy. Whilst we recognise that our customers prefer supply-side options such as reservoirs, these simply cannot be delivered into service in AMP8. Instead, we will use transfers to utilise existing water in our network, as well as installing new equipment at our treatment works so it can treat the existing water available to us. This strategy, of utilising existing resource and moving it to areas in deficit, will allow us the time to develop the Fens and Lincolnshire reservoirs.

We have engaged with customers through multiple channels to allow us to cross check findings and get a full understanding of customer preferences.

3.3 Cost efficiency

3.3.1 Developing costs

The development of the supply-side improvement costs in our plan follows our cost efficiency 'double lock' approach set out in chapter 7 of our business. plan. Through this approach we have ensured that are costs are efficient in their bottom-up build up, and this is cross-checked through external benchmark approaches. This section sets out how we have ensured cost efficiency of our supply-side improvements through step one of our double lock approach. Step 2 is explored in the Benchmarking section below.

We have taken a robust approach to developing our supply-side improvement costs, building on our experience from delivering similar schemes into the bottom-up development of costs (before external cost benchmarking challenges are applied in step 2 of our 'double-lock' approach). The detail of the cost development approach is set out below, along with a breakdown of costs we provide in table CW3.

Cost Estimation Methodology

We follow a common cost development methodology across our enhancement investments in a three phase process:

1. Establish cost and carbon models
2. Input the cost drivers into the model (including location specific factors)
3. Data validation, internal challenge and assurance.

In phase 2, we derived our total cost estimation for each supply-side improvement scheme by gathering location based data which influences the cost estimates for each scheme. For supply-side improvement schemes, this included:

- Individual Site surveys/investigation to ascertain what aspects of the WTW were restricting performance and scope to provide assets to eliminate these restrictions
- Site specific operational assessment of risk on process by products (i.e bromate formation)
- Process calculation
- Desktop propose route for pipeline connections
- Hydraulics parameters to meet the minimum delivery pressure
- Topography and surface types (i.e roads, field, verge)
- Current site assets configuration

- Operability and connection to existing assets
- Other site specific requirements and
- Assessment of construction constraints such as access constraints , SSSI areas.

The table below summarises the scope designed to each project and the capital and operational cost forecast to incurred in AMP8 for the supply-side improvement schemes to be delivered. This table includes capital costs to be incurred in AMP7 for schemes which we expect to deliver through transition allowances and/or Accelerated Infrastructure Delivery.

Table 19 Overview of supply-side schemes, scope and costs

Investment ID	Investment name	Scope	Length (km)	Dia (mm)	Flow (Ml/d)	Capital Cost £k AMP7	Capital Cost £k AMP8	OPEX Cost £k (25-30)	£m/MLD
I041168	FND22b Marham surface water abstraction relocation	*Water mains and fittings *Two Pumping Stations ; 234 kW and 108 kW *Site Ancillaries (access road, fences, landscaping, telemetry)	13.2	396	13.6	-	20,700	136	1,522
I041273	SWC13 Suffolk West & Cambs groundwater relocation	*New BH site sized for 2.6 Ml/d *Water main and fittings	6.09	246	2.6	-	8,682	76	3,339
I041169	FND22a Marham surface water abstraction relocation	*Pre Ozone system *Clarification by DAF *Membrane Filtration *Post Ozone *Standby power *Building to inhouse processes units *Reservoir 3,250m3 *Site Ancillaries (access road, fences, landscaping, telemetry)			13	880	26,336	57	2,026
I034661	LNC30 - Hall WTW surface water enhancement	Asset Interventions to enable works to output 20Ml/d daily for sustained periods without risk of THMs. *TOC removal plant (Submerged Ion Exchange "SIX" Process) *5th Membrane train *Mussel trap SIX plant process will treat 100% of flow so the new flow to be treated for carbon calc purposes will be 20 Ml/d.			20	-	27,707	426	1,385

Investment ID	Investment name	Scope	Length (km)	Dia (mm)	Flow (Ml/d)	Capital Cost £k AMP7	Capital Cost £k AMP8	OPEX Cost £k (25-30)	£m/MLD
I039996	RTS21 Ruthamford South surface water enhancement	Installation of two 2 New Processes: *Clarification - DAF process and Nitrate Removal *Interstage PS to return flows toexisting WTW *Site Ancillaries (access road, fences, landscaping, telemetry) Upgrade existing WTW as below : *Final water pumps *Raw Water Pumps *run to waste for GAC system *Membranes - Lining of membrane tanks to reduce outages, provide trains with additional modules, tank to enable module storage and changing and chemical dosing in external Kiosks *Standby Generator and Building			25.7	-	32,869	221	1,279
I040062	LNE12 Lincolnshire East Surface Water enhancement	*Upgrade WTW to achieve peak 60Ml/d and average 52Ml/d: (draw off pipeline, UV plant , upgrade existing processes) *New sludge treatment processes *Automation of Abstraction at Cloves Br, Louth WRC, Covenham WTW, River Lud, & Tetney *Mussel shell removal with Micro strainer Replacement *Site Ancillaries (access road, fences, landscaping, telemetry)			60	-	56,375	210	940
I040181	LNE11 Lincolnshire East Groundwater enhancement	*New assets for 4BHs (2 small 28l/s and 2 x large 53l/s)- Pumps, starter , valving. *New lining of transfer from Healing to Little London *Provide new Nitrate removal and UV disinfection at Little London			29	2,890	14,634	987	505
I041094	SUE23 Suffolk East groundwater enhancement	* UV plant 6,000 m3/d *Chlorination plant *Phosphate Dosing Plant to maintain peak flow 6MLD *New High Lift pumps to matchalteredcapacity *Site Ancillaries (access road, fences, landscaping, telemetry)			6	970	3,900	859	650
I041265	WRMP24 Supply Side Options - Recirculation Schemes	New recirculation Schemes at 13 sites *Tanks *pipes, fittings and valves *monitors					7,000		
I041246	LNN3 Lincolnshire Retford and Gainsborough resource optimisation	*GAC to treat 8Ml/d * 110kW PS at Sturton le Steeple. *Site Ancillaries (access road, fences, landscaping, telemetry)			8		5,394	217	

Investment ID	Investment name	Scope	Length (km)	Dia (mm)	Flow (Ml/d)	Capital Cost £k AMP7	Capital Cost £k AMP8	OPEX Cost £k (25-30)	£m/MLD
						4,740	203,597	3,191	

Table 20 Overview of Supply demand balance improvements delivering benefits starting from 2031

Investment ID	Investment name	Scope	Length (km)	Dia (mm)	Flow (Ml/d)	Capital Cost £k AMP7	Capital Cost £k AMP8	OPEX Cost £k (25-30)	£m/MLD
I040919	EXS19b Colchester 15.2MLD Supply transfer BVP	*Water mains and fittings *Pumping Stations in network - 306 kW *Site Ancillaries (access road, fences, landscaping, telemetry)	9.59	494	15.2	3,800	14,540	606	957
I040966	Colchester Reuse - Pilot Plant	as per AID programme				600	4,451		
I041170	Adaptive Planning	WRMP29 adaptive planning studies - 2 sites as per PR19					12,104		
I040827	Colchester Reuse DPC allowance	Outline design and market engagementto appoint CAP					8,727		
		Total				**4,400**	**39,822**	**606**	

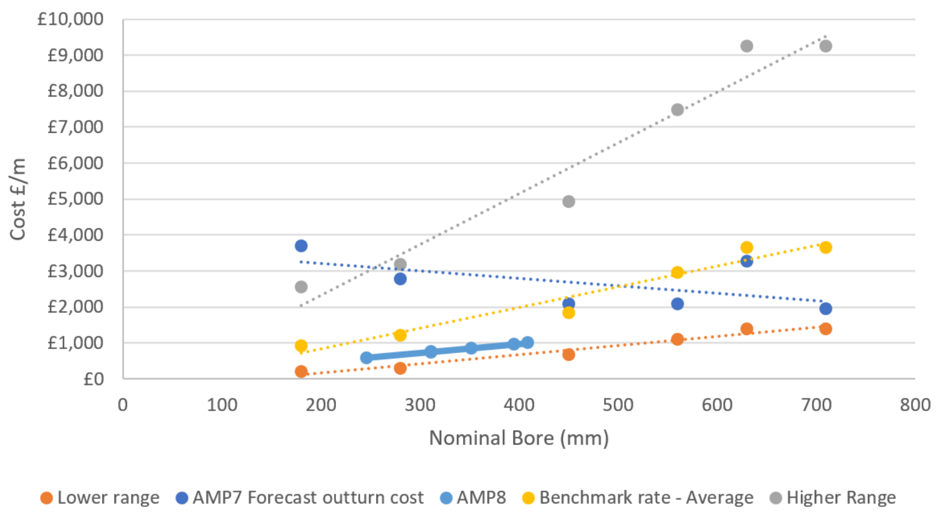
3.3.2 Benchmarking

Infra

The costs that we have developed for our supply-side schemes have been developed using similar scheme outturn data on a bottom-up basis.

For infra assets, which represent 21% of the direct asset costs of the programme, the benchmarking findings from our interconnectors investments also provide assurance on the efficiency of our pipes estimated in the supply side, as both use the same approach in the build up of the bottom up cost estimates. We have used the analysis of unit rate to benchmark the overall AMP8 unit rate calculated at each scheme in the programme, this can be seen below:

Figure 14 AMP8 interconnectors and overall benchmarking of isolated pipe rates - HPPE

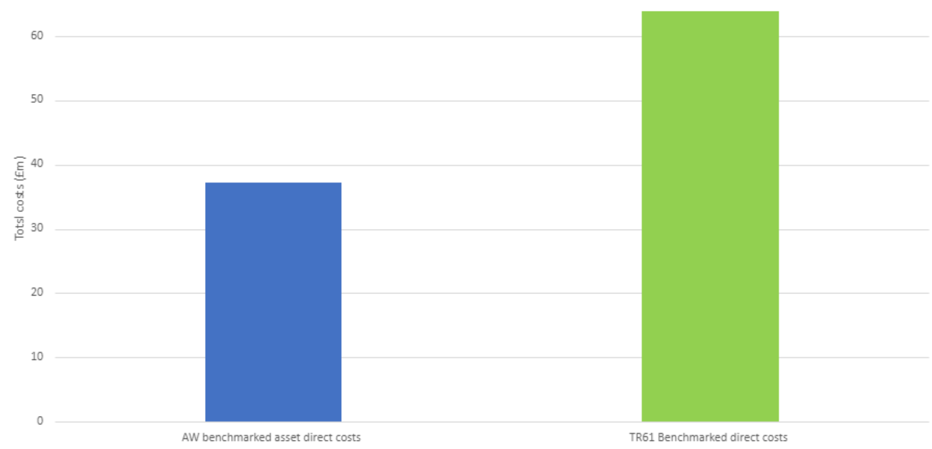


The solid blue line represents the costs shows the costs we have used for our pipe rates. The chart shows that these unit costs are below the average compared to the benchmark and close to the lower range of unit costs. This provides assurance that the infra costs included in our supply-side investments represent efficient costs.

Non-infra

For the non infrastructure assets, we have sought assurance on the efficiency on the costs through by benchmarking to the available parametric models build by WRCs TR61.Figure 15 Supply-side non-infra assets direct costs benchmarked shows that our comparable non-infra costs (blue bar) are below the industry data WRC TR61 (green bar).

Figure 15 Supply-side non-infra assets direct costs benchmarked



3.3.3 Assurance

The development of our costs within our cost estimation system (C55) have been assured by Jacobs. Our cost estimation process was assured by Arup.

3.4 Customer protection

Customers will be protected if our supply-side WRMP schemes are cancelled, delayed or reduced in scope by a Price Control Deliverable on the water available for use (WAFU) in water resource zones (WRZs). Our proposed PCD protects customers across the full scope of benefits to be delivered by supply schemes by being defined against the outcome that the supply schemes will deliver rather than the input (i.e. specific schemes) which could be subject to change before the WRMP is approved by the Secretary of State, or in delivery where new and more effective ways of the delivering the outcome may be identified.

For more detail on the Water Available for Use in Water Resource Zones PCD, please refer to the appendix 'Price Control Deliverables'[5]

5 ANX ANH37

4 Strategic Resource Solutions

Overview

- The East of England faces significant challenges in the availability of water for public water supply and for nature. The statutory Water Resource Management Plans WRMP19 and WRMP24 identified the need for significant new water resources in our region, to ensure we can maintain a sustainable and secure supply of water for our customers.
- These new water resources will enable us to comply with Environment Agency (EA) targets to reduce unsustainable abstraction for public water supply, and to increase the level of resilience to drought as climate change continues to affect weather patterns, with a target of being resilient to a 1 in 500 year event.
- This enhancement strategy covers the following strategic resource options:
    - Fens Reservoir
    - Lincolnshire Reservoir
    - Peterborough to Grafham Transfer
- The PR24 development costs for these projects is shown in the table below.

Table 21 Investment Summary

PR24 costs (£m)	
Capex	0.0
Opex	232.6
Totex	232.6
Benchmarking	
Method	Scheme outturn costs Market testing of costs
Findings	The external review of costs supported the view that our costs are efficient.
Ofwat data table	
CWW3.183-CWW3.184	SROs

4.1 Delivering for the long term

4.1.1 Investment context

The East of England faces significant challenges in the availability of water for public water supply and for nature. The water resources planning process sets out the need for investment: the statutory Water Resource Plans WRMP19 and WRMP24[6] have identified the need for significant new water resources in our region to ensure we can maintain a sustainable and secure supply of drinking water for our customers.

This new water resources in our region is required in addition to our interconnectors and supply-side schemes programmes. Our interconnectors will support us to move water around our region to locations in deficit, however investment into the geographical distribution of water doesn't increase the overall supply. Our supply-side schemes to be developed in AMP8 (which includes backwash recovery, groundwater development, and relocation of surface water abstraction) are limited by availability (e.g. licenses) therefore are fairly small scale. Therefore given the scale of deficits - notably environmental impacts on supplies - much larger supply-side capacity is required in addition to interconnection and supply-side solutions.

These new water resources will enable us to comply with Environment Agency (EA) targets to reduce unsustainable abstraction for public water supply, and to increase the level of resilience to drought as climate change continues to affect weather patterns, with a target of being resilient to a 1 in 500 year event. Unsustainable licences are those that have led to a requirement within law to cap groundwater licences to avoid the risk of ecological deterioration, and in the longer term to meet environmental ambition to leave more water for nature in our rivers and groundwater. We have worked with the EA to identify which abstraction licences must reduce in order to return flows in rivers to levels necessary to protect vital ecosystems such as chalk streams. We have implemented measures to achieve these improvements via physical modifications to rivers, river support schemes and interconnectors to bring water from other supply areas, but these on their own are not sufficient and so as a result we have now included in our plans two new 55 million m3 reservoir systems (Fens reservoir at Chatteris and Lincolnshire reservoir at Sleaford); the usable volume of water is 50 million m3.

To arrive at the conclusion that the reservoirs are necessary and low regret in the context of potential future changes, extensive water resources planning exercises have been completed at the regional[7] and company level. The regional water resources management plan used a multi-objective robust decision making approach to identify low regret options i.e. options that are selected across a wide range of potential future scenarios of growth, climate change and abstraction reduction. The Fens and Lincolnshire Reservoirs were both selected as low regret options on this basis.

Company level modelling has independently identified the need for the reservoirs based on multi-objective best value criteria and using the Economics of Balancing Supply and Demand (EBSD) model. This model was developed collaboratively across the UK water sector[8] and uses constraints such as the size of deficit in supply vs demand, the timing of when the deficit occurs, and the locations of the deficits in specific water resource zones to identify best value and least cost options to resolve the deficits. Additional considerations include the chemistry of the available water and therefore the ability to blend water in supply. The model uses hundreds of supply options as described in the WRMP including sea tankering of water from other countries, desalination, transfer pipelines from areas of surplus to re-distribute available resources and water reuse.

It is important to understand how our plans respond to future uncertainty, as we do not want wasted investment or stranded assets. To achieve this, we conduct thorough sensitivity testing, stress testing and least worst regrets analysis. This testing enabled us to analyse how the future could impact our choice of plans. We found that:

- Varying the climate change scenario does not significantly impact the plan.
- All plans need an element of desalination capacity. When we excluded desalination there were insufficient alternative options to meet the need. The reservoirs options could be replaced with desalination but at considerably higher operational costs.
- Desalination is scalable so can be sized to meet the need.
- Exclusion of either reservoir impacts the ability to supply Cambridge Water; therefore these scenarios are considered unfeasible as these plans do not meet regional needs.
- Extending the length of the planning period from 25 years to 50 years shows that our plan is stable, with the reservoir options developed at the same time, and with the other new resource options and the interconnector network remaining the same prior to 2036.
- Our preferred plan was the best performing in the least worst regrets analysis

6 https://www.anglianwater.co.uk/siteassets/household/about-us/wrmp/rdwrmp24-main-report.pdf
7 https://wre.org.uk/the-draft-regional-plan/
8 UKWIR publication 12/WR/27/6

Our WRMP24 modelling confirmed the need for the reservoirs with unconstrained model runs selecting both reservoirs at their adopted capacities. Through the sensitivity and stress testing this has demonstrated that for both reservoirs the 50MCM is the most robust sized reservoir.

- The Lincolnshire Reservoir is consistently selected at 50 MCM across all sensitivity and stress test portfolios.
- The Fens Reservoir is selected at 50 MCM across the majority of stress test, but does show more variability, with larger and smaller options selected in specific scenarios. For the sensitivity tests we did not constrain any of the options including the regional no-low regret ones and only included the proportion of the Fens Reservoir allocated to Anglian Water for the costs and the benefits. When the needs of Cambridge Water are included the Fens Reservoir is always selected at 50 MCM.

We also found that the reservoirs satisfied more objectives on our best value planning framework than feasible alternatives, such as desalination or water reuse. The reservoirs provide the greatest potential for net beneficial opportunities for local communities. An independent socio-economic review found that they have more potential to provide benefits to communities, stemming from recreational activities and public access to green space. These benefits include mental and physical health, education, tourism and wider economic benefits due to increased visitors to surrounding areas.

Additional detail on the options appraisal process for supply side investments is available in Section 8 of our revised draft WRMP24 Main report.

Table 22 The SROs and their drivers

Item	Mandatory	Discretionary	Investment driver
Fens Reservoir	100%	-	Environment Agency caps to groundwater licences, with abstraction maintained via cases of Overriding Public Interest (OPI) until the Fens Reservoir is in service.
Lincolnshire Reservoir	100%	-	Environmental Destination between 2035 and 2050; 1:500 year drought resilience by 2040 as defined in Water Resources Planning Guidance.
Peterborough to Grafham Transfer	100%	-	1:500 year drought resilience by 2040

An independent national model, the Water Resources of England and Wales water resources model, also identified the need for and value of both the Lincolnshire and Fens reservoirs. This modelling also confirmed that both reservoirs are resilient against uncertainty in supply and demand over the long-term.

A set of WINEP investigations (Environmental Destination driver) will be undertaken over the next 3-4 years (including under transition funding) to define the long-term abstraction changes. WRMP24 has been designed with this in mind, with the reservoirs providing sufficient water to meet a lower level of environmental ambition. If further reductions are required, then this will be reflected in PR29, with desalination likely to become necessary during the 2040s.

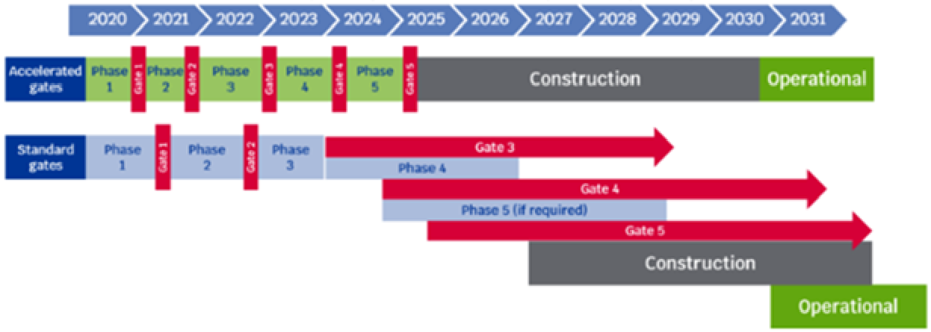
4.1.2 Scale and timing

Investigation and feasibility work for these projects began as early as AMP4, therefore the investment already uses a multi-AMP phased approach. These investments are part of an overarching strategy of balancing supply and demand in the region and only become necessary having already completed other less complex investments in previous periods.

The total estimated cost of delivery of these projects stands at around £5.2bn (in 2022/23 prices), making them comparable with the very small number of other nationally significant major infrastructure projects. These are the first reservoirs of this size to be developed in the UK for around 40 years, and therefore significant collaboration between stakeholders, regulators and the supply chain will be essential for their success. The scope includes raw water abstraction from rivers including measures to avoid harm to fish and eels at these locations, raw water transfers to the reservoir locations, water treatment works and potable transfer pipelines into distribution, as well as a large potable piped transfer from the Lincolnshire Reservoir south into Anglian Water's western supply area, known as the Peterborough to Grafham Transfer. The projects will supply c.250 million litres per day (MLD), enough to supply around 750,000 homes, with the output shared as 213 MLD to Anglian Water and 44 MLD to Cambridge Water. Collectively they are referred to as SROs, and form part of a wider set of SROs being developed nationally under the regulatory oversight of a new body, the Regulators' Alliance for Progressing Infrastructure Development (RAPID), which is made up of Ofwat, Environment Agency and DWI[9]. RAPID are using a gated process to oversee progress in the development of the projects.

9 RAPID - Ofwat

Figure 16 RAPID gated process



The Lincolnshire Reservoir and associated Peterborough to Grafham transfer are solely for the use of Anglian Water. The Fens Reservoir is being jointly developed between Anglian Water and Cambridge Water (part of South Staffs Water), and therefore the costs of that project are shared. This enhancement case has been jointly drafted by Anglian Water and Cambridge Water, referred to as the Sponsors. **The Fens Reservoir is dependent on each Sponsor securing 50% of the funding to enable the scheme to progress.**

The desired in-service date for the reservoirs is 2036 for the Fens reservoir and 2040 for the Lincs reservoir. As these are projects that span several AMPs, the current development costs in the period 2020-2025 are funded via Ofwat's PR19 determination and associated reconciliation mechanisms, whereas the future spend 2025-2030 will be funded via the PR24 Final Determination and subsequently PR29 for costs beyond 2030. Both projects have passed gate 2 in RAPID's standard process[10], meaning the solutions have been approved to continue into further, more detailed investigations.

We have carefully reviewed options of further phasing for this investment over a longer period, and provide a summary below. However, at present we do not believe it is possible to delay these projects without changes to the timing of environmental and customer outcomes currently set by law and by statutory guidelines.

Table 23 Investment phasing of options and their implications

	Investment phasing options	Implications of phasing options		
		Cost	Performance	Risk
Fens Reservoir	Potential to delay in service date beyond 2036	Unlikely to reduce cost to Sponsors in AMP8 as IP takes on main liability beyond 2028	Could jeopardise OPI cases and EA likely to insist other schemes brought forward. Increases risk to Cambridge customers.	Infeasible to phase given that Overriding Public Interest (OPI) to extend abstraction licences already being used. Other schemes would be required such as desalination and reuse which are not available in short term
Lincolnshire Reservoir	Potential to delay in service date from 2040 to 2041 or 2042 if legal requirements were deferred by Defra	Unlikely to reduce cost to Sponsors in AMP8 as IP takes on main liability beyond 2028	Would delay achievement of environmental destination and 1 in 500-year drought resilience	Investment modelling with a delay to 2042 would bring forward the need for desalination, increasing overall whole life cost
Peterborough to Grafham Transfer	Delay beyond 2040	Potential £8.4M saving	Would require further work to evaluate, potential impact on supply deficits	Could compromise Lincs Reservoir business case given the dependency on the transfer to convey a significant fraction of the water, i.e. it would make the Reservoir a largely stranded asset. However, we are considering delaying the start of this scheme until 2030, which still provides sufficient time to commission by 2040.

10 The RAPID gated process and the proposed water resource solutions - Ofwat

4.1.3 Interaction with base expenditure

These are completely new greenfield solutions and therefore do not overlap with base expenditure. This is in line with the approach taken to new supply-demand investments in previous AMPs.

4.1.4 Long term context (historic)

Reservoirs have long been part of the feasible option set and in WRMP19 we identified the need to progress development of the Lincolnshire Reservoir, along with early development of the Fens Reservoir. The Lincolnshire Reservoir had been developed conceptually in AMP6 with Water Resources East and stakeholders in the South Lincolnshire Water Partnership. The Lincolnshire Reservoir was included in RAPID's initial list of SROs. In early AMP7, following a change in abstraction licence capping policy, it became clear that the Fens Reservoir would be required, also to support Cambridge Water's needs. As such the companies jointly requested the Fens Reservoir to join the RAPID process, with a full Gate 2 submission made in autumn 2022. Ofwat included a reconciliation mechanism to allow increased allowances to be applied retrospectively in 2024. The development costs beyond Gate 2 (November 2022) will exceed the original allowances provided, in order to meet the full requirements of the DCO planning process and the delivery stage procurement towards SIPR. Subsequently via the RAPID Gate 2 approvals this reconciliation mechanism has been extended to cover the additional costs being incurred before 2025.

4.1.5 Long term context (future)

In the WRMP we define our preferred best value plan as comprising a core pathway and an adaptive pathway to meet our preferred most likely scenario. The adaptive pathway contained within our preferred best value plan can be contrasted with alternative adaptive pathways that would be triggered if circumstances turn out differently to what we consider most likely at present (as described in our preferred most likely scenario). See Section 10 of our revised draft WRMP24 Decision Making technical supporting document.

Our core pathway consists of the no-and-low-regret investments we need to commit to in AMP8, this includes the SROs due to the length of time to plan, design and construct them. The core pathway includes:

- Transfers needed in AMP8 to connect water resource zones to the WRMP19 interconnectors.
- Options where we are making upgrades/improvements to maximise output from existing resources.
- Water reuse scheme required in early AMP9, but development/design must start in AMP8 approved as part of the Accelerated Infrastructure Development programme.
- The two SROs, Fens and Lincolnshire reservoirs.
- Our preferred demand management strategy.

The need for these investments is clearly articulated in the WRMP which is a key part of our long term delivery strategy at PR24, defining the core and adaptive pathways to 2050 to achieve supply demand balance. Delivery at the scale and complexity of the SRO programme has not previously been seen in the UK water industry, perhaps with the exception of the c.£4bn Thames Tideway project which is clearly a very different asset in a Central London location. The Sponsors (Anglian Water and South Staffs Water) hold project promotion and interface risks, including for DCO planning and delivery stage procurement; the IPs (new entities awarded via the procurement process) hold delivery stage and operations/maintenance risk. Once completed, the Sponsors will then purchase treated water from the IPs via bulk supply agreements. There are many first-of-a-kind elements to the programme which require significant stakeholder consultation, including agreement of regulatory and planning routes to ensure delivery success. [11]

4.1.6 Customer support

Our Customer Synthesis Report collates our insight from our PR24 and BAU customer engagement. It shows that consistently across our research, providing a constant supply of high-quality drinking water is seen as a fundamental for a water company. Customers raise the need to not only maintain but improve and upgrade the current infrastructure and increase water storage to ensure continual supply.

We have engaged extensively with our customers on supply-side options through our WRMP. Reservoirs are seen as a familiar, tried and tested option which are environmentally friendly and an attractive community asset. Specifically for these projects we held an informal phase one consultation between October and December 2022, drawing in customer opinions on siting of the reservoirs as well as design and aesthetic impacts. The consultation materials were promoted on the project website and we held consultation events both online and via a series of events in the core consultation geographic zone. For the Fens Reservoir, 552 people attended our events, and we had 37,000 visits to our project website with 349 customers completing feedback forms. For the Lincolnshire Reservoir, 892 people attended, we received 330 feedback forms, 37,000 web visits. People in the consultation zones are a mixture of Cambridge Water and Anglian Water customers. The results of the engagement were summarised into a report. Overall

11 Please refer to Section 2.2.2 Water Resources in our LTDS for more information.

people responding are positive about the reservoirs. We are maintaining close ongoing dialogue with customers directly affected for example the effect of the projects on property sales in the area.

4.1.7 Cost control

The table below sets out the costs we are requesting for each component. These costs are development costs , with the project being handed over to an Infrastructure provider circa 2028 whose costs are not included in this

Table 24 Costs requested for each component of SROs

Cost Element	P2G	Lincs	Fens	Total
RAPID Gate 4				
Project Management, Commercial, PMO, Assurance	0.1	1.2	0.5	1.7
Design and Option Development	0.3	5.5	4.3	10.2
EIA, Data Collection, Sampling, Surveys	0.7	11.8	8.0	20.5
Procurement Strategy	0.1	1.8	1.5	3.5
Planning & Stakeholder Engagement	0.1	1.6	0.9	2.5
Land Options & Early Property Support Scheme	-	15.2	10.5	25.8
Overhead, Risk, Inflation, Legal, etc.	0.5	11.3	6.1	18.0
RAPID Gate 5				
Project Management, Commercial, PMO	1.6	11.3	11.3	24.3
Design, Environment, Technical	0.2	1.6	1.6	3.4
Constructability Advisory	0.1	0.9	0.9	1.9
Planning & Stakeholder Engagement	0.3	1.9	1.9	4.0
Procurement Strategy	-	7.3	7.3	14.5
Overhead, Risk, Inflation, Legal, etc.	0.8	5.3	5.3	11.3
Client Integration				
Client-Side Operations Team	0.3	1.4	1.4	3.1
Client-Side Integration (PMC)	-	1.5	1.5	3.0
Constructability Advisory	-	2.5	2.5	5.0
Shadow IP & Project Management Consultancy (PMC)				
Shadow IP Establishment (Executive, Governance, VDD	-	38.6	38.6	77.2
PMC (Directorate, Project Controls, Quality, etc)	-	36.5	36.5	73.0
Total	5.1	157.2	140.6	302.9

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4.2 Unlocking greater value for customers, communities and the environment

4.2.1 Option consideration

The WRMP24 in conjunction with the RAPID gate 1 and 2 submissions have clearly outlined the options considered, including other supply side and demand side options such as smart metering, desalination and effluent re-use. Within the context of the reservoir options the documents also describe the process used to select preferred locations and routes of transfers. We set out below provide more context and links to information about the options considered and scheme development.

We have considered an appropriate range of supply-side options across WRZs in our region, following the 8-stage framework set out in the UKWIR Guidance on decision making processes. For the development of feasible options, we developed an unconstrained options list by:

- Identifying all the options considered in the previous planning round, as well as any options identified since.

- Exploring options presented by regional groups, including regionally scaled and joint-company options. We also identified potential transfers from neighbouring water companies and engaged with third party options.
- Reviewing the Environment Agency's Catchment Abstraction Management Strategies (CAMS).

These options were then subject to a coarse screening exercise, before progressing to feasible studies and fine screening. This process resulted in 1528 unconstrained options being reduced to 151 constrained options which entered into our decision making processes. As highlighted in our draft WRMP24 consultation, these options provided nearly three times the amount of deployable output required by our region.

The supply-side option types taken forward to the constrained list included:

- Aquifer storage recovery (ASR)
- Backwash recovery
- Bulk/intra company transfers of treated water
- Conjunctive use- 3rd party
- Desalination
- Drought permit
- Groundwater sources
- New reservoir
- New surface water
- Sea tankering
- Water quality schemes increasing deployable output
- Water reuse

We provide a brief summary of the option types considered for WRMP24 below, with further information available in our revised draft WRMP24 Supply-side options development technical supporting document.

Aquifer storage and recovery (ASR) is a technique used to replenish and store groundwater in aquifers for subsequent abstraction and supply. We don't currently operate ASR in our region, and there are limited examples of its use in the UK. The earliest delivery date of the ASR options is 2032.

Backwash recovery involves cleaning filter backwash water and returning it to the head of a water treatment works to be treated again, rather than discharged to the environment or sewer. The amounts associated with such returns are generally small, with their benefits localised to the WRZ. The earliest delivery date for these options is 2027 to 2030.

Bulk/intra company transfers of treated water move surplus water between WRZs. The transfer routes were developed using a specialist tool and internal workshops. The earliest deliverable date for transfers is 2028 to 2030.

We also explored **conjunctive use** which describes when we share resource between us and other companies. For instance, there could be an instance where a power company possesses a consumptive abstraction licence that is not being fully utilised. In this circumstance, there could be the opportunity to purchase the unused volume of these licences, abstract and treat it, to support our own supply needs. The earliest deliverable date for these options is 2030.

An investigation was undertaken to determine where **desalination** (the process of removing salt from water, then treating it and conditioning it to make safe, drinking water) is viable in our region. This evaluation encompassed 500km of coastline, including estuaries. Some of these desalination options contained a conjunctive use element, for instance, discussing possibilities to share outfall structures with energy producers. The earliest deliverable date for desalination is 2032 to 2035.

We also included **drought permits** in our constrained option set. These permits secure additional water resources by modifying or suspending conditions on an abstraction licence. An application is reviewed and determined by the Environment Agency. The delivery dates of these are dependent on the monitoring requirements, and approval, by the Environment Agency.

Groundwater sources have also been developed. As previously discussed, our options for taking any additional water from the ground are limited with many of our sources being subject to licence caps or complete cessation of licence. We have reviewed these, as well as CAMS, and believe there are some options which could yield a small deployable output benefit. These groundwater options are available between 2027 and 2030.

Sea tankering, the importing of water from countries outside of the UK, has also been explored.

As well as groundwater, we have also reviewed the availability of **surface water**. This review, and liaison with the Environment Agency, has determined surplus water for the Fens and Lincolnshire reservoirs and the relocation of the River Nar abstraction. The earliest delivery date for new surface water (excluding the reservoirs) is 2030.

There are also instances where our existing treatment works cannot treat the water due to water quality issues, such as rising nitrate level. We have reviewed our works, their available water and the constraints associated with them, to determine where enhancement investment could be utilised for **water quality schemes** to increase deployable output. The earliest delivery dates for these options is 2027 to 2030.

Water reuse options have also been developed. This involves the advanced treatment of final effluent before returning it to the environment. It is then abstracted and treated to a drinking water standard at one of our water treatment works. We assessed the suitability of our Water Recycling Centres for water reuse against criteria designed to ensure that any options were cost effective and did not deprive sensitive environments of vital flow. The earliest delivery date for water reuse is 2032 to 2035.

As part of our strategy development, we have a commitment to minimise operational energy and carbon. Our decision making has found that similar capacity desalination options to the Fens and Lincolnshire reservoirs requires significantly higher operational carbon and costs compared to the reservoirs, see Section 6.2 of the Decision Making report.

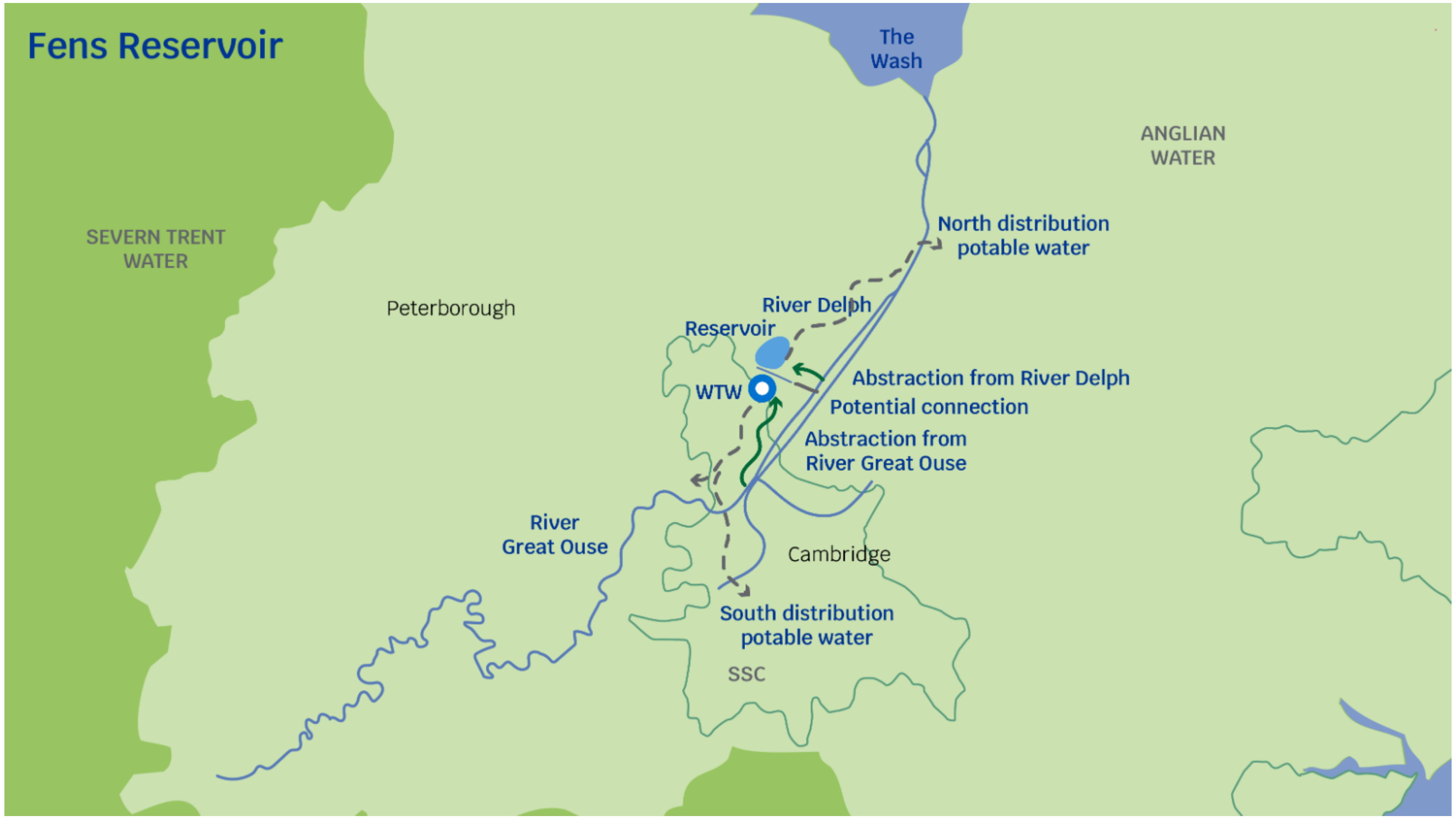
Reservoirs give us the opportunity to provide outdoor spaces and recreation. An external study of the recreational and socio-economic benefits associated with reservoirs in comparison to desalination and reuse options found that the key socio-economic benefits delivered by reservoirs stemmed from recreational activities and public access to green space. These benefits included mental and physical health, education, tourism and wider economic benefits due to increased visitors to surrounding areas. Desalination and water reuse present more limited opportunities to create these benefits.

Desalination plants are more scalable and can be sized to provide the exact capacity needed compared to reservoirs. Therefore to develop an adaptable plan it is preferable to build the reservoirs earlier and add desalination plants later in the plan once the need and scale has been confirmed by the WINEP investigations. Delivering desalination plants later in the plan also provides greater opportunity for technological developments that may increase efficiency and reduce energy requirements.

Fens Reservoir

The Fens Reservoir is jointly developed between Anglian Water and Cambridge Water and therefore the costs of the project are shared. The costs shown above are the Anglian Water 50% share only. The output of this reservoir is subject to ongoing work and is likely to be at least 100 MLD in our October 2023 additional evidence submission to RAPID; revised draft WRMP24 modelling is based on 89 MLD.

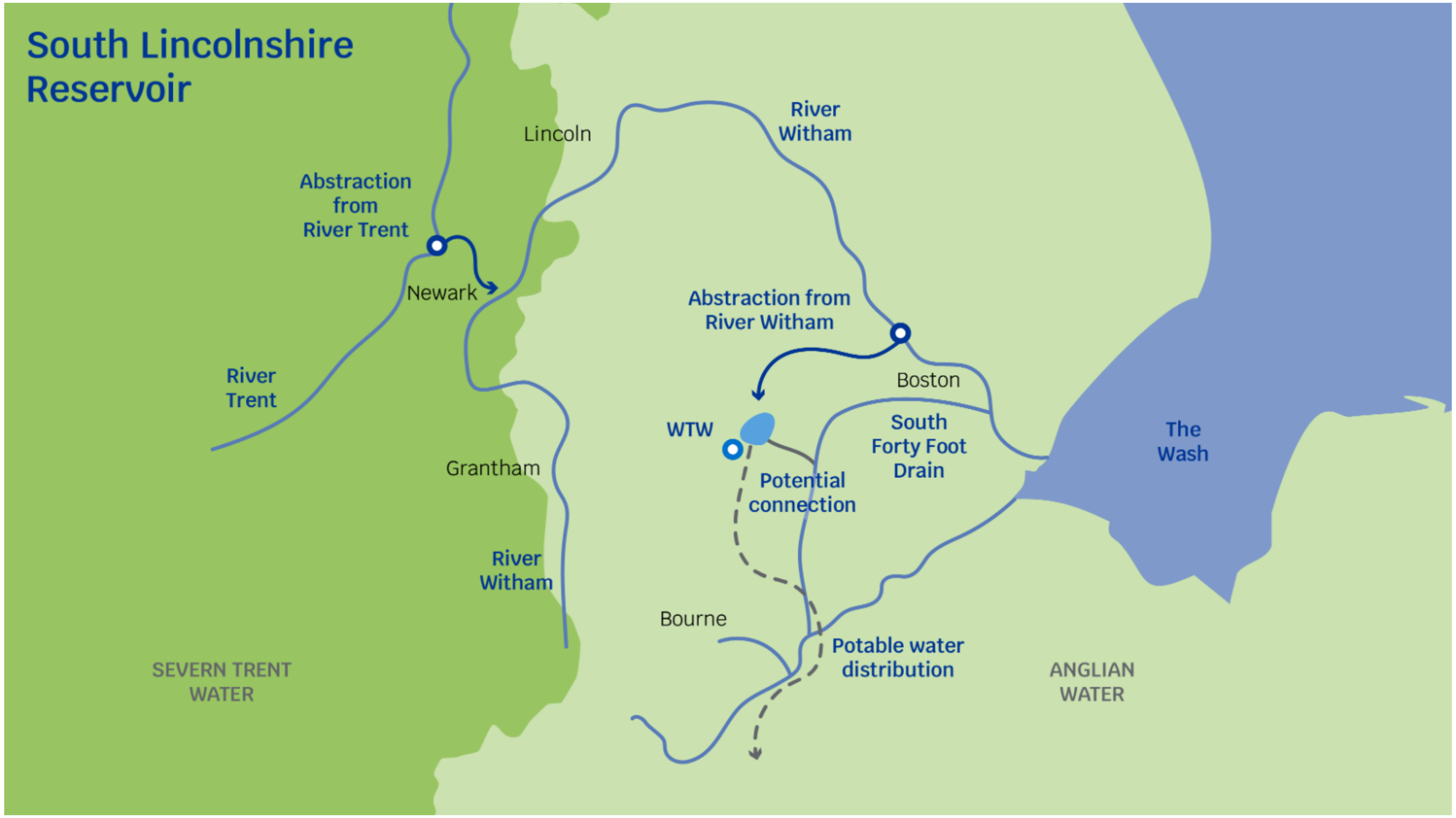
Figure 17 Fens reservoir



Lincolnshire Reservoir

The Lincolnshire Reservoir was due to be jointly developed with Affinity Water, but an alternate supply scheme has now been selected for that region and now this scheme is Anglian Water only. The outputs of this reservoir is likely to be 169 MLD.

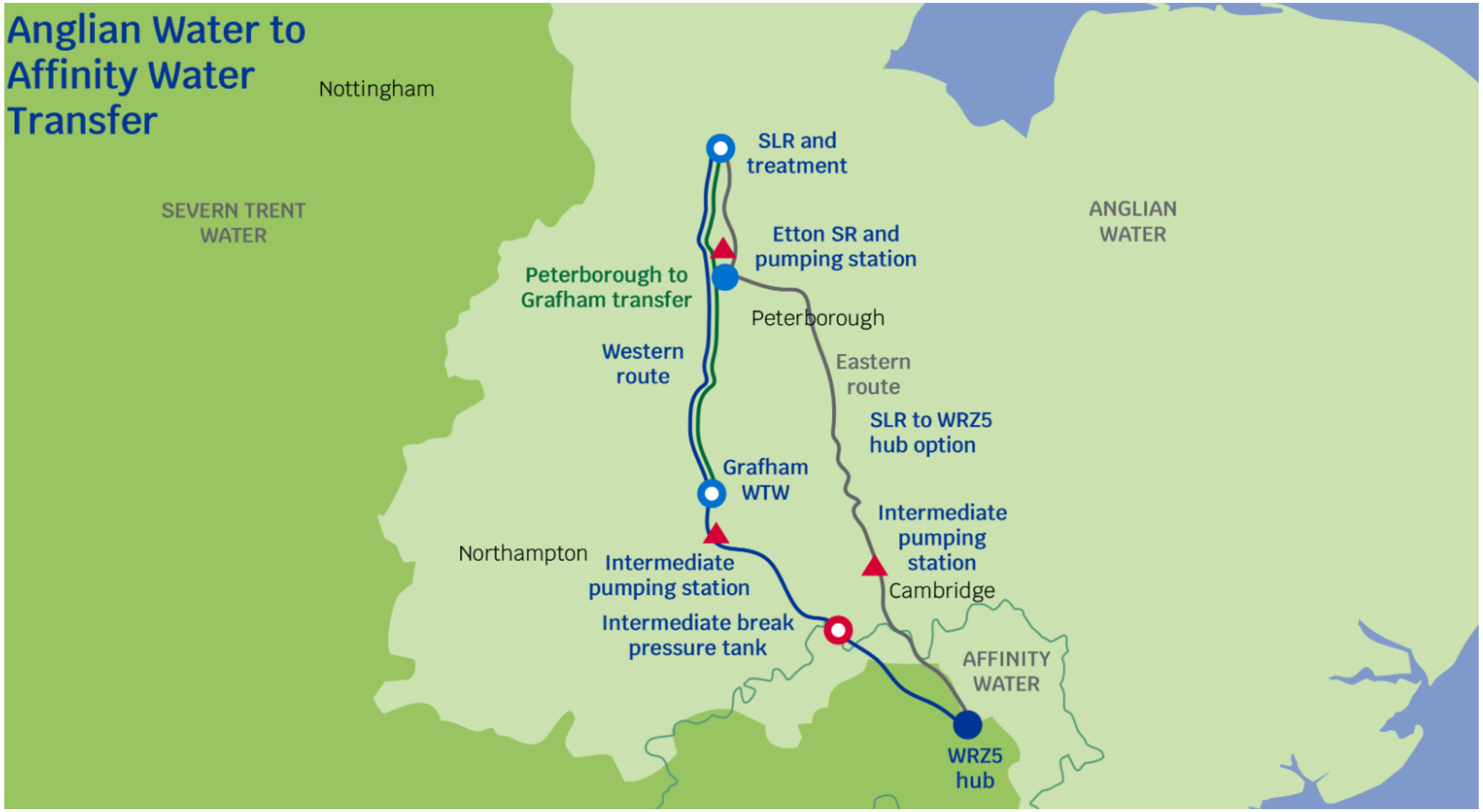
Picture 1 South Lincolnshire reservoir



Peterborough to Grafham transfer

The full scheme previously referred to as the Anglian to Affinity transfer (A2AT) is no longer being progressed, however the Peterborough to Grafham Transfer component, with a capacity of up to 150MLD, is still included in WRMP24 by Anglian Water alone.

Figure 18 Peterborough to Grafham transfer



4.2.2 Cost-benefit appraisal

Our WRMP24 decision making looks beyond cost and seeks to deliver benefits to customers and society, as well as the environment, whilst listening and acting on the views of our customers and stakeholders. Our plan is assessed using our best value plan framework which is based on objectives of what we would like our plan to achieve. These objectives are aligned to our strategic outcomes to customers.

We also develop a least cost plan which considers only cost and none of the other best value metrics. This provides a benchmark to be compare our plan against. Further detail is available in the WRMP24 Decision Making technical supporting document.

For the revised draft WRMP24 we have modelled the SROs as unconstrained where appropriate, this ensures the full range of reservoir sizes and yields can be considered by the model. Through the sensitivity and stress testing this has demonstrated that for both reservoirs the 50MCM is the most robust sized reservoir. Both reservoirs are selected in the best value and least cost versions of the plans, see Section 7.5 of the Decision Making report.

4.2.3 Environmental and social value

Our proposed enhancement spend was selected by following our WRMP24 best value decision making process. This process has been developed based on our regulatory requirements, and following consultation with our customers and stakeholders. It aligns with Ofwat's public value principles.

The best value plan metrics we have used within our decision making process include both option level benefits and impacts, and those that apply at the broader system level. For example, capital and operational carbon impacts, and the effect of options on natural capital and biodiversity apply at option level, whilst wider benefits such as the scale and timing of reducing abstraction from unsustainable sources apply at the overall system scale.

As part of our best value process, we have quantified the impact of a range of policy decisions, alternative plans and stress and sensitivity tests on our best value metrics. This has enabled us to transparently demonstrate the trade-offs inherent in selecting a best value plan for our water resources, as described in further detail within the WRMP24 decision making technical supporting document.

Carbon

We developed capital and operational carbon impact estimates for each feasible option in tonnes of CO2 equivalent.

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 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.

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.

As described in our WRMP24 decision making technical supporting document (Appendix D: Future Carbon Pathways) the delivery of our WRMP24 strategy will take place in the context of delivery of our company level net-zero strategy. In that section, we demonstrate that the true carbon impact of our plan is likely to be significantly reduced during the design, delivery and operation stages as part of our net-zero strategy.

Natural Capital

Natural Capital Assessment (NCA), including the assessment of changes to Ecosystem Services (ESS), has been undertaken of the options in our constrained list of supply-side options.

The NCA process identified permanent changes in natural capital (habitat types) predicted to result from the options. The assessment of ESS included: carbon sequestration (climate regulation), natural hazard regulation, water purification, water regulation, air pollutant removal, recreation & amenity value, food production. The findings are presented in the Biodiversity net gain and natural capital assessment sub-report to the WRMP24's Environmental Report, as well as feeding into that over-arching report's findings.

Biodiversity Net Gain

Biodiversity Net Gain (BNG) assessments have been undertaken of the options in our constrained list of supply-side options. This approach meets both the WRPG's requirements to consider biodiversity and habitats related ESS impacts and to assess net gain to biodiversity. The findings are presented in the Biodiversity net gain and natural capital assessment sub-report to the WRMP24's Environmental Report, as well as feeding into that over-arching report's findings

Summary

The table below sets out a top level summary of the carbon and wider impacts from the schemes included in our PR24 plan. The assessment and quantification of our wider options are presented in the WRMP supply-side option development report and are not included here for simplicity.

Table 25 High level overview of carbon and wider impacts of the SROs

Scheme	Operational carbon emissions under maximum utilisation scenario (tonnes CO2e per annum)	Embedded carbon emissions (tonnes CO2e)	Habitats units (required restoration)	Biodiversity net gain cost (£k)
Fens Reservoir (FND29)[a]	4,200.36	161,796.45	288.02	8640.6
Lincolnshire Reservoir (RTN17)	13,953.89	449,737.89	0	0
Peterborough to Grafham Transfer (RTS24)	2,053.57	17,974.71	23.224	696.72

a Metrics for the Fens Reservoir have been halved to reflect shared allocation with Cambridge Water.

Alongside the provision of customer-funded public water supply, there is an aspiration to attract funding from third parties for multi-sector systems-wide additional benefit for the region, as articulated in the Future Fens: Adaptation Strategy[12]. These benefits are likely to include flood risk reduction (linking to the Environment Agency's National Flood and Coastal Risk Management Strategy, which specifically refers to the Fens), food security due to water use in agriculture and carbon sequestration.

We are also currently exploring ways in which the construction phase can leave a legacy for the affected communities, for example re-use of transport links in the post construction phase that were put in place for construction movements. We will continue to develop this thinking as the project progresses.

Our requested costs currently exclude any additional costs for the above.

4.2.4 Investment benefits

The reservoirs will provide substantial benefits in later AMPs, helping to meet legal obligations to avoid the risk of deterioration, as well as meeting long-term environmental and resilience obligations. The reservoirs will become a permanent part of their local landscapes and provide a wider range of social, economic and environmental benefits to local communities. In addition, there are significant system-wide opportunities that are being explored for example in relation to flood risk management, provision of water for agriculture and carbon sequestration.

As these assets will not be operational during AMP8 they will have no effect on PR24 Performance Commitments. Any carbon emissions either operational or embodied will be excluded from PR24 reporting as they will fall into the reported emissions of the IP.

4.2.5 Managing uncertainty

Our WRMP24 has been tested, using the common reference scenarios, for robustness to future uncertainty through sensitivity and stress testing, as well as least worst regrets analysis. We also conducted modelling to generate alternatives, to add further robustness. Both the reservoir options are selected in the four alternative plans tested.

Given the early stages of the development and the pioneering nature of the work, project-related uncertainty is extremely high across many aspects, meaning that cost estimates for development and procurement work represent a central assumption only. We believe that the level of uncertainty means that potentially an Interim Determination is likely to be required during AMP8 as the projects evolve. For this reason we propose that the Reservoirs are defined as a Notified Item in the PR24 Final Determination. We have attached as an appendix the full assessment of SIPR to support this enhancement strategy. Some specific areas of uncertainty to highlight are:

- **Legal -** Given the fact that this is only the second time the SIPR route has been used nationally and the first time for potable water assets there is significant uncertainty inherent in the scheme, there is a lack of clarity of liability for prosecution under Water Industry Act for water quality breaches and under the Reservoir Act for reservoir safety breaches - this has the potential to change assumptions about the scope of works included within SIPR, specifically the water treatment works
- **Commercial -** Lack of clarity on specific aspects of commercial risks to be defined in the negotiation of the SIPR deal with the IP, including the scope to be included within the SIPR deal as above, and how daily regional production planning is factored into these arrangements

12 The Future Fens: Integrated Adaptation - Cambridgeshire & Peterborough Combined Authority (cambridgeshirepeterborough-ca.gov.uk)

- **Supply Demand & Environmental -** The Environmental Destination investigations which will proceed as part of our AMP8 transition programme under WINEP will inform a trigger point in our adaptive plan on the scale of abstraction licence change required and therefore the options required in future WRMPs (likely to be principally the number and size of desalination plants)
- **Location -** Whilst extensive work has been carried out on the site selection, there is unique deliverability risk (and opportunity) for the Lincolnshire Reservoir site as the southern part of the preferred site is owned by the Crown Estate which carries specific legal circumstances.
- **IP revenue -** We have not included any costs for IP revenue post award at this stage as the timing and scale of that is dependent on the SIPR deal and market engagement
- **Development risks -** such as the extent of DCO conditions applied by the Secretary of State, or ground condition risks
- **Availability of supply chain**
- **Availability of financing**

Raw water reservoirs have not been built in the UK for 30+ years, so delivery capability is not proven, although there is a degree of relevance from other sectors that can be applied along with overseas experience. The scale of reservoir earthworks is very significant alongside other competing projects that may be in their construction phases at a similar time resulting in resource constraints that will need to be mitigated. Large raw water open channel and piped transfers will also be challenging. Water treatment plants delivery is not anticipated to require particularly novel technology, although commissioning and integrating new facilities is always complex. Together the asset integration risk is significant, coupled with a new SIPR procurement model.

4.2.6 External funding

As explained in the section on wider environmental and social benefits, extensive work has already been completed through Water Resources East and other stakeholder groups to attempt to secure external funding and achieve wider benefits. We see huge potential for these projects to leave a legacy for the region beyond public water supply, and help to achieve our Purpose of bringing environmental and social prosperity to the region we serve. Examples of externally funded components of the project could include improved integration with navigable waterways, transport links and cycleways, improved connectivity with agricultural irrigation systems, and landscape scale habitat creation.

Given the scale of the projects and consequent decision to use SIPR, the extent to which external funding can be secured will be a joint matter to discuss with the IP once appointed.

4.2.7 Direct procurement

We have completed screening of these projects and concluded that they are unsuitable for DPC. We have reviewed Ofwat's guidance[13] on the selection of specified infrastructure projects, and conclude these projects are more suited to the use of SIPR. For more detailed information on this assessment, see appendices ANH34 (SIPR Specification report for Lincs reservoir) and ANH35 (SIPR Specification report for Fens reservoir).

The table below shows the ratio of current RCV to project share for each Sponsor demonstrating the issue:

[redacted]

Our proposed approach for PR24 is to use the Specified Infrastructure Projects Regulations (SIPR), as used for the Thames Tideway Tunnel, to procure third party Infrastructure Providers (IP's) to construct, own and operate these assets. Ofwat's Final Methodology allows for this in section 2.4.5 of appendix 5

[14]

We have reviewed the legal risks of this procurement route and understand that use of SIPR may require changes to primary legislation, in particular to clarify liability for failures in drinking water quality or reservoir safety. In discussion with Ofwat, we believe that these changes will be implemented by 2026, ahead of the appointment of the IP's. As explained later in this document, we have completed an assessment of the eligibility of these projects for the use of SIPR. The assessment is appended to this enhancement case, and further explains the reasons for choosing SIPR.

13 Criteria for selecting specified infrastructure projects (ofwat.gov.uk)
14 PR24_final_methodology_Appendix_5_DPC.pdf (ofwat.gov.uk).

The projects will be delivered by new IP companies with their own licences, owners, boards of directors and employees. Our working assumption is that by 2030 these companies will be appointed, with project licences in place. In preparation for that, to support the most effective procurement of an IP and associated cost of finance and thereby achieve a lower cost to our customers, our plan includes the sponsors to:

- complete development work, design, site investigation, public engagement and consultations, and regulatory submissions (RAPID Gates),
- undertake market engagement and legal processes to use SIPR to appoint the IP's
- design, establish and operate shadow IP's prior to appointment
- operate property support schemes for residents facing property blight, as well as securing options on land as appropriate, and
- obtain Development Control Order (DCO) planning approval from the Secretary of State to grant permission for the projects to proceed

We include in our PR24 plans to collect the required funding from our customers to enable us to do all of that.

Once appointed, the IP's will be responsible for:

- providing equity and debt for the main project costs
- land acquisition
- discharging DCO conditions required (such as pre-construction visual and environmental mitigation works, plus enabling such as modifications to existing road/access arrangements, site power provision etc.)
- obtaining relevant abstraction licences from the Environment Agency
- obtaining relevant approvals relating to drinking water quality from the DWI
- obtaining relevant approvals relating to cyber and physical security from Defra
- detailed design, construction, commissioning and operation of the assets
- interfacing with Sponsors' assets

Below is a rough illustration of indicative total scheme profile across all parties:

[redacted]

[redacted]

4.3 Cost efficiency

4.3.1 Developing costs

The development of the Strategic Resource Solutions costs in our plan follows our cost efficiency 'double lock' approach set out in chapter 7 of our business. plan. Through this approach we have ensured that are costs are efficient in their bottom-up build up, and this is cross-checked through external benchmark approaches. This section sets out how we have ensured cost efficiency of our Strategic Regional Solutions costs through step one of our double lock approach. Step 2 is explored in the Benchmarking section below.

The construction costs of the projects were developed in conjunction with external consultants including Mott MacDonald, and have been scrutinised as part of the RAPID gated process. This includes extensive challenge of cost base and risk assumptions.

Table 27 High level overview of schemes, scope and costs

Investment ID	Project Name	Scope	Capital Cost £m AMP8	OPEX Cost £k (25-30)
I040373	SRO Development - Lincs Reservoir	*Further Assessment and Developed Design *Option benefits development and appraisal *Environmental Assessment *Data Collection, Sampling, and Pilot Trials *Procurement and Planning Strategy *Legal/Others	0	157,140
I041262	SRO Development - Fens Reservoir	*Programme and Project Management *Further Assessment and Developed Design *Option benefits development and appraisal *Environmental Assessment *Data Collection, Sampling, and Pilot Trials *Procurement and Planning Strategy *Legal/Others	0	70,325
I041263	SRO Development - A2AT	*Land & property acquisition *Construction Enabling / DCO condition discharge	0	5,096
		Total	**0**	**232,560**

The development costs for these schemes were prepared following advice from KPMG on the costs of SIPR establishment taking learning from the Thames Tideway model in conjunction with our Major Infrastructure and Procurement teams. We have used their rates for items like labour costs for project resources, and compared those with known salary costs. The overall cost confidence is currently low because of the ambiguity described above. We discuss this further in the section on customer protection.

4.3.2 Benchmarking

We engaged a discrete team within KPMG to benchmark and review our development costs, including testing the robustness and transparency of the process adopted, along with reviewing if the proposed developmental costs are within plausible ranges compared to other water and energy infrastructure projects. These included other SROs going through RAPID gates such as SESRO, but also recent comparators such as London effluent re-use, Thames Tideway, Havant Thicket reservoir, and within the energy sector the Offshore Transmission Owner (OFTO) projects.

[redacted]

5 Storm overflows

Overview

We have made significant progress over time to reduce the use of storm overflows since privatisation in 1990, such that today only 0.3% of the flow we receive into our sewers goes out untreated through overflows with the rest treated to high standards. Over that period we have invested to tackle intermittent discharges that have the highest ecological impact, and completely removed 220 overflow locations, but any spill that has the potential to harm to the environment is unacceptable and we are focused on reducing spills even further.

This investment is required to address the potential for environmental harm and public health which can result from discharges from storm overflows. We will increase the capacity of our networks and improve management of surface water flooding in periods of high rainfall. The need for investment is predominately specified by statutory WINEP obligations. Our ambition to improve in this area is captured by our Get River Positive commitments, which we launched in partnership with Severn Trent in March 2022.

We expect our programme to deliver 15.6% overall improvements at all our storm overflows, including a 48% improvement at our high priority overflows. These improvements are captured in our Storm Overflows performance commitment level. To achieve this reduction, we will invest £457.6m into the following activities:

- Spill reductions at 148 overflows to deliver new spill targets of 10 spills / year (for all overflows) and 2-3 spills per bathing water season for 25 of these overflows
- Investigations and then improvements to achieve no adverse ecological impact at 142 overflows. This includes all overflows discharging to shellfish waters and those being the confirmed or probable reason for the water body not achieving good status.

We considered a wide range of traditional and nature-based solutions. For each site at least one traditional grey solution was costed (i.e. storage tank/sewer), plus at least one other solution based on the feasible options from our optioneering process. **In our PR24 business plan 'green' solutions (either as the full solution or via a blended approach) account for 48% of our preferred solutions to address storm overflows.** We will also use digital solutions to manage flows and support delivery of our Get River Positive pledges.

Table 28 Investment Summary

PR24 costs (£m)	
Capex	445.2
Opex	12.3
Totex	457.6
Benchmarking	
Method	Scheme outturn costs Industry cost models from TR61 Asset level cost comparison with other companies
Findings	A more efficient delivery route for SuDS raingardens was identified, removing £19m. Other aspects of storm overflows investment were found to be efficient.
Customer Protection	
Price Control Deliverable	Number of sites improved Number of emergency overflow installed Number of screens installed
Performance commitment	Storm Overflows
Ofwat data table	
Part of CWW3.16-CWW3.18 CWW3.19-CWW3.21 CWW3.22-CWW3.24 CWW3.31-CWW3.33	Increase storm tank capacity at STWs - grey solution; (WINEP/NEP) [£154.2m capex, £1.5m opex - the remainder of this line is reflected in chapter 6 (Increasing FFTs and storm tanks]

CWW3.34-CWW3.36 CWW3.37-CWW3.39 CWW3.43-CWW3.45 CWW3.46-CWW3.48 CWW17.16-CWW17.18 CWW17.19-CWW17.21 CWW17.31-CWW17.33 CWW17.34-CWW17.36	Increase storm system attenuation / treatment on a STW - green solution; (WINEP/NEP) Storage schemes to reduce spill frequency at CSOs etc - grey solution; (WINEP/NEP) Storm overflow - increase in combined sewer / trunk sewer capacity; (WINEP/NEP) Storm overflow - sustainable drainage / attenuation in the network; (WINEP/NEP) Storm overflow - source surface water separation; (WINEP/NEP) Storm overflow - sewer flow management and control; (WINEP/NEP) Storm overflow - new / upgraded screens (WINEP/NEP) Increase storm tank capacity at STWs - grey solution; (WINEP/NEP) Increase storm system attenuation / treatment on a STW - green solution; (WINEP/NEP) Storm overflow - increase in combined sewer / trunk sewer capacity; (WINEP/NEP) Storm overflow - sustainable drainage / attenuation in the network; (WINEP/NEP)

5.1 Delivering for the long term

Storm overflows (SOs) currently play an important role protecting domestic homes and businesses from flooding. They are located on combined sewers (collecting both wastewater and rainwater from the catchment) and were part of wastewater sewer design prior to privatisation. Storm overflows operate by releasing excess water to the river or sea in times of rainfall or snow melt. The vast majority of what comes out of storm overflows is rainwater and therefore has very low or no ecological impact on the receiving environment. We have permission use these storm overflows as the Environment Agency (EA) issue permits for them. We operate them under the conditions of the permit and report the number of times they spill to the EA, Rivers Trust and publish the data on our website. Although the EA has calculated that storm overflows are responsible for just 1-4% of poor river health, we recognise our customers and stakeholders are increasingly concerned by these overflows and there is a growing perception of the unacceptability of storm spills to the environment.This forms a key part of our SDS commitment to work with others to achieve significant improvements in ecological quality of catchments.

We expect our AMP8 programme to deliver 15.6% overall improvements at all our storm overflows, including a 48% improvement at our high priority overflows. To achieve this reduction, we propose the following investment:

- Spill reductions strategies at 148 overflows to deliver new spill targets of 10 spills / year (for all overflows) with a reduction to 2-3 spills per bathing water season for 25 of these overflows.
- Investigations and any improvements required to achieve no adverse ecological impact at 142 overflows. This includes all overflows discharging to shellfish waters and those being the confirmed or probable reason for the water body not achieving good status .

5.1.1 Investment context

This investment is required to address the potential for harm to the environment and public health which can result from discharges from storm overflows through increasing the capacity of our networks and tackling surface water flooding in periods of high rainfall. As this is a step change in investment which will deliver environmental improvement relative to current levels we have included this investment as part of our enhancement programme. The need for investment is predominately specified by statutory obligations with our WINEP, where obligations have been set under the following drivers

Table 29 WINEP drivers for storm overflows

Driver	Description	Obligations
EnvAct_INV4	Investigations to reduce storm overflow spills to protect the Environment so they have no local adverse ecological impact.	For EnvAct_INV4 schemes scheduled for PR24 or PR29. For PR24 EnvAct_INV4 schemes, these should be completed by 30th April 2027.
EnvAct_IMP2	Improvements to reduce storm overflows spills to protect the Environment so they have no local adverse ecological impact.	Companies should achieve no local adverse ecological impact of: · 75%+ storm overflows discharging in or close to high priority sites by 2035

Driver	Description	Obligations
		· 100% overflows discharging in or close to high priority sites by 2045 · All remaining storm overflow sites by 2050 For storm overflows impacting shellfish waters the target is 2030.
EnvAct_IMP3	Improvements to reduce storm overflows that spill to designated bathing waters to protect public health.	Companies should profile this driver over PR24 and PR29, and should include this driver at their own discretion as early contribution to building their programme to achieve the Defra consulted target date of 2035. Schemes at newly designated bathing waters at poor status should be prioritised for PR24.
EnvAct_IMP4	Improvements to reduce storm overflows spills so that they do not discharge above an average of 10 rainfall events per year by 2050.	By 2030, companies should achieve a reduction of spills by at least 38% at high priority overflows and 14% at their total stock of storm overflows.
EnvAct_IMP5	Improvements to reduce storm overflow aesthetic impacts by installation of screens.	All Overflows screened to 6mm in 2 dimensions by 2050.

This requirement set out in the WINEP is underpinned by national legislation and planning frameworks, including the Environment Act. The Environment Act 2021 places a legal duty on sewerage undertakers to progressively reduce both the number of discharges from storm overflows and the associated adverse impact. Building on this legislation, the Storm Overflows Discharge Reduction Plan also sets out strengthened monitoring requirements to build a more comprehensive picture of the use and impact of storm overflows and introduces expectations for the water industry to maintain and enhance infrastructure without a greater number of discharges in the face of urban growth and climate change. Failure to act to progressively reduce the harm from storm overflows and meet legal obligations outlined in the Storm Overflows Discharge Reduction Plan will result in enforcement action by Defra and regulators under new duties in the Environment Act 2021.

In addition to statutory requirements to address storm overflows, our ambition to improve performance in this area is captured within our Get River Positive commitments which we launched in partnership with Severn Trent in March 2022.

Get River Positive was developed in recognition of the priorities of our customers and stakeholders and their expectation of stretching improvements within the short to medium term to reduce any potential ecological harm from SOs. As part of our Get River Positive pledges, we have committed that our operations will not be the reason for unhealthy rivers by 2030 and to be more transparent about our progress on river health. This target aligns with the long-term targets set out by the Environment Act and emphasizes the need for investment within AMP8 to enable a progressive reduction in spills.

Figure 22 Our Get River Positive commitments

5.1.2 Scale and timing

The Storm Overflows Discharge Reduction Plan introduces the following statutory targets for companies:

- Water companies will only be permitted to discharge from a storm overflow where they can demonstrate that there is no local adverse ecological impact.
  - The headline target must be achieved for most (at least 75%) of storm overflows discharging in or close to high priority sites by 2035.
  - It must be achieved for all (100%) storm overflows discharging in or close to high priority sites by 2045.
  - Water companies must achieve this target for all remaining storm overflows sites by 2050.

- Water companies must significantly reduce harmful pathogens from storm overflows discharging into and near designated bathing waters, by either: applying disinfection; or reducing the frequency of discharges to meet Environment Agency spill standards by 2035.
- Storm overflows will not be permitted to discharge above an average of 10 rainfall events per year by 2050.
- Water companies will be required to ensure all storm overflows have screening controls.

Figure 23 Storm Overflow Reduction Plan (August 22) indicative trajectory of improvements and spill reductions to be achieved from a 2020 baseline

Year	2030	2035	2040	2045	2050
% of 'high priority site' storm overflows improved	38%	75%	87%	100%	100%
% of total storm overflows improved	20%	40%	60%	80%	100%
Indicative reduction in number of spills per year (relative to 2020 baseline)	64,000	128,000	192,000	256,000	320,000

We note the republication of Storm Overflows Discharge Reduction Plan on 25th September 2023, and the change in the indicative performance trajectory (shown above). The previous version of the reduction plan showed a trajectory that by 2030 we should have improved in total 14% of storm overflows, on the path to long term targets. As noted above our plan exceed that trajectory with 15.6% of overflows improved by 2030. However, the expanded plan now shows an indicative trajectory reaching 20% by 2030. At this late stage we are not able to amend our PR24 plan, but we do not believe that the change affects our ability to hit the statutory targets set out for 2035, and will take this into account at PR29.

Addressing storm overflows is a complex and costly process, with phasing of investment required over multiple price review periods. However, as outlined in the Environment Act and related WINEP drivers, getting on track to meet 2035 and 2050 reduction targets will require targeted intervention within AMP8 which balances affordability and deliverability, and potential amenity value to get us on the right path to reaching long-term targets. The scale and timing of our plan is, we believe, the correct one to meet this balance of needs.

To determine the best pathway to meet our statutory and voluntary targets and in line with the preferences of our customers, investment in AMP8 is targeted at addressing the highest priority sites based on the receiving environment to maximise the reduction in adverse impacts which can potentially result from storm spills. This aligns with the strategic approach outlined in the Storm Overflow Discharge Reduction Plan. To determine which sites are high priority we collated environmental information based on DEFRA's definition of high priority sites, alongside other factors identified by our external stakeholders (for example known wild swimming areas, limestone watercourses). We have used hydraulic modelling to estimate the spill frequency of storm overflows at our sites due to hydraulic causes. Outputs of the modelling were cross-checked and verified with Event Duration Monitoring (EDM) data as enabled through our monitor rollout in AMP7.

For the EnvAct_IMP3 driver investments we have selected for PR24, we have not phased these as the bathing water sites were identified as high priority by internal and external stakeholders. Additionally, all shellfish waters must be completed by 2030, so EnvAct_IMP3 sites which are also shellfish waters must be completed by 2030 and cannot be deferred. Our selected EnvAct_IMP3 driven schemes also count for EnvAct_IMP4 obligations, so effectively deliver two obligations at once.

5.1.3 Interaction with base expenditure

This investment reflects additional statutory obligations, not included in previous AMPs and therefore is considered to be fully enhancement investment, with no implicit allowance within the base models

This enhancement programme does not include the expected increase in the base expenditure required to maintain our EDMs rolled out during AMP7 and only addresses improvements to be delivered by addressing hydraulic reasons (ie. Increased flow). Non- hydraulic factors which cause overflow spills (I.e. excess infiltration, pipe siltation, pump deterioration etc) will be addressed through maintenance schemes, therefore are considered base and not captured within this investment. We have allocated these costs to base expenditure following the

EA's guidance on this issue. We anticipate the cost of maintenance schemes associated with this enhancement programme to be £32million for the period 2025-2030.

The table below highlights the investments we have considered to be covered by base (and not included in this enhancement plan) and enhancement activities (included within this enhancement plan).

Table 30 AMP8 storm overflow investment: base vs enhancement

Base	Enhancement
Investment to maintain the water recycling network to prevent increase in the impact of storm overflows on the environment due to excess infiltration and pipe siltation	Investment to reduce impact of storm overflows on the environment due to external factors which increase flow
Spills recorded by event duration monitors but not predicted by hydraulic models	Spills predicted by hydraulic models during storm events

5.1.4 Long term context (historical)

Our extensive Event Duration Monitor (EDM) rollout during AMP7 has given us greater visibility of the frequency and duration of our spills, informing our overall strategy of reducing environmental storm overflows and their impact in AMP8 and beyond.

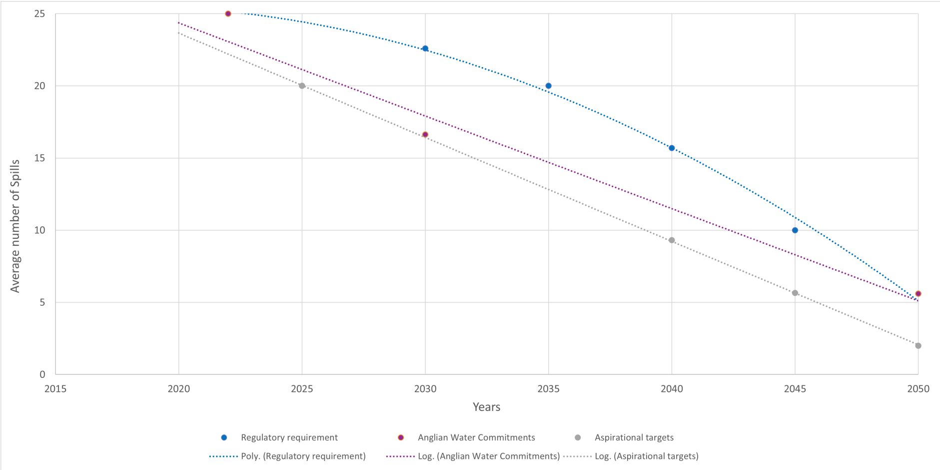
In the period 2020-25, we committed to reducing spills from storm overflows to an average of 20 per year by the end of the AMP. In line with our PR19 final business plan, our enhancement programme for the period 2020-25 includes the installation of additional storm tanks at 125 Water Recycling Centres (WRCs), increasing the amount of flow passed forward to full treatment at 41 WRCs and 10 schemes to deliver less than 40 spills at 10 high spilling storm overflow identified as causing an environmental impact.

Our 2022 EDM data shows that we're making good progress in reducing spills to an average of 20 per year by 2025 across all storm overflows with EDMs in place.

5.1.5 Long term context (future)

We view the investment proposed during in AMP8 as low-regret, enabling a progressive reduction towards zero spills over multiple AMPs to achieve our SDS ambition to improve the ecological quality of catchments whilst reflecting affordability and deliverability constraints, as highlighted in the scale and timing of our investment in section 2 above. As outlined above, we will prioritise addressing high priority storm overflows in the short to medium term on the pathway to eliminating all harm from overflows by 2050 in order to meet targets specified under the Storm Overflows Discharge Reduction Plan and the Environment Act up to 2050.

Figure 24 Storm overflow spills projected 2020-2050



The investments identified for improvements to storm overflows for the period 2025-2030 all account for a 2 degree climate change scenario in line with our core pathway.

Regarding our LTDS, our Drainage and Water Recycling sub-strategy for AMP8 and associated investment reflects our WINEP plan for storm overflow reduction as this is our most accurate and up to date view of short-term requirements. All storm overflow reduction schemes within the core pathway for AMP8 have therefore been through cost benefit and best value appraisal as part of our WINEP process. Solutions in AMPs 9-12 will undergo cost benefit and best value appraisal as they are progressed into the WINEP; however, we will be working during AMP8 to improve our understanding of risk and refine our storm overflow plan to ensure that it is best value for our customers and the environment. [15]

5.1.6 Customer support

As this is a challenge where the public, government and media have collectively pushed for greater ambition by the industry, we have engaged extensively with our customers and external stakeholders through various channels to inform the

15 Please refer to Section 2.2.5 'Drainage and wastewater' in our LTDS for more detail.

scale and timing of our investments beyond that which is required by our statutory drivers. Insight drawn from all our research shows that our customers are concerned regarding pollution and the potential impacts on public health and the environment, but that customers want a balanced programme of improvements including use of more 'green' nature-based solutions. This has been reflected in our plan following consultation with external and internal stakeholders via prioritisation exercises, and to support Get River Positive pledges. **In our PR19 business plan traditional 'grey' storage solutions accounted for 100% of our proposed solutions for storm spill reductions. In our PR24 business plan 'green' solutions (either as the full solution or via a blended approach) account for 48% of our preferred solutions for storm overflows.** As highlighted in our Customer Principles Report (attached as an appendix to our business plan), our customers support focus on addressing storm overflows that link directly to rivers with the highest amenity values as customers feel this will have the most impact.

Customer engagement focused on storm overflows conducted by Incling with our Online Community in February 2023 found the participants had a preference of acting sooner rather than later to address storm overflows, and preferred activities to create an overall reduction in the frequency of spills rather than disinfection of the actual spills.

Many of our customers were not aware of the purpose of storm overflows to prevent homes and businesses from flooding and were not aware why storm water reuse was not an option to address this challenge. As such, we have sought to be more transparent in our communications with customers on storm overflows to ensure they are educated and informed in an honest and transparent way.

Our Online Community research demonstrated that although customers support efforts to reduce the number of spills, they wish for targets (such as the Defra 2050 target) to be hit sooner rather than later, and for zero spill incidents in the long term. As such, we have increased our ambition to improve in this area beyond the minimum required statutory limit whilst factoring in customers' views on phasing over the short and long term

5.1.7 Cost control

This investment is a statutory requirement specified through the WINEP, therefore the scale and timing of this programme is primarily outside of management control, with limited option to defer investments to later price control periods. The scale of the investment has also been designed to align with the customer engagement set out in the previous section above.

In addition, growing pressures on the sewerage system including climate change and extensive population growth within the East of England are factors which are outside of management control and increase reliance on storm overflows as an emergency mechanism to prevent our customers' homes from flooding. As legacy infrastructure water companies inherited from pre-privatisation, this investment is required to correct this and ensure the sewerage system we have adopted is fit for purpose with sufficient capacity to address these challenges.

We have taken steps to ensure we have controlled costs. We have applied place-based thinking to combine investments where there are multiple flow drivers identified for the same catchments. For example, there are geographical overlaps in the investment for storm overflows and:

- Schemes to improve bathing water and shellfish waters
- Increasing FFTs and storm tanks at STWs
- Growth at STWs

5.2 Unlocking greater value for customer, communities and the environment

5.2.1 Option consideration

In developing our options to deliver improvements to meet drivers EnvActIMP2, EnvActIMP3 and EnvActIMP4, we considered a wide range of options to manage flows and increase storage capacity as part of our WINEP Option Development Report process. This included a range of traditional and nature-based solutions, including innovative approaches such as surface water separation and flow balancing through smart sewerage networks.

The following table sets out our unconstrained options (any option available to address potential harm from storm overflows), constrained options (removing options that are currently not available etc) and the feasible options (those that can achieve the required outcome).

Table 31 Options assessment

	Option	Description	Unconstrained	Constrained	Feasible
1	Utilise modelling to determine catchment opportunity to develop near real time smart networks to manage flows	This includes real time monitoring, modelling automated valve technology	Yes	Yes	Yes
2a	Creating extra storage volume in the network or at the WRC (storage tank/ sewer)		Yes	Yes	Yes
2b	Creating extra storage volume at WRC (lagoon)		Yes	Yes	Yes
3	Remove surface water from network via new surface water sewers	Cost as new sewer system	Yes		
4	SuDs install upstream/downstream of CSO to reduce spills		Yes	Yes	Yes
5	Remove surface water from network via property level soakaway - disconnection		Yes	Yes	Yes
6	Send discharge through a wetland	Wetland would need to be designed to the sanitary parameters agreed with the EA.	Yes	Yes	Yes
7	Physical habitat restoration - river restoration: remove flow restrictions upstream to all spill impact to be diluted	In consultation with our external stakeholder River Trust are reviewing opportunities for river restoration schemes and checking alignment with Storm overflows	Yes		
8	Increase pass forward flow at WRC	Send flow to WRC / increase FFT at WRC	Yes	Yes	Yes
9	UV or disinfection treatment on discharges entering bathing water	Treat flows to prevent the discharge from impacting the environment	Yes		
10	Treatment such as flexifilters on the overflow	Treat flows to prevent the discharge from impacting the environment	Yes		
11	Enabling Water Smart Communities - less water use = reduced waste water and so less discharges	£6m project being led by Anglian Water that seeks to advance Integrate Water Managment practice in the UK through infrastructure, tech, policy and behaviour change initiatives.	Yes		
12	Incentivising community-centric rainwater management	Project led by Thames Water that we are supporting to encourage the adoption of rainwater capture tools and solutions to prevent rain entering sewer network. Testing incentivisation approaches with communities	Yes		

	Option	Description	Unconstrained	Constrained	Feasible
13	Catchment Systems Thinking Cooperative	£7m project led by United Utilities and Rivers Trust where we will be delivering a demonstrator catchment in the Anglian region for circa £600k to build an evidence base for system-based investment towards environmental challenges including river water quality.	Yes		
14	Remotely actuated valves to prevent harmful discharges from CSO's.	Used as part of integrated control system to mitigate and prevent polluting effects of CSO operation at sensitive receiving waters.	Yes		
A	Feasible Option: Strategic catchment Surface Water removal				Yes

We have sought to prioritise nature-based solutions to address spills from storm overflows within AMP8 rather than traditional solutions where feasible. However, current regulatory constraints have limited the breadth of 'green' solutions that could be considered throughout the optioneering process and where these could be implemented. Solutions such as wetlands face additional stipulations from the Environment Agency in order to be considered permissible despite strong support from external stakeholders for these types of solutions. Nonetheless, at present the EA only permits wetlands where a continuous discharge permit is in place; implementing solutions such as wetlands for intermittent discharges will require further conversation with the EA and stakeholders to implement.

5.2.2 Cost-benefit appraisal

For this investment area, the unconstrained options were assessed against the following criteria:

- Does this meet the EnvAct_IMP2 driver?
- Does this meet the EnvAct_IMP3 driver?
- Does this meet the EnvAct_IMP4 driver?
- Would this reduce the number of spills?
- Would this reduce the number of pollution incidents
- Would this have any impact on operational carbon?
- How many sites would benefit from this?
- What scale of impact would this have on the site?
- How likely will this meet WINEP obligations?
- Is it technically feasible?
- Are there any constraints in terms of deliverability?
- When should we consider this option?
- When should we discount this option?

Through the process of condensing options into the constrained list, the following options were ruled out for the following reasons as determined by assessment against the criteria. We note the EA will only consider solutions that stop spills. Options that try to treat stormwater (ie UV or disinfection / other treatment options) or provide extra resilience to the receiving environment (river restoration) could not be considered as EA would not accept it as meeting the WINEP obligations.

Table 32 Unconstrained option assessment

3	**New surface water sewers**	Discount until detailed catchment investigations have taken place. SuDs should be considered in preference to this
7	**River restoration**	Only viable for EnvIMP2 locations
9	**UV/ disinfection of discharge**	EA do not consider flow treated through UV a spill. High carbon solution.
10	**Other spill treatment options**	Not suitable, would require trial
11	**Smart water communities**	Not suitable in isolation, but consider as part of A-WINEP strategic catchments

12	**Incentivising community-centric rainwater management**	Not suitable in isolation, but consider as part of A-WINEP strategic catchments
13	**Catchment Systems Thinking Cooperative**	Not suitable in isolation, but consider as part of A-WINEP strategic catchments
14	**Remotely actuated valves to prevent discharge**	Not suitable in isolation - consider adding this to option 1 and 4 when at WRCs.

Table 33 Constrained option assessment

No.	Option	Feasibility & risk	Feasibility & risk	Performance	Engineering	Cost & benefit	Environmental
1	Utilise modelling to determine catchment opportunity to develop near real time smart networks to manage flows	Meets statutory obligation	Potential to increase flooding risk if not managed correctly	Delivers required outcome	Medium - high reliance on detailed modelling		
2a	Creating extra storage volume in the network or at the WRC (storage tank/ sewer)	Meets statutory obligation	Lower operational risk	Delivers required outcome	Low (medium in some networks with little space)	...	...
2b	Creating extra storage volume at WRC (lagoon)	Meets statutory obligation	Higher operational risk than with storm tanks. Past issues with liners when cleaning	Delivers required outcome	Low		
4	SuDs install upstream/downstream of CSO to reduce spills	Meets statutory obligation - but longer delivery times	Ownership and maintenance of SuDs features needs to be considered	Likely to meet required outcome	Medium - high = due to locations in urban areas, third party agreements etc		
5	Remove surface water from network via property level soakaway - disconnection	Possible - depends on customer uptake. Only likely where close to spill frequency already	Would need to clarify ownership and responsibility	May meet required outcome - depends on customer uptake. Only likely where close to spill frequency already.	Low		
6	Send discharge through a wetland	Does not meet obligation unless the discharge permit is changed to a continuous discharge one.	Would need to clarify ownership and responsibility	No - spills still occuring. Site permit would need changing so requires further discussion with EA about how this would work	Medium (depends on location)		
8	Increase pass forward flow at WRC	Meets statutory obligation - but WRC permit may need to be altered	Would increase site running costs and treating more flow.	Delivers required outcome	Wide range - depends on change in flow required		

Table 34 Feasible option assessment

No.	Option	Feasible solution (Y/N)	Justification	No of sites
1	Utilise modelling to determine catchment opportunity to develop near real time smart networks to manage flows	Y	Taken forward when multiple PS catchment - or when modelling assessment concluded there may be capacity in the existing system not being fully utilised, Assumption is one smart PS removes the need for 12m3 of storage	In total 68 schemes propose the use of this approach as the preferred solution (including when it is blended with other solution types)
2a	Creating extra storage volume in the network or at the WRC (storage tank/ sewer)	Y	This was taken forward as a feasible option for all sites	In total 85 schemes propose the use of this approach as the preferred solution (including when it is blended with other solution types)
2b	Creating extra storage volume at WRC (lagoon)	Y	This was taken forward as a feasible option for all WRC sites. It was then discounted when large quantities of lagoons were required or where site assessments concluded space was limited on site or underground utilities would prevent a lagoon from being built.	In total 20 schemes propose the use of this approach as the preferred solution (including when it is blended with other solution types)
4	SuDs install upstream/downstream of CSO to reduce spills	Y	This was taken forward as a feasible option for all catchment locations where medium-large storage volumes would be required. When considered as a solution for a WRC site an acutated value solution has been incorporated into the solution. Further assessment was then carried out using SuDs studio to analysis the opportunities for SuDs scheme and determine if they would be viable. Where SuDs was not viable in isolation, blended solutions have been considered.	In total 52 schemes propose the use of this approach as the preferred solution (including when it is blended with other solution types)
5	Remove surface water from network via property level soakaway - disconnection	Y	This was taken forward for lower spill frequency sites due to the risk associated with gaining customer support and access for disconnections. A review of the catchment pe and housing age was also considered to estimate the scale of the opportunity.	In total 12 schemes propose the use of this approach as the preferred solution (including when it is blended with other solution types)
6	Send discharge through a wetland	Y	This option was assessed for 5 WRC sites with high spill frequencies and potentially suitable locations for wetlands. One solution was accepted by the EA as potentially meeting their criteria for a wetland solution.	In total 1 scheme proposes the use of this approach as the preferred solution (including when it is blended with other solution types)
8	Increase pass forward flow at WRC	Y	This option was assessed for WRC sites when the additional flows were no more that 1/3 of the existing site capacity.	In total 6 schemes propose the use of this approach as the preferred solution (including when it is blended with other solution types)

In addition, a further option was introduced and deemed feasible at this stage of the optioneering process - strategic catchment surface water removal.

Table 35 Additional options at Feasible Option Assessment stage

A	Strategic catchment Surface Water removal	Y	Seven catchments with several flow related risks were considered for a strategic catchment approach for surface water removal using blue / green technologies only. Of these two catchment (Caister Catchment covering Great Yarmouth, and Southend Catchment) have been selected as our Advanced WINEP submission, as an alternative approach.

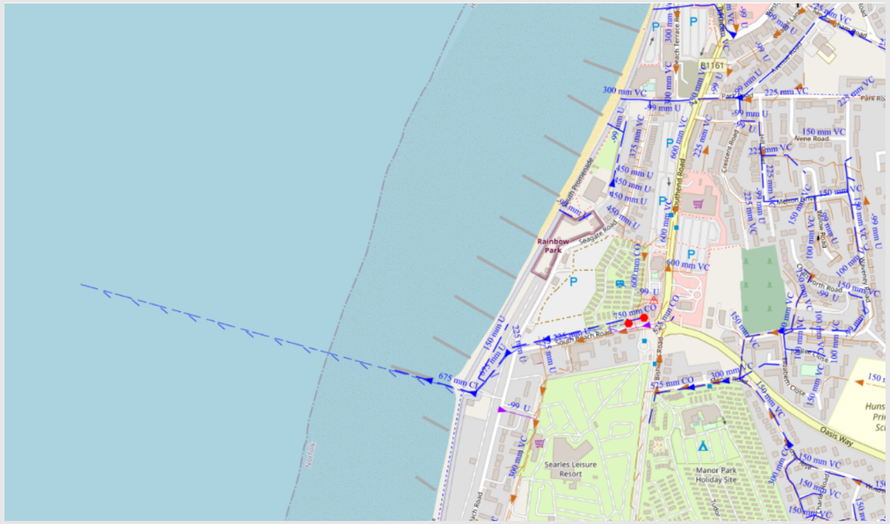
The solutions required at each site were then selected from this list of feasible solutions dependent on site-specific factors (including spill frequency and location) and presented to the EA as the ‘best value solution’. Where feasible, nature-based solutions have been put forward as the preferred solution, with an alternative ‘grey’ solution also put forward to the EA in case this can not be delivered. As part of this process, we have conducted site visits to 'sense-check' the preferred option at each site.

For each site at least one traditional grey solution was costed (ie storage tank/sewer), plus at least one other solution, based on the feasible solutions outlined above. Where further analysis (ie the use of SuDs studio) identified either option was no longer feasible a third, or fourth solution was then explored. For example, for Aldwincle pumping station two solutions (offline storage and SuDs) were originally created. Further investigation concluded that for feasible SuDs uptakes (40% road removal and 60% roof removal) a spill reduction to 14 spill per year rather than the required 10 spills per year was all that could be achieved. As a result a third option (in this case a blended solution of SuDs plus flow balancing within the catchment) was therefore investigated which was ultimately taken forward as the preferred solution.

Case study - Hunstanton, South End Road TPS CSO

Hunstanton South End Road overflow discharges close to a bathing area. The EDM located on the CSO at Hunstanton, South End Rd TPS has shown that there were 16 spills between 1/1/20 to 15/9/20. Further investigation has identified that the existing on site storage capacity is not being fully utilised during wet weather/storms leading to premature spills from the CSO. During 2021-2022 we modified the hydraulic configuration of the connection between Hunstanton, South End Rd TPS and the storage volume to allow full use of the available capacity during wet weather. Scheme completed in March 2022 for £21k. For the period April 22 - July 23 we have recorded two spills from the overflow. The learning from this scheme will be taken forward into our flow balancing and smart network solutions within our accelerated infrastructure delivery programme.

Figure 25 Hunstanton water recycling system



Case study - Latchingdon

Latchingdon is a catchment suffering from a number of flow related problems including: A spilling storm overflow at Latchingdon WRC classified as having a very severe impact in the SOAF (Storm Overflow Assessment Framework) assessments completed in AMP7, a risk of DWF (Dry Weather Flow) non compliance as a result of existing and future growth, a storm tank scheme.

The proposed solution is the installation of Real Time Control ('RTC') across the 14 pumping stations in the Latchingdon catchment that will allow the smart control of the foul sewerage network as currently there are some areas that struggle with capacity issues during storm conditions. This is a whole catchment innovative approach that will build on pilot schemes at the beginning of AMP7 and is due to be completed by the end of 2023. The PS smart control will automatically control flows across the network, either stopping or redirecting, to allow excess flow to be managed in a storm period and flows to be balanced to the Water Recycling Centre, the treatment works struggles with DWF capacities and poor treatment. Therefore, we are going to utilise the same control philosophy to balance flows into the WRC to aid this. Expected cost of this scheme is £1.5m. Outcome is hoped to be reduced spills, and also reduced 'build' solution for the DWF scheme at the WRC.

The learning from this scheme will then by applied to our AID storm overflow programme.

5.2.3 Environmental and social value

The wider environmental benefits of the solutions were considered as part of optioneering process as measured against the EA value metrics (as captured in the table below.

Whole life cost and benefit was assessed for a 30 year time frame in completion of EA Option appraisals reports. The best value (greatest benefit to cost ratio) was selected as the preferred solution providing total cost of the scheme was no more than 30% higher than the lowest cost option.

Table 36 EA value metric assessment of feasible options

EA Value Metric									
	% net gain in biodiversity using Natural England's Biodiversity metric	Area of wetland	Reduction in Eutrophication and increased in biodiversity	m3 of water abstracted	Net Zero: carbon sequestration as a result of land use change	Amenity access and engagement: number of visits and value of visits	Estimate the number of nature-based volunteer hours expected from the intervention	Number of educational visits by school children to nature reserves
1	Smart catchment	N/A	N/A	Where overflow is RNAG (Reason for Not Achieving Good) assumption used is 1km of waterbody improved from moderate to good status	N/A	N/A	When overflow is in close proximity to an area of recreational value, assumption is visits increase by 0.5% due to number of storm discharges decreasing to 10/yr. Assumption is visits increase by 1% when storm discharges decrease to 2/bathing water season.	N/A
2a	Storage tank	If at WRC assume tank is above ground and therefore permanently reduces biodiversity The biodiversity value of all of our WRCs have been assessed individually and this has been used to determine loss of units	N/A	Where overflow is RNAG assumption used is 1km of waterbody improved from moderate to good status	N/A	N/A	OrVal tool used as per DEFRA guidance. When overflow is in close proximety to an area of recreational value, assumption is visits increase by 0.5% due to number of storm discharges decreasing to 10/yr. Assumption is visits increase by 1% when storm discharges decrease to 2/bathing water season.	N/A
2b	Storage lagoon	N/A	N/A	see above	N/A	N/A	see above	N/A

EA Value Metric								
	% net gain in biodiversity using Natural England's Biodiversity metric	Area of wetland	Reduction in Eutrophication and increased in biodiversity	m3 of water abstracted	Net Zero: carbon sequestration as a result of land use change	Amenity access and engagement: number of visits and value of visits	Estimate the number of nature-based volunteer hours expected from the intervention	Number of educational visits by school children to nature reserves
4	Install SuDs	Natural England's Biodiversity metric has been used.	N/A	N/A	N/A	N/A	OrVal tool used as per DEFRA guidance. When overflow is in close proximity to an area of recreational value, assumption is visits increase by 1% due to number of storm discharges decreasing to 10/yr and new amenity areas created via SuDs. Assumption is visits increase by 2% when storm discharges decrease to 2/bathing water season.	Based on our experiance from Ingoldisthorpe wetland. 15 volunteer days per year per hectare for low resourced sites, 200 volunteers, per year per hectare low resourced sites. Assume all SuDs are low resourced sites and 7 hours per day = 105 hours per hectare"
5	Property level soakaway/ disconnection	N/A	N/A	N/A	Potential link with reduced consumption	N/A	Same as 1-3	N/A
6	Install wetland	Natural England's Biodiversity metric has been used.	N/A	N/A	N/A	Area of wetland used to calculate this	Same as 4	Based on our experiance from Ingoldisthorpe wetland. 15 volunteer days per year per hectare for low resourced sites, 200 volunteers, per year per hectare low resourced sites. Assume all SuDs are low resourced sites and 7 hours per day = 105 hours per hectare"
7	Increase pass forward flow to WRC	When solution includes new tanks assume impact equal to Option 2.	N/A	N/A	N/A	N/A	Same as 1-3	N/A

EA Value Metric								
	% net gain in biodiversity using Natural England's Biodiversity metric	Area of wetland	Reduction in Eutrophication and increased in biodiversity	m3 of water abstracted	Net Zero: carbon sequestration as a result of land use change	Amenity access and engagement: number of visits and value of visits	Estimate the number of nature-based volunteer hours expected from the intervention	Number of educational visits by school children to nature reserves
		The biodiversity value of all of our WRCs have been assessed individually and this has been used to determine loss of units						

5.2.4 Investment Benefits

We expect this investment will deliver the majority of improvement for the Storm Overflows PC. Our PCL has been calibrated to reflect this improvement to be delivered from PR24 enhancement expenditure and the estimated spill reduction from this portfolio. The quantified benefit can be found in table CWW15. More detail of our approach to the Storm Overflows PC can be found in the table commentary for PR24 data tables OUT1-7.

5.2.5 Managing uncertainty

Spill frequency is dependent on a number of factors outside our control including:

- Extreme weather conditions (ie very high rainfall)
- Third party misconnections
- Sewer misuse (ie blockages, illegal discharges).
- Asset failure
- High groundwater levels leading to excessive infiltrations

Therefore, although we have calibrated the PCL of our Storm Overflows PC to account for the benefits from this enhancement expenditure, our performance will still be impacted by factors outside of our control.

Our storm overflow programme will create significant delivery challenges due to the size of the programme and there is potential uncertainty regarding the deliverability of this investment given the scale of the industry WINEP programme for AMP8. This potentially places significant pressure on both supply chains and qualified individuals required to deliver schemes.

We aim to mitigate delivery challenges by:

- Prioritising storm overflows based on environmental need, rather than only selecting our highest spilling sites. This has provided us with a range of scheme sizes and complexities (from minor disconnections / storage through to major infrastructure projects), which will allow us to spread this programme across a wider range of delivery partners.
- Our intended approach to use digital solutions to manage flows across catchments has given us the opportunity to begin our AMP8 programme early. Whilst there is an inherent risk with any new technology, this early delivery programme will allow us to learn lessons quickly and apply that learning across the reminder of the storm overflow programme. If successful this approach will enable low build, low carbon solutions to storm overflows to be shared across the industry.
- Our ambitious programme to deliver storm overflows reductions through SuDs solutions is the right thing to do for wider customer amenity improvements, biodiversity, and benefits to operational carbon, but also poses the greatest risk to our programme in terms of deliverability. This is primarily the result of the need for 3rd party support for SuDs solutions and our current level of experience of this technology. Our AWINEP submission proposes the creation of a partnership centre of excellence, which if approved will create a template for best practice partnership working and support the delivery of SuDs solutions for storm overflows across two Anglian Water catchments. This learning can then be applied through the reminder of the programme.
- We are utilising our surface water management programme for flooding resilience in AMP7 to identify learning for the delivery of sustainable drainage schemes so that this can be applied to our PR24 storm overflow programme.

5.2.6 External funding

Our existing storm overflow programme does not include any expectations of external funding. Instead, our SuDs programme has been costed based on a 'zero additional amenity' approach. For example, no allowance has been made to include amenity features such as seating areas, educations facilities, sports facilities etc as part of these schemes. Instead it is has been assumed that the cost of any 'wider benefits' would be mitigated through securing third party funding, and that the wider benefits delivered would therefore be dependant on what any third party identified as being of sufficient value to them to incentivise them to invest. This approach has also been followed for our A-WINEP submission.

5.2.7 Direct Procurement

We have considered each of our investments for their suitability for delivery through DPC.

Our programme contains a range of investments of different sizes, none of which individually exceeds the whole life totex threshold of £200m. Whilst a small number of projects do exceed the £5m threshold set for bundling projects, the majority do not, and it may not be practical to subdivide the programme based on this threshold. We also note that Ofwat's additional discreteness guidance stated that SuDS solutions were not intended to be captured by the programme scalability test.

The solutions are likely to be heavily integrated into our network, with preferred solutions requiring a range of a range of traditional and nature-based solutions depending on spill frequency and location.

For these reasons, this investment is not considered eligible for DPC.

5.2.8 Customer view

Our Online Community, as established in the engagement by Incling in February 2023, generally acknowledge that 'grey' solutions may be required to address storm overflows as they are 'tried and tested' solutions, nonetheless support us to continue to develop 'green' solutions where possible. Respondents recognise that a full 'green' approach would not be sufficient for meeting all storm overflow targets, but form a part of a 'portfolio' of solutions. This has been used to inform our optioneering process to strike the right balance between grey and green solutions.

5.3 Cost efficiency

5.3.1 Developing costs

The development of the storm overflows costs in our plan follows our cost efficiency 'double lock' approach set out in Chapter 7 Driving cost efficiency of our business plan. Through this approach we have ensured that are costs are efficient in their bottom-up build up, and this is cross-checked through external benchmark approaches. This section sets out how we have ensured cost efficiency of our storm overflow investments through step one of our double lock approach. Step 2 is explored in section 7.3 of our plan.

We have taken a robust approach to developing our storm overflow costs, building on our experience from delivering similar schemes into the bottom-up development of costs (before external cost benchmarking challenges are applied in step 2 of our 'double-lock' approach). The detail of the cost development approach is set out below, along with a breakdown of costs we provide in table CWW3.

Cost Estimation Methodology

We follow a common cost development methodology across our enhancement investments in a three phase process:

1. Establish cost and carbon models
2. Input the cost drivers into the model (including location specific factors)
3. Data validation, internal challenge and assurance.

Phase 2; We derived our total cost estimate for each scheme through the following process:

- gathering information on the proposed location which influenced the cost estimates for each scheme, including:
  - storm discharge asset type
  - annual spill count and volume (modelled)
  - storage required (modelled)
  - Event Duration Monitoring data (linked to the root cause of spills)
  - discharges into a bathing water or shellfish water (to define the environmental act necessary)
  - Operability and connection to existing assets
  - site specific requirements and
  - assessment of construction constraints such as SSSI areas.

Site visits were carried out for prioritised sites identified by the above data, which allowed an assessment of feasibility for each scoped solution. Expert knowledge was also used to help define scope selection.

Therefore, standard solution scopes (but with modelled volumes specific to each storm overflow) were used for the majority of alternatives. These solutions can be broadly grouped by type of assets required at each site; screen retrofitting, storage solutions and storage solutions including SUDs.

In addition, in order to ensure efficiencies are achieved whenever possible, for the sites that are required to meet more than one obligation (multidriver scheme), we have scoped all of the solution to be delivered at the same time, therefore, ensuring efficiencies on site set up, management and preliminaries can be achieved.

The following table summarise the scope designed to each projects and the Capital and Operational cost forecast in AMP8 for the chosen option proposed. The schemes in this table has been grouped by their scope and the WINEP driver code is provided to each of the schemes.

Table 37 Investment and cost overview

WINEP driver	Investment ID	Investment Name	Scope	Capital Cost £k AMP7	Capital Costs £k AMP8	OPEX cost £k (25-30)	CWW ref
IMP5	Various	117 specific locations	*CSO screen retrofit *kiosk * telemetry *ultrasonic level monitor	260	39,729	54.43	CWW3.46
IMP4	Various	19 specific locations	SuDS, PLC, cabling Telemetry	-	11,091	11	CWW3.43/3.34
IMP 3&4	Various	30 specific locations	SUDs (incl raingardens, wet swale, disconnection of downpipes, water butts)	237	10,293	6	CWW3.34/3.37
IMP3/4	I034072	Caister WRC EnvActIMP4 /IMP3 **Multidriver scheme**	*Storm tanks, * SUDS - raingardens *Storm Pumping station *Ancillaries (footpath, landscaping, access road, telemetry)	-	26,341	210.51	CWW3.34/3.16
IMP4	I033801	Broadholme WRC EnvIMP4 **Multidriver scheme**	*Storm tanks, * SUDS - raingardens *Storm Pumping station *Ancillaries (footpath, landscaping, access road, telemetry)	-	17,360	174.88	CWW3.34/3.16
IMP 3&4	Various	47 specific locations	*Offline storage *Interconnecting Gravity sewers and Rising main *SUDs * Ancillaries (roads, fences, telemetry)	1,197	162,362	578	CWW3.34/3.22 /3.31
IMP 3&4	Various	19 specific locations	* Storm Tanks * Storm Pumping station	1,038	121,022	1,253	CWW3.19/3.43 /3.22/3.16

WINEP driver	Investment ID	Investment Name	Scope	Capital Cost £k AMP7	Capital Costs £k AMP8	OPEX cost £k (25-30)	CWW ref
			*Ancillaries (footpath, landscaping, access road, telemetry,Lightning Conductors)				
IMP 2	I034515	IMP2 - No ecological impact Storm Overflows	220 Sewer monitors 44 Smart network solution incl radio link, PLC, actuators, cabling and penstocks	-	4,055	1.70	CWW3.43
IMP 3&4	Various	12 specific locations	Online Storage	-	431	-	CWW3.31
IMP4	Various	3 specific locations	*Chambers *penstoks/valves *flowmeters	-	404	-	CWW3.16
IMP 3&4	Various	18 specific locations	*Lagoon storm *Storm Pumping station *Interconnecting pipework *Ancillaries (footpath, landscaping, access road, telemetry)	498	22,446	900	CWW3.19/3.43
IMP4	I034151	Shenfield and Hutton WRC EnvActIMP4	*16,228 m3/d Inlet works *3,017 m3 Aeration system *16,228 m3/d SAF *1,264m3 Final settlement tanks *90kW Interprocess Pumping Station *Ancillaries (footpath, landscaping, access road, telemetry)	-	10,861	278	CWW3.16
IMP4	I034331	Briston WRC EnvImp4	*856 m3 Sand filters *4 kW Interprocess pumps *40 m3 Humus tank *Screening , instruments *Ancillaries (footpath, landscaping, access road, telemetry)	-	2,211	33	CWW3.16

WINEP driver	Investment ID	Investment Name	Scope	Capital Cost £k AMP7	Capital Costs £k AMP8	OPEX cost £k (25-30)	CWW ref
IMP4	I034537	Great Oxendon WRC EnvImp4	*26 m3 Tanks *Interconnecting pipeworks *6 kW submersibles pumps *Instruments	-	397	1	CWW3.16
IMP4	I034817	Horning Knackers Wood WRC EnvActIMP4	*Storm Screens *1135 m3 Wetland *Inline Pumping Station *Interconnecting sewer and outfall *Ancillaries (footpath, landscaping, access road, telemetry)	-	1,280	5	CWW3.19
IMP4	I031443	Kings Lynn STC KLYNST Disinfection **Multidriver scheme, only 26% is allocated in storm lines**	*Offline storage 1,660 m3 *Interconnecting Gravity sewers and Rising main *Interprocess pump 60 kW *UV disinfection unit 64,800 m3/d *Ancillaries (road, fence, telemetry)	814	1,095	313.13	CWW3.31/3.88
IMP4	I031886	Boston WRC BOSTST Disinfection **Multidriver scheme, only 70% is allocated in storm lines**	*6 Storm Tanks 2,010 m3 each *Interprocess PS 45 kW *UV disinfection units 27,113 m3/d *Ancillaries (road, fence, telemetry)	2,847	3,827	745.02	CWW3.31/3.88
IMP 3/4	I033732	Hunstanton CSOs Bathing Waters	*Offline storage 600 m3 and 100m3 *Interconnecting Gravity sewers and Rising main *Performic acid (disinfection) 3,464 m3/d *SUD Biorentation 300m2 and raingarden 300m2 *Ancillaries (road, fence, telemetry)	-	2,868	34.24	CWW3.22
IMP 2,3,4,5	I040895	Permitting of EnvActIMP2,3,4, 5 WINEP drivers **Multidriver scheme**	292 named sites with WINEP obligations with permit change	-	264	-	CWW3.46/3.34

WINEP driver	Investment ID	Investment Name	Scope	Capital Cost £k AMP7	Capital Costs £k AMP8	OPEX cost £k (25-30)	CWW ref
IMP4	I041202	Southend-Burdett Road CSO - EnvIMP4	New EA Permit	-	0.90	-	CWW3.31
IMP4	I041214	Southend-Prittle Brook Storage Tank - EnvIMP4		-	0.90	-	CWW3.31
IMP4	I041180	Bungay-Ditchingham Dam SP EnvActImp4 OPEX	54 water butts.	-	-	41.62	CWW3.31
IMP4	I041201	Waterbutts for disconnections Opex	10,000 water butts.	-	-	7,707.74	CWW3.34
			Total	6,892	438,339	12,349	CWW3.34

5.3.2 Benchmarking

In stage 2 of our cost efficiency 'double-lock' on storm overflows, we used a variety of methods to assess, benchmark and challenge the costs in our plan based on the availability of benchmarking data on storm tanks, offline storage and SuDS schemes included in our plan.

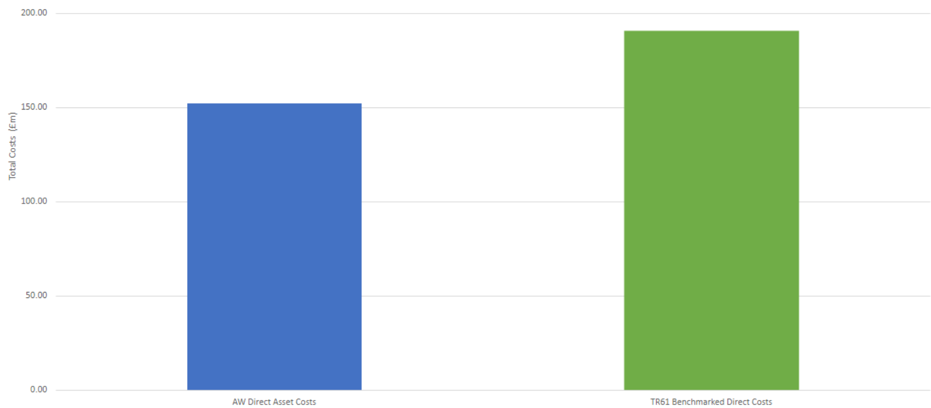
Scheme outturn costs

We have continuously captured outturn cost data of all projects delivered in our capital investments, including granular cost components such as pumps, tanks, other types of storage, and on costs, etc. These outturn costs have been the input of the specific parametric models of each asset. Building outturn costs into our cost assumptions in this way builds cost efficiency into the build-up of costs.

Offline storage and storm tanks benchmarking

The storm overflow enhancement investment costs have been benchmarked, where possible, against the available models built by WRCs TR61.These benchmarking results shows that for those areas where comparable benchmarking data is available, storm overflow programme our costs are 13% less expensive than the industry data comparisons at delivering the assets benchmarked, can be seen in the graph below.

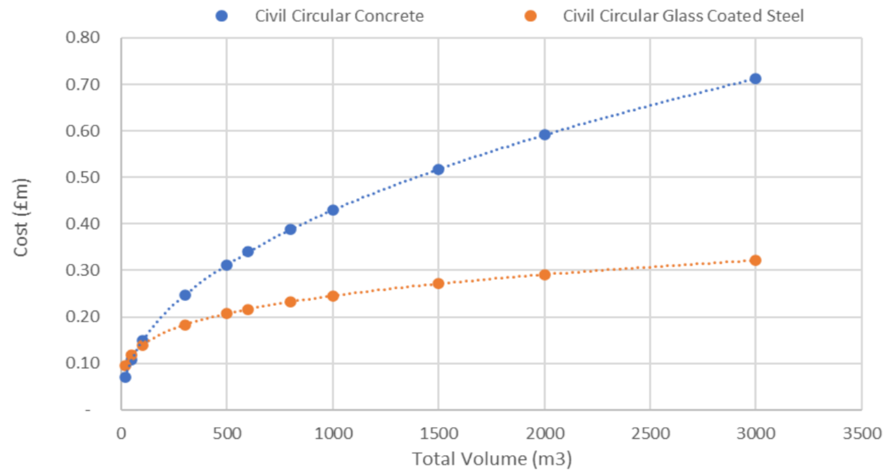
Figure 26 Storm overflows offlline storage and storm tanks direct asset cost benchmarked to industry data WRC TR61



In addition, when developing the storm tank solutions, internal benchmarking took place to measure the savings that could be achieved by constructing tanks made from different materials. This considered in-situ concrete (which has been most commonly use historically), and glass coated steel installations, as we had robust and granular breakdowns for each type. The assessment showed that glass coated steel, although it required earthing for lightning conductivity, was 67% less expensive to install (from 20m^3 to 3000m^3 volume) than in-situ concrete tanks.

This analysis triggered a change in the solution design across the programme and meant that, where possible, glass coated steel tanks are the recommended tank material.The following graph shows this comparative between the tanks materials.

Figure 27 Storm overflows offline storage and storm tanks direct asset cost benchmarked to industry data WRC TR61



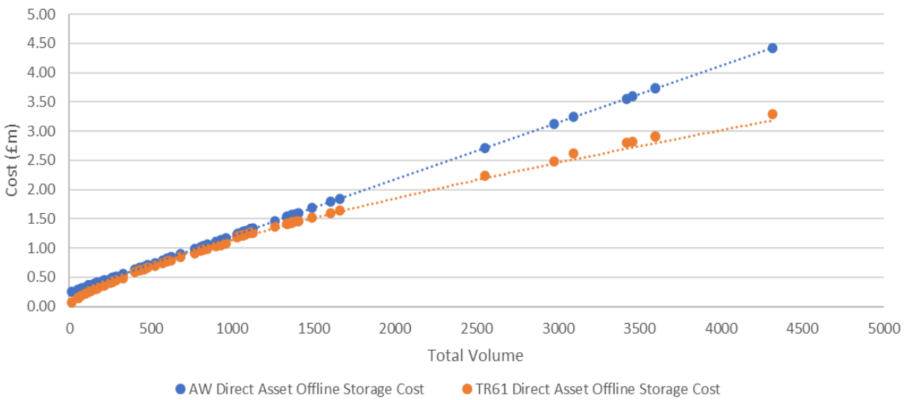
Additionally, further internal benchmarking was undertaken after site visits and expert knowledge revealed if there were any disused tanks on existing sites. For these sites, the recommended solution involved the creation of a storm lagoon, enhancing the sites' ability to store storm flows without the need for additional carbon and cost. This ensures the programme is considering efficient enhancements across the region wherever possible to save costs.

Offline storage benchmarking

For the offline storage element of the programme, 89% of the storage being installed is less than 2000m³ total volume, where our costs are comparable to TR61's records.

However, a small proportion of the estimates show Anglian Water's costs are higher than TR61's records are in the larger volumes, where the current data is showing efficiencies in delivering smaller storage sizes.We have 8 offline storage solutions for volumes greater than 2500m³ that appear above the TR61 industry data. These underground tanks are to be located close to the coast andrequired more civil works due to ground instability and a high water table. Therefore, whilst our costs are greater than the benchmark for these schemes, we consider that this can be explained by site factors, rather than inefficiency.

Figure 28 Benchmarking of concrete vs glass coated steel storm tanks direct asset costs



Sustainable drainage schemes (SuDS) benchmarking

£67 million (in direct asset cost) of the programme scope is sustainable drainage solutions (SuDS). Owing to the lack of industry wide construction experience, consistent cost data is not readily available to use for benchmarking purposes. With this in mind, we have sought to identify additional cost efficiencies which could be made through rigorous internal challenge.

Additional efficiencies were made when the. We undertook a number of activities to develop our internal challenge of SuDS costs. For example, we completed site visits, liaising with Enfield Borough Council to investigate delivery costs and informing the models used to estimate the programme's SuDS scope and costs. This identified measures such as installing of SuDS around existing network assets such as gullies and existing watercourses, reducing the need for additional connections to the existing network which reduced our cost assumptions (removing the need for a connection costs for over three quarters of SuDS installations.

5.3.3 Assurance

The development of our costs within our cost estimation system (C55) have been assured by Jacobs. Our cost estimation process was assured by Arup.

5.4 Customer protection

Customers are protected in the event of non-delivery through the following:

- enforcement action from the EA for failure to deliver an obligation;
- our Price Control Deliverable which will return enhancement allowances to customers if any investment is cancelled, delayed or reduced in scope;
- the Storm Overflows common performance commitment level is aligned with our enhancement investment.

For more detail on our Storm Overflow PCD, please refer to the appendix 'Price Control Deliverables'[16]

16 ANX ANH37

6 Increasing FFTs and storm tanks

Overview

- Flow to full treatment (FFT) refers to the maximum volume of wastewater a WRC must be able to treat at peak. If this flow is exceeded, for instance in the case of a storm or heavy rainfall, then the flow in excess of the FFT limit is diverted to storm tanks where the sewage is stored until normal conditions resume and the flow can be treated through the WRC.
  - As required by WINEP obligations, we will invest £59m into 3 schemes to increase our FFT capacity at WRC sites and at 37 sites to increase our storm tank capacity.
  - After considering a range of solutions, to increase FFT capacity we invest in 2 schemes to increase hydraulic capacity of existing treatment streams, and 1 scheme to create a new side stream. We have also considered a range of traditional and nature-based solutions for increasing storage capacity.
- We have built up our costs using own experience of delivery of similar projects and benchmarked our costs via an external consultant WRc using an industry cost database known as TR61, this shows that our costs for the assets we propose to construct are 40% below industry average, giving us confidence that our costs are efficient.

Table 38 Investment Summary

PR24 costs (£m)	
Capex	55.1
Opex	4.3
Totex	59.4
Benchmarking	
Method	Scheme outturn costs Industry cost models from TR61
Findings	Industry cost models showed our FFT and storm tank costs to be significantly below the industry benchmark.
Customer Protection	
Price Control Deliverable	WINEP Obligations
Ofwat data table	
CWW3.13-CWW3.15	Increase flow to full treatment; (WINEP/NEP
Part of CWW3.16- CWW3.18	Increase storm tank capacity at STWs - grey solution; (WINEP/NEP) [£34.4m capex, £2.5m opex - the remainder of this line is reflected in 5 Storm overflows

6.1 Delivering for the long term

6.1.1 Investment context

Flow to full treatment (FFT) refers to the volume of wastewater a WRC must be able to pass to treatment. If the flow from the upstream catchment exceeds this volume due to heavy rainfall or snowmelt, then the excess flow is permitted to be discharged to a storm tank for settlement and detention. WRCs are normally designed to treat a volume of flow of three times the maximum Dry Weather Flow (DWF), but flows seen in practice can vary over time due to climate change making rainfall more intensive, or changes in the sewer catchment such as housing or industrial customers. The Environment Agency (EA) expects that companies must design WRCs to treat FFT.

We are investing to ensure that our WRCs identified as having low permitted DWF to FFT ratios reach three times DWF capacity. This ensures we will meet the regulatory standard for flow treatment at WRCs and increases operational resilience of WRCs to storms and heavy rainfall and will decrease the likelihood of storm spills to the environment. We are also investing to deliver the construction or upgrade of storm tanks at multiple sites to provide more capacity to store flow in the event of heavy rainfall or storms. New capacity is required where existing capacity is insufficient to retain flow for two hours at maximum flow or capacity for 68 litres per person served in that sewer catchment.

This enhancement strategy focusses on the following programmes of work within the WINEP.

Table 39 WINEP drivers for FFT and storm tank investment

WINEP driver	Description
U_IMP_5	Investment to increase flow to full treatment capacity where we have known lack of capacity
U_IMP_6	Investment to increase storm tank volume to reduce the risk of spills in storms at WRCs

6.1.2 Scale and timing

Our investment to increase FFT and install or enhance storm tanks fully aligns with our statutory WINEP obligation dates as specified by the Environment Agency. With the agreement of the Environment Agency, we phased 12 WINEP schemes to increase capability to treat Flow to Full Treatment (FFT) into AMP9. This means that, at PR24 the required number of schemes has been reduced to 3 following a review of recent flow data.

The investment included in this plan consists of investments in storm tanks that we asked for deferral from PR19 and so there is no scope to further challenge whether these obligations could be further deferred to future AMPs if this was in the interests of customers and the environment. There is no further opportunity to defer any of the investment proposed to later AMPs as a result if this. For our FFT investment, we are required to meet a 2027 delivery date to meet our WINEP obligations. In addition, we are required to meet our storm tank storage scheme obligations by 2027.

6.1.3 Interaction with base expenditure

Enhancement expenditure reflects investments which improve or enhance the capacity or quality of service beyond current levels. This investment is enhancement rather than base as it enhances the DWF capacity of WRCs, which constitutes an uplift on existing service levels. In addition, construction or enlargement of storm tanks is enhancement as this increases the storage capacity at WRCs in excess of current levels. We have excluded from this enhancement investment any activities on WRCs or storm tanks which could be implicitly funded through base models. The table below summarises the activities that we have considered to be base (and excluded from enhancement investment) and enhancement for the storm tanks element of this investment in the table below.

17 For more detail, please refer to Section 2.2.5 'Drainage and water recycling' in our LTDS.

Table 40 Activities split between enhancement and base expenditure

Base activities	Enhancement activities
Repair of existing storm tanks	Increasing storm tank volume to 68l/head
Increasing volume above that required by the obligation	
Increases to balance tank volumes	
Work on assets not linked to storm volume	

6.1.4 Long term context (historic)

We deferred 37 schemes to enhance or construct storm tanks from PR19 to PR24. We also deferred a scheme to increase FFT at Wymondham WRC. This agreement was made prior to business plan submission and were not included in our PR19 plan. These schemes now have 2027 obligation dates.

At PR19 we were funded to deliver:

- 40 FFT schemes to address a 1,105l/s shortfall and;
- 127 storm tank schemes delivering 83,653m3 storage

6.1.5 Long term context (future)

Investment in AMP8 is low regret as it improves the capacity of our WRC to address higher levels of flow. The increase in data confidence resulting from investment in U_MON3 and U_MON4 monitors at PR19 and PR24 will permit us to make more informed decisions on increasing FFT and the requirements for additional attenuation in future AMPs. Although we note the potential for additional pressures on flow and attenuation capacity due to climate change in future AMPs, we assume that better data confidence will support us to address this pressure in the future.. Therefore, our AMP8 investment is low regret as it supports the adaptive planning approach outlined in our LTDS. [17]

For future AMPs, as captured in our Drainage and wastewater sub strategy we will continue to explore possibilities to utilise green solutions for grey water and effluent reuse to reduce flow, in addition to green solutions to increase storm system attenuation at WRCs, as knowledge of these solutions increases.

6.1.6 Customer support

The need for investment is primarily driven by a need to meet statutory obligations and ensure we are compliant with the EA driver obligation dates. Nonetheless we have sought to integrate the views of our customers into our decision-making process where possible. As seen in our Willingness to Pay evidence, our customers have a strong preference for avoiding deterioration in service levels especially in relation to environmental outcomes. Participants in the 'Customer preferences on added value for large resource schemes' research conducted by Accent showed for new infrastructure schemes our customers value both environmental and economic benefits and support the introduction of nature-based solutions where appropriate to create a 'win-win' in terms of compliance, cost and environmental protection.

6.1.7 Cost control

This investment is driven by obligations set out in the WINEP and is therefore a statutory driver outside of management control. Failure to comply may result in the Environment Agency taking legal enforcement action.

6.2 Increasing FFT

6.2.1 Unlocking greater value for customers, communities and the environment

Option consideration

In developing our options to increase FFT to three times DWF, we have considered a wide range of options as part of our WINEP Option Development Report process for driver U_IMP_5. Using a NBS solution may be possible but they are currently untested in this scenario and would form part of a detailed design process.

The following table sets out our unconstrained options (any option available to increase FFT), constrained options (those that are currently possible) and the feasible options (those that can achieve the required outcome).

Table 41 Unconstrained options for FFT

No.	Option	Unconstrained	Constrained	Feasible
1	Pump away - to nearby works with DWF headroom capacity	Yes	Yes	Yes
2	New WRC to take additional flow	Yes		
3	Side stream to take additional load	Yes	Yes	Yes
4	Remove flow from the catchment	Yes		
5	Increased hydraulic capacity	Yes	Yes	Yes
6	Increased biological capacity	Yes	Yes	Yes
7	Increased biological and hydraulic capacity	Yes	Yes	Yes

Cost-benefit appraisal

In this section, we set out the outcomes of our cost-benefit appraisal for the enhancement schemes within the FFT and storm tanks capacity programme. We first present the outcome of our unconstrained, constrained and feasibility assessment for increasing FFT, before moving onto our unconstrained, constrained and feasibility assessment for increasing storm tank capacity.

The following table sets out our assessment of our options against a range of criteria, as required through the WINEP ODR process:

Table 42 Unconstrained option assessment

No.	Option	Required outcome	Technical feasibility	Wider environmental outcomes	Customer support	Risk and uncertainty	Environmental risks
1	Pump away - to nearby works with DWF headroom capacity			N/A	N/A	N/A	
2	New WRC to take additional flow						
3	Side stream to take additional load						
4	Remove flow from the catchment						
5	Increased hydraulic capacity						
6	Increased biological capacity						
7	Increased biological and hydraulic capacity						

As required by the WINEP ODR process, we assessed our constrained options against the following criteria:

Table 43 WINEP constrained optioneering criteria assessment

<table>
<tr><th>No.</th><th>Option</th><th>Feasibility</th><th>Risk</th><th>Performance</th><th>Engineering</th></tr>
<tr><td>1</td><td>Pump away - to nearby works with DWF headroom capacity</td><td rowspan="5">Meet statutory obligations</td><td rowspan="5">Residual risk has been considered</td><td rowspan="5">Delivers required outcome, but on a site-by-site basis and not suitable for every site</td><td rowspan="5">High complexity</td></tr>
<tr><td>3</td><td>Side stream to take additional load</td></tr>
<tr><td>5</td><td>Increased hydraulic capacity</td></tr>
<tr><td>6</td><td>Increased biological capacity</td></tr>
<tr><td>7</td><td>Increased biological and hydraulic capacity</td></tr>
</table>

Table 44 Final assessment of feasible options

No.	Option	Feasible solution (Y/N)	Justification
1	Pump away - to nearby works with DWF headroom capacity	Y	Meets statutory requirement
2	New WRC to take additional flow	N	Dependent on land purchase and permit application and would be a very high cost option
3	Side stream to take additional load	Y	Meets statutory requirement
4	Remove flow from the catchment	N	Dependent on identification of infiltration in the catchment and ability to remove it enough to reduce the current permitted DWF. The is technically difficult and increases risk. It would only be possible for sites with large DWF headroom.
5	Increased hydraulic capacity	Y	Meets statutory requirement
6	Increased biological capacity	Y	Meets statutory requirement
7	Increased biological and hydraulic capacity	Y	Meets statutory requirement

For the five options progressed as ‘feasible solutions’, the feasibility of these was assessed on a site-by-site basis. The feasible options to be deployed on each WRC site is dependent on the complexity of the site. Each site was reviewed and its ability to pass and treat the new FFT was assessed, the solutions were then generated so address the bottlenecks in the process. e.g for Swaston WRC it has been determined that increased biological treatment capacity is required to treat the increase in FFT flow.

On the basis of the process undertaken above we have included the following number of schemes in our plan

Table 45 Solutions selected for schemes

Solution	Number of schemes
Pump away	
Side stream	1
Increased hydraulic capacity	
Increased biological capacity	2
Increased hydraulic and biological capacity	

Environmental and social value

Using a value framework allows us to capture theanticipated benefits (and disbenefits) of our investments which are then tracked and updated through a robust Benefits Realisation Management process, a key part of our Totex Delivery Process.

In this investment area we considered the impact the investment would have on biodiversity net gain, noise generated by construction activities and traffic movements. Due to the types of investments the impact is similar across all solutions.

Investment benefits

Each option is assessed from a benefits perspective using our Value Framework.

A baseline position is established that captures any current or expected impacts to service, customers, the environment, safety etc (and their respected likelihoods).

Each alternative (i.e. option) is appraised to establish a residual position, with updated impacts and likelihoods. This residual position also considers any additional benefits and disbenefits that may apply as a result of the intervention. These could be permanent (e.g. visual impact) or temporary (traffic disruption during construction) and consider a range of environmental and social measures including both capital and operational carbon.

This investment area primarily provides benefits in the following categories within our Value Framework:

- Volumetric compliance

In addition we have assessed these investments to consider further impacts on society including:

- Traffic Disruption
- Construction Noise
- Visual impact
- Biodiversity Net Gain

Managing uncertainty

The primary uncertainties for the investment to increase FFT and build/expand storm tanks are:

- The cost of land on which to build new assets.
- The availability of construction materials, such as steel and concrete. This risk can be partly mitigated by altering the option at each site dependent on the availability of materials.

We also note that investment to address flow at WRCs will not necessarily correlate exactly with a reduction in the number of spills, as the number of spills is also based on other factors such as infiltration and factors outside of company control. Nonetheless, there is a high certainty in the solutions we have proposed will reduce the overall number of spills.

External funding

We do not consider third party funding feasible for this investment.

Direct procurement

We have considered the suitability of this investment for delivery through DPC in accordance with Ofwat's guidance.

Our programme contains a range of investments of different sizes, none of which individually exceeds the whole life totex threshold of £200m. Whilst a small number of projects do exceed the £5m threshold set for bundling projects, the majority do not, and it would not be practical to subdivide the programme based on this threshold.

The solutions involved in reducing FFT are novel and evolving, and do not necessarily lend to a clear scope that could be put out to tender under DPC. Further, the schemes will interact heavily with existing assets, which challenges the ability to transfer construction, operation and maintenance risks effectively. Therefore, we have assessed that FFT schemes are ineligible for delivery via DPC.

Customer view

Customers support our ambition to make the East of England resilient to the risk of drought and flood, however customers have not been involved in the proposed solutions as part of the customer engagement work. The investment has been driven by statutory drivers and the most effective way to increase FFT is highlighted in our cost-benefit appraisal section (section 9 above).

6.3 Storm tanks

6.3.1 Unlocking greater value for customers, communities and the environment

Option consideration

We also considered a wide range of options as part of the WINEP Option Development Report for driver U_IMP_6. This builds upon our learning from delivery of schemes within AMP7.

The following table sets out our unconstrained options list, all potential options we considered before assessing if they were feasible for the schemes in question.

Table 46 Unconstrained optioneering summary

No.	Option	Unconstrained	Constrained	Feasible
1	Concrete storm tank with PS	Yes	Yes	Yes
2	Glass coated steel tank with PS	Yes	Yes	Yes
3	Glass coated steel tank (2035) with PS	Yes	Yes	Yes
4	Glass coated steel tank with PS, wetland	Yes	Yes	Yes
5	Storm lagoon PS	Yes	Yes	Yes
6	Pump away to another WRC	Yes		
7	Treat all flows at WRC	Yes		
8	Remove connected PE from the catchment	Yes		
9	Remove flow from the network	Yes		
10	Reuse of existing assets on site	Yes		

Cost-benefit appraisal

In this section, we set out the outcomes of our cost-benefit appraisal for the enhancement schemes related to storm tanks capacity . We first present the outcome of our unconstrained, constrained and feasibility assessment for increasing FFT, before moving onto our unconstrained, constrained and feasibility assessment for increasing storm tank capacity.

The following table sets out the options assessed against the EA's constrained optioneering criteria, which was used to whittle down options

Table 47 Unconstrained option assessment

No.	Option	Required outcome	Technical feasibility	Wider environmental outcomes	Customer support	Risk and uncertainty	Environmental risks
1	Concrete storm tank with PS			N/A	N/A		
2	Glass coated steel tank with PS			N/A	N/A		
3	Glass coated steel tank (2035) with PS			N/A	N/A		
4	Glass coated steel tank with PS, wetland						
5	Storm lagoon PS			N/A	N/A		
6	Pump away to another WRC			N/A	N/A		
7	Treat all flows at WRC			N/A	N/A		
8	Remove connected PE from the catchment			N/A	N/A		
9	Remove flow from the network			N/A	N/A		
10	Reuse of existing assets on site			N/A	N/A		

Table 48 Assessment against feasible optioneering criteria

No.	Option	Feasibility	Risk	Performance	Engineering	Cost & benefit	Environmental assessment
1	Concrete storm tank with PS	Meet statutory obligations	Residual risk has been considered	Delivers required outcome	Medium to high complexity		Yes - minimal impact
2	Glass coated steel tank with PS						
3	Glass coated steel tank (2035) with PS						
4	Glass coated steel tank with PS, wetland	Meet statutory obligations -- includes a wetland which is a non-statutory addition to this driver		Goes beyond statutory requirement	High complexity		Yes
5	Storm lagoon PS	Meet statutory obligations		Delivers required outcome	Medium to high complexity		Yes - minimal impact

Feasible option assessment

Table 49 Feasible options for increasing storm tanks

No.	Option	Feasible option (Y/N)	Justification
1	Concrete storm tank with PS	Y	Meets statutory requirement
2	Glass coated steel tank with PS	Y	Meets statutory requirement
3	Glass coated steel tank (2035) with PS	Y	Meets statutory requirement
4	Glass coated steel tank with PS, wetland	Y	Meets statutory requirement, and includes a nature-based solution as a non-statutory addition to this driver
5	Storm lagoon PS	Y	Meets statutory requirement
6	Pump away to another WRC	N	The option is not based at the WRC, so this potentially causes DWF issues at the WRC
7	Treat all flows at WRC	N	Option doesn't meet storm tank capacity driver
8	Remove connected PE from the catchment	N	Option is not based at WRC
9	Remove flow from the network	N	Option is not based at WRC
10	Reuse of existing assets on site	N	Learning from AMP7 is that assets are rarely in the correct location or connected by the correct pipework - it has proven to be more difficult, timely and costly to reuse assets where compared to a new glass coated steel tank.

The solution utilising wetlands provides additional social and environmental benefits (ie smoother flow to river course, polishing flow, creating habitats etc). Due to detail within the obligation, we are required to build a storm tank in addition to this wetland. We also note that there is limited biodiversity benefit in constructing wetlands that only operate when dry weather flow is exceeded.

Based on learning from AMP7 we have proposed a glass coated steel tank with pumping station at all sites in our plan.

6.3.2 Environmental and social value

Using a value framework allows us to capture theanticipated benefits (and disbenefits) of our investments which are then tracked and updated through a robust Benefits Realisation Management process, a key part of our totex delivery process.

In this investment area we considered the impact the investment would have on biodiversity net gain, noise generated by construction activities and traffic movements. Due to the types of investments the impact is similar across all solutions.

Investment benefits

Each option is assessed from a benefits perspective using Anglian Water's Value Framework.

A baseline position is established that captures any current or expected impacts to service, customers, the environment, safety etc (and their respected likelihoods).

Each alternative (i.e. option) is appraised to establish a residual position, with updated impacts and likelihoods. This residual position also considers any additional benefits and disbenefits that may apply as a result of the intervention. These could be permanent (e.g. visual impact) or temporary (traffic disruption during construction) and consider a range of environmental and social measures including both capital and operational carbon.

This investment area primarily provides benefits in the following categories within our Value Framework:

- Volumetric compliance

In addition we have assessed these investments to consider further impacts on society including:

- Traffic Disruption
- Construction Noise
- Visual impact · Biodiversity Net Gain

From our Predictive Analytics modelling, we anticipate this investment will offset a deterioration in performance for the Discharge Permit Compliance PC. However, given the deterioration trend identified by Predictive Analytics, this enhancement expenditure will not drive an improvement in performance.

Managing uncertainty

The primary uncertainties for the investment to increase FFT and build/expand storm tanks are:

- The cost of land on which to build new assets.
- The availability of construction materials, such as steel and concrete. This risk can be partly mitigated by altering the option at each site dependent on the availability of materials.

We also note that investment to address flow at WRCs will not necessarily correlate exactly with a reduction in the number of spills, as the number of spills is also based on other factors such as infiltration and factors outside of company control. Nonetheless, there is a high certainty in the solutions we have proposed will reduce the overall number of spills.

External funding

As investment addresses a statutory obligation, we do not consider third party funding feasible for this investment. The only area where third party funding may be considered in AMP is where wetlands are selected.

Direct procurement

We have considered the suitability of this investment for delivery through DPC in accordance with Ofwat's guidance.

Our programme contains a range of investments of different sizes, none of which individually exceeds the whole life totex threshold of £200m. Whilst a small number of projects do exceed the £5m threshold set for bundling projects, the majority do not, and it would not be practical to subdivide the programme based on this threshold.

Customer view

Although all the need for investment is specified by the EA, we have engaged with customers and stakeholders to determine the appetite for nature-based solutions (such as wetlands and lagoons) over conventional options where this is permissible to also meet our WINEP obligations. As part of our Trinity McQueen (phase 3) Customer Priorities Research, 73% of participants stated that developing nature based solutions instead of grey solutions was an important or very important area for us to invest in. Although there are currently limited options for nature based solutions to increase FFT and storm tank capacity, this customer sentiment has led us to consider where lagoons may be used instead of storage tanks, which would be our default option.

6.4 Cost efficiency

6.4.1 Developing costs

The development of the FFT and storm tanks costs in our plan follows our cost efficiency 'double lock' approach set out in chapter 7 of our business plan. Through this approach we have ensured that are costs are efficient in their bottom-up build up, and this is cross-checked through external benchmark approaches. This section sets out how we have ensured cost efficiency of our FFT and storm tank investments through step one of our double lock approach. Step 2 is explored in the Benchmarking section below

We have taken a robust approach to developing our FFT and storm tank costs, building on our experience from delivering similar schemes into the bottom-up development of costs (before external cost benchmarking challenges are applied in step 2 of our 'double-lock' approach). The detail of the cost development approach is set out below, along with a breakdown of costs we provide in table CWW3.

Cost Estimation Methodology

We follow a common cost development methodology across our enhancement investments in a three phase process:

1. Establish cost and carbon models
2. Input the cost drivers into the model (including location specific factors)
3. Data validation, internal challenge and assurance.

Phase 2; We derived our total cost estimate for each scheme through the following process:

- Gathering on propose location basis data which influence the cost estimates for each scheme, including
- New required Full Flow to treatment (FFT m3/d)
- Current Dry Weather Flow (DWF m3/d)
- Population equivalent predictions
- Existing site capacity and process
- Total new storage required
- Operability and connection to existing assets
- site specific requirements and
- assessment of construction constraints such as SSSI areas.

The following table summarises the scope designed to each project and the capital and operational cost forecast in AMP8 for the chosen option proposed. The schemes in this table have been grouped by their scope and the WINEP driver code.

Table 50 Investment and cost overview

WINEP Driver	Investment ID	Investment Name	Scope	Storm Tank Vol (m3)	Pumping Stations Total kW	Capital Cost £k AMP8	OPEX cost £k (25-30)
U_IMP_6	I034809	Aldborough Thwaite Farm STW U_IMP6	*Storm Tanks *Storm Pumping station *Ancillaries (footpath, landscaping, access road, telemetry, Lightning Conductors)	33	4.4	419	31
U_IMP_6	I034759	Alford WRC U_IMP6		259	4.4	571	40
U_IMP_6	I034608	Ashwellthorpe WRC U_IMP6		50	4.4	439	33
U_IMP_6	I034778	Benhall WRC U_IMP6		79	8	519	39
U_IMP_6	I034779	Bourne WRC U_IMP6		1174	34	1,136	81
U_IMP_6	I034781	Brackley New WRC UIMP6		1815	26.3	1,287	81
U_IMP_6	I034784	Brandon WRC U_IMP6		1177	16.2	1,030	66
U_IMP_6	I034793	Bungay U_IMP6		514	7.52	723	49
U_IMP_6	I034795	Canwick WRC U_IMP6		5031	356.69	2,844	348
U_IMP_6	I034796	Clifton WRC U_IMP6		420	15.54	766	55
U_IMP_6	I034797	East Harling WRC U_IMP6		217	4.4	550	39
U_IMP_6	I034799	Fornham All Saints U_IMP6		3334	81.97	1,925	141
U_IMP_6	I034800	Fritwell WRC U_IMP6		50	4.4	439	33
U_IMP_6	I034819	Great Doddington WRC U_IMP6		189	4.4	536	39
U_IMP_6	I034820	Great Wenham WRC U_IMP6		220	4.4	552	39
U_IMP_6	I034825	Guilden Morden WRC U_IMP6		26	4.4	409	31
U_IMP_6	I034853	Haslingfield WRC U_IMP6		468	11.95	753	52
U_IMP_6	I034844	Haughley Old WRC U_IMP6		576	4.4	699	46
U_IMP_6	I034847	Hitchin WRC U_IMP6		1789	4.4	1,082	60
U_IMP_6	I034855	Kirton Drunkards Lane WRC U_IMP6		223	4.4	553	39
U_IMP_6	I034858	Leighton Linslade WRC U_IMP6		9322	40.61	3,325	148

WINEP Driver	Investment ID	Investment Name	Scope	Storm Tank Vol (m3)	Pumping Stations Total kW	Capital Cost £k AMP8	OPEX cost £k (25-30)
U_IMP_6	I034857	Letchworth WRC U_IMP6		2356	53.5	1,564	107
U_IMP_6	I034854	Marston WRC U_IMP6		2107	69.29	1,548	117
U_IMP_6	I034852	Mildenhall WRC U_IMP6		831	23.84	971	68
U_IMP_6	I034846	Newmarket WRC U_IMP6		2654	31.78	1,554	93
U_IMP_6	I034856	Newnham (Northants) WRC U_IMP6		60	4.4	449	33
U_IMP_6	I034843	Poppyhill WRC U_IMP6		2751	25.07	1,544	88
U_IMP_6	I034835	Purleigh WRC U_IMP6		48	4.4	437	33
U_IMP_6	I034834	Saxlingham WRC U_IMP6		193	4.4	538	39
U_IMP_6	I034832	Spilsby WRC U_IMP6		139	4.4	507	37
U_IMP_6	I034828	Tillingham WRC U_IMP6		49	4.4	438	33
U_IMP_6	I034824	Toppesfield WRC U_IMP6		44	4.4	433	32
U_IMP_6	I034821	Weston by Welland WRC U_IMP6		22	4.4	403	30
U_IMP_6	I033525	Whilton WRC U_IMP6		3401	35.67	1,777	102
U_IMP_6	I033528	Wymondham WRC U_IMP6		315	23.52	778	75
U_IMP_6	I033526	Willingham WRC U_IMP6		37	4.4	424	32
U_IMP_6	I033527	Wrestlingworth WRC U_IMP6		70	4.4	458	37

WINEP Driver	Investment ID	Investment Name	Scope	Storm Tank Vol (m3)	Pumping Stations Total kW	Capital Cost £k AMP8	OPEX cost £k (25-30)
U_IMP_5	I034016	Wymondham WRC U_IMP5	*6696 m3/d Inlet works *9000 m3 Aeration system , *473m3 Final settlement tanks *450 m3 BAF *2 x 120kW Interprocess Pumping Station *Ancillaries (footpath, landscaping, access road, telemetry)		240	18,033	1,774
U_IMP_5	I034010	Sawston WRC U_IMP5	*800 m3 Biofilters *Interconnecting pipework, chamber *Ancillaries (footpath, landscaping, access road)			1,503	37
U_IMP_5	I034017	Yardley Hastings WRC U_IMP5	*226 m3 Biofilters *Interconnecting pipework, chamber *Pumping station 4.4kW *Ancillaries (footpath, landscaping, access road)		4.4	1,185	33
					Total	**55,100**	**4,293**

6.4.2 Benchmarking

In stage 2 of our cost efficiency 'double-lock' on FFT and storm tanks, we used a variety of methods to assess, benchmark and challenge the costs in our plan.

Scheme outturn costs

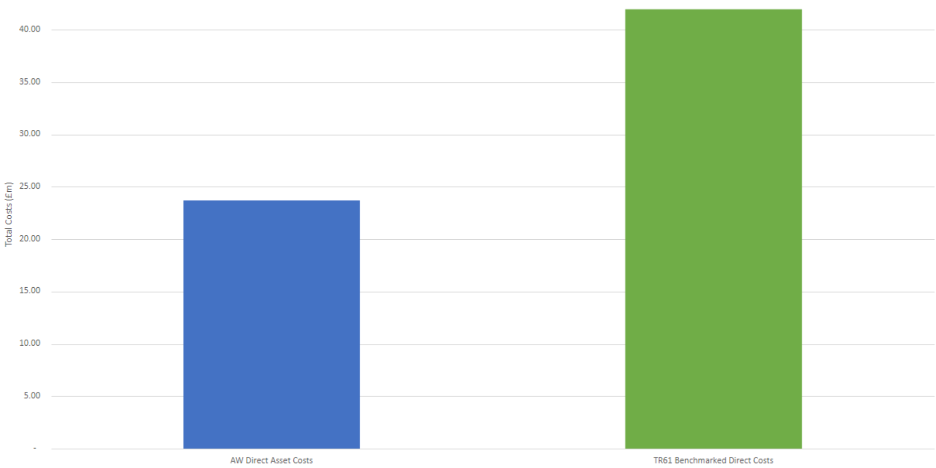
We have continuously captured outturn cost data of all projects delivered in our capital investments, including granular cost components such as pumps, tanks, and on costs, etc. These outturn costs have been the input of the specific cost models of each asset. Building outturn costs into our cost assumptions in this way builds cost efficiency into the build-up of costs.

Industry cost models from TR61

The Increasing FFTs and storm tanks enhancement investment costs have been benchmarked, where possible, against the available cost models built by WRCs TR61. Comparable external benchmarks are available for £37 million of the investment included in our plan. Of this, £7.5 million relates to Storm Tanks (20%), £8 million to storm pumping (21%), £5 million to aeration (13%) and £3 million to BAF plants (8%).

The benchmarking results show that across the programme our costs are 40% below the benchmark costs for the industry. This provides assurance that our costs are efficient.

Figure 29 Increasing FFT and Storm Tanks direct asset cost benchmarked to industry data WRc TR61



In addition to this, when developing the storm tank solutions, we undertook internal benchmarking to measure the savings that could be achieved by constructing tanks made from different materials. This considered in-situ concrete (which has been most commonly use historically), and glass coated steel installations, as we had robust and granular breakdowns for each type. The assessment showed that glass coated steel, although it required earthing for lightning conductivity, was 67% less expensive to install (from 20m^3 to 3000m^3 volume) than in-situ concrete tanks. This analysis triggered a change in the solution design across the programme and meant that, where possible, glass coated steel tanks are the recommended tank material.

6.4.3 Assurance

The development of our costs within our cost estimation system (C55) have been assured by Jacobs

6.5 Customer protection

Storm tank and FFT investments are part of our WINEP Price control deliverable covering forecast delivery of WINEP obligations. As our investment is fully linked to the statutory obligations within the WINEP and the PCD is directly driven by WINEP obligations, we are confident that the PCD covers all the benefits that we intend to deliver through the storm tank and FFT programmes.

7 Reducing flooding risk for properties

Overview

- This investment is required to enhance our sewerage system to reduce the risk to properties and external areas of flooding from sewers. Our investment programme for PR24 allocates 67% of our requested allowance to strategies targeting blockages, and 33% targeting hydraulic flood risk.
- We considered a range of options, and selected as our options network sensors and monitoring, surface water management, and sewer enhancements.
- Working with others is central to this investment proposal - the proposed investments have been built up through conversations with partners, and delivery will be through collaborative working wherever possible. We have recognised the importance of co-funding opportunities to share the cost of flooding protection across all responsible parties. We have set ourselves the challenging target of delivering 50% of our named hydraulic schemes through partnership approaches and this has been reflected in the costs we have assigned to this programme.

Table 51 Investment Summary

PR24 costs (£m)	
Capex	45.1
Opex	15.4
Totex	60.5
Benchmarking	
Method	Scheme outturn costs Industry cost models from TR61
Findings	The cost differential between our costs and industry cost models was found to be explainable by exogenous factors (ground instability and high water table).
Customer Protection	
Performance commitment	Internal sewer flooding PCL
	External sewer flooding PCL
Ofwat data table	
CWW3.156-CWW3.158	Reduce flooding risk for properties

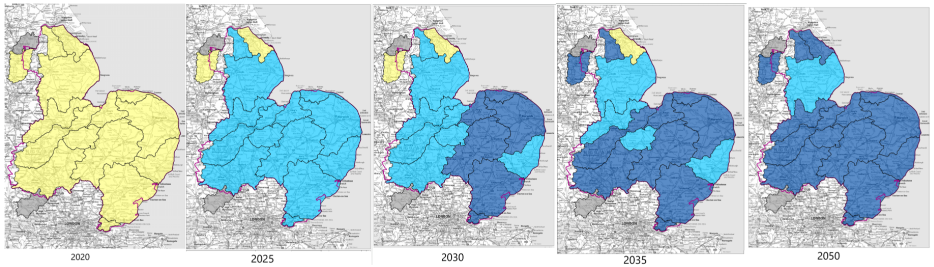
7.1 Delivering for the long term

7.1.1 Investment Context

This investment is required to enhance our sewerage system to reduce the risk to properties and external areas of flooding from sewers. This investment excludes enhancement activities where reducing sewer flooding risk is a secondary benefit, which are addressed in other portfolios. Flooding is caused by either insufficient hydraulic capacity or failures of the sewer system due to blockages or asset failure. The majority of flooding incidents (70-80%) result from blockages in the sewer system often caused by a build up of unflushables or FOG (fats, oils and grease). The proportions of annual flooding incidents attributed to hydraulic capacity varies due to weather conditions but is typically between 10-25% of total flooding incidents. Our PR24 investment programme recognises these two causes of flooding, with 67% of our investment strategies targeting blockages, and 33% targeting hydraulic flood risk (by value).

As set out in our Drainage and Wastewater Management Plan (DWMP), the next 25 years will increase hydraulic flooding risk in many catchments in the East of England due to more intense rainfall resulting from climate change, especially as 28% of our region being below sea level. For each of our catchments, our DWMP Baseline Risk and Vulnerability Assessment (BRAVA) assessed the risk of flooding from a 1 in 50-year storm through modelling of estimate rainfall and river flood frequency among other factors. We carried out modelling to understand this risk and used supporting materials such as The Flood Estimation Handbook (UK Centre for Ecology & Hydrology), to help estimate rainfall and river flood frequency, and development site runoff rates. The BRAVA identified a significant increase in risk of flooding between 2020 and 2050 if no action is taken in the following catchments as shown in map of our region below:

Figure 30 Increase in risk for external flooding from 2020 to 2050 if no action is taken



Key

- Low concern
- Medium concern
- Highest concern

This increasing flood risk is in part exacerbated by forecast housing growth and urban creep. This approach supports our SDS ambition to make the East of England resilient to the risk of flooding, and our continual investment in flooding caused by hydraulic overloading.

7.1.2 Scale and timing

Our long-term approach to addressing hydraulic flooding is informed by our 25-year approach to risk reduction and mitigation as outlined in our DWMP strategic planning framework. The DWMP presents a catchment-level long-term strategy for addressing flooding over a 25-year planning horizon and recognises that hydraulic flood risk is the collective responsibility of a wide number of stakeholders including the water industry.

We have identified that the scale of investment in hydraulic flood prevention proposed within our DWMP is not feasible for AMP8 whilst balancing affordability and competing pressures for investment. As a result we are proposing a lower investment in AMP8 than that recommended within our DWMP. The long-term strategy as identified in the DWMP will remain the same.

For our PR24 investments we recognise the requirement to balance long term aspirations of improved hydraulic resilience with more immediate flood risk resolution through property mitigation and solutions to reduce the risk of blockages forming or leading to flooding. Whilst blockage risk is often a consequence of sewer misuse, we have recognised that recent advances in digital capabilities provide us with the opportunity to proactively identify a blockage formation and resolve the problem before it leads to property flooding. Our PR24 investment strategies seek to continue our AMP7 deployment of sewer level monitors which will mitigate flood risk through proactive blockage removal.

7.1.3 Interaction with base expenditure

Our long-term approach to addressing hydraulic flooding is informed by our 25-year approach to risk reduction and mitigation as outlined in our DWMP strategic planning framework. The DWMP presents a catchment-level long-term strategy for addressing flooding over a 25-year planning horizon and recognises that hydraulic flood risk is the collective responsibility of a wide number of stakeholders including the water industry.

We have identified that the scale of investment in hydraulic flood prevention proposed within our DWMP is not feasible for AMP8 whilst ensuring affordability of bills. As a result we are proposing a lower investment in AMP8 than that recommended within our DWMP. The long-term strategy as identified in the DWMP will remain the same.

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Table 52 Reducing flooding risk - activities split by base and enhancement

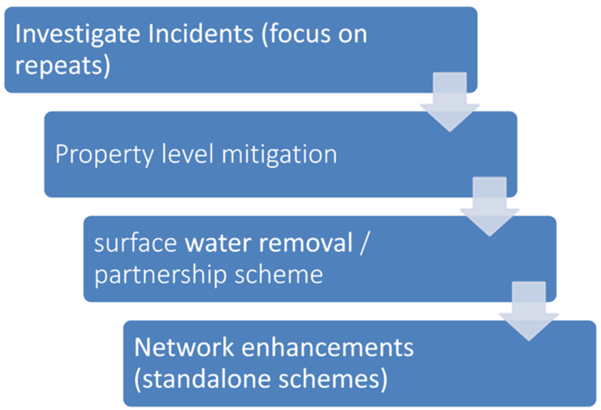
Base	Enhancement
Maintenance of existing sewerage assets	Investment to increase the capacity of our wastewater network
Replacement of monitors installed in previous AMP periods	Installation of new monitors to proactively identify blockage build up before it results in a flooding event.
The relining of sewers to reduce infiltration	The removal or attenuation of surface water from combined systems

Base	Enhancement
Sewer jetting programmes to maintain serviceability of our wastewater network for sewers that have history previous blockages	Installation of new property flood mitigation (ie non return valves, flood doors etc)

7.1.4 Long term context (historic)

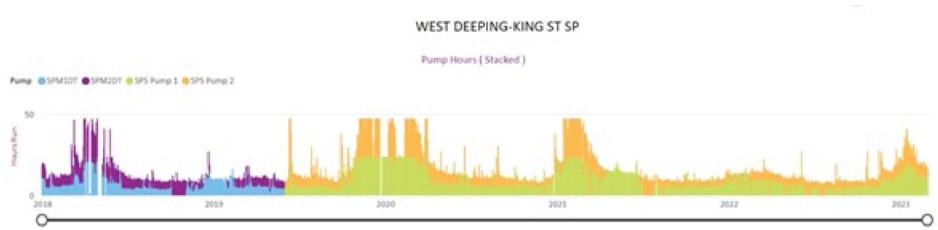
At PR19, our allowance for this investment area was ultimately reflected in the botex plus models. We note that at PR24, Ofwat has indicated that it should be included within companies enhancement investment costs (table CWW3) and so we have treated it as such in our plan. In AMP7, we have invested to continue managing property level flood risk to ensure our customers were protected. Our approach has followed the approach to install property level flood mitigation for location which experience repeat flooding events of at least 1 in 5 years in frequency. Where property level flood mitigation is not suitable, or has previously been installed and subsequent flooding has occurred we then investigate opportunities to remove surface water to reduce hydraulic demand on the system, through a partnership approach where possible. A scheme increase sewer capacity will only be considered where neither mitigation or surface water removal are possible or successful at resolving flooding risk.

Figure 31 Flooding mitigation



An example of our AMP 7 approach is West Deeping. During early 2021 after a period of heavy rain, the foul pumping station at King Street West Deeping became unable to keep up with flows; the sewerage network became hydraulically overloaded and properties suffered with flooding and loss of facilities. Previous flooding had occurred in 2020 and 2019. Investigative work and CCTV on the foul sewer system in West Deeping identified a number of sources of surface water connected to the foul sewer network, including 27 properties with surface water roof connections, ingress of surface water through manhole lids/chambers partially due to a blocked third party surface water sewer. Work to restore full capacity of the surface water system and to redirect property surface water into the surface water system was completed in partnership with Lincolnshire County Council Highways at the end of 2021 and pumping station run times show a significant improvement since this time. Our AMP8 programme seeks to deliver more of these types of interventions, working with third parties wherever possible to share costs to resolving flooding.

Figure 32 West Deeping King Street pumping station run time



AMP7 a large majority of our partnership working has been to resolve flood risk that benefits Anglian Water asset when it is identified by third parties as their highest priority. Schemes such as the above demonstrate the opportunity to work with third parties on Anglian Water identified flood risk, and therefore are more beneficial to our customers. In AMP8 we seek to refocus our partnership work of the catchments that are identified under DWMP as being our highest priorities for future flood risk.

7.1.5 Long term context (future)

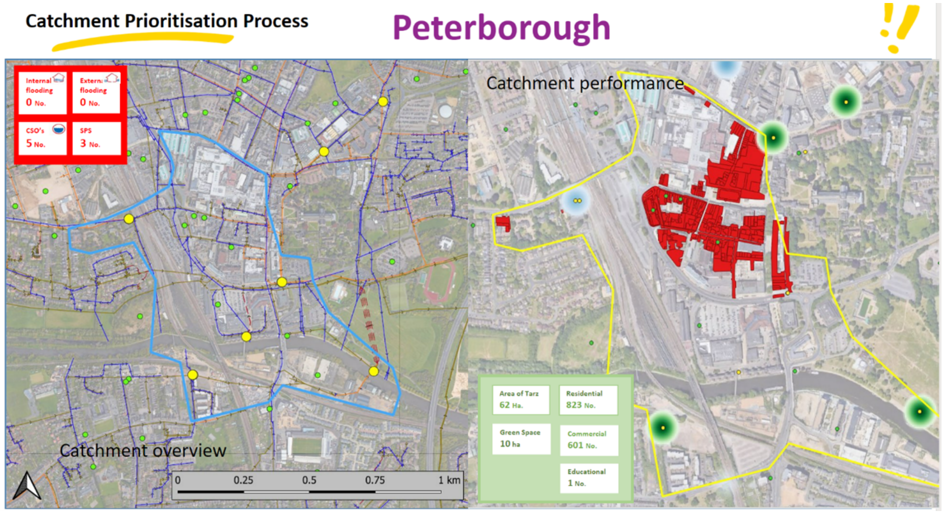
Our long-term strategy to address flooding risk is outlined within our DWMP strategic planning framework as well as our Long-Term Delivery Strategy. Addressing flooding risk forms part of our drainage and water recycling LTDS sub strategy. Our ambition is to substantially reduce sewer flooding by 2050 (by 90%), and in the long term to eliminate sewer flooding in our region. This investment is low regret as it is required to achieve our ambition in all of the twelve scenarios tested. We note a significant uplift would be required in future AMPs in an adverse climate change scenario, nonetheless this AMP8 investment places us on the right path to deal with this if this transpires.[18]

The DWMP process recognises the importance of considering all risk factors in the identification and prioritisation of strategic resilience interventions within a catchment. We have applied this approach to 4 pilot sub-catchments (within Peterborough, Kings Lynn, Watton and March) which were selected for proactive surface water management removal schemes due to hydraulic risk factors (including flooding, future growth, storm overflow spills, wastewater treatment works flow compliance). These schemes are all expected to be delivered by March 2025, and learning from these schemes will be fed into our AWINEP programme for AMP8 & 9 which will focus on two whole catchment surface water removal schemes in Gt Yarmouth and Southend to target spill reduction and long term flooding resilience. These catchments approaches directly align with DWMP and will build on our surface water management and partnership learning from AMP7, with an ambition to seek 60% co-funded solutions through the application of best principle of partnership working via a new centre of excellence.

If successful this approach will be expanded to other catchments areas, an offer an efficient way of delivering our ambitions for climate and growth resilience as part of our LTDS by establishing best practise for partnership working.

18 For more detail, please refer to 2.2.5 'Drainage and water recycling' in our LTDS.

Figure 33 Flooding catchment prioritisation in Peterborough



7.1.6 Customer support

As captured within our Customer Synthesis Report, our customers at PR24 continue to consider flooding to be a particularly serious (although rare) service failure. Participants in Ofwat/CCW's Customer Preferences Research (April 2022) ranked internal and external flooding in the highest importance category for us to address, alongside supply interruptions and water quality. 70% of the customers surveyed as part of national Water Matters 2020-21 Customer satisfaction study were satisfied with companies' actions to minimise flooding. We expect the investment strategies, we have proposed to deliver continued improvement in both external flooding and internal flooding performance commitments, which recognises the importance customers place on these measure. We have tempered our ambition on flooding performance to allow us to keep customers bills as affordable as possible, which is also a key customer priority. This has led to us deferring some hydraulic schemes, for the preference of schemes that target floodings caused by blockages which tend to offer a high benefit to cost ratio.

Additionally, customer research conducted during the development of our DWMP (July 22) found that with an increase in flooding being witnessed in hometowns and on the news, our customers perceive flooding as an imminent and realistic risk which could cause significant damage to homes, the environment, and the economy. Therefore, AW investing in reducing flooding risk in the short-term is seen as of paramount importance for the wellbeing and safety of customers.

7.1.7 Cost control

As stated above, we have prioritised investment in AMP8 to improve service while balancing affordability. Nonetheless, we are satisfied the investment proposed will drive sufficient improvements in addressing external and internal sewer flooding experienced by customers, addressing the customer-facing element of this challenge.

We have recognised the importance of co-funding opportunities to share the cost of flooding protection across all responsible parties. We have set ourselves the challenging target of delivering 50% of our named hydraulic schemes through partnership approaches and this has been reflected in the costs we have assigned to this programme.

7.2 Unlocking greater value for customers, communities and the environment

7.2.1 Option consideration

Our optioneering process considered both the available feasible options to address flooding risk and the selection of sites to apply these options at.

Our option consideration to mitigate the risk of flooding have been informed through the creation of benefit maps which identify the root causes of flooding, the assets to target with our interventions, and the funding mechanism for that investment area (ie enhancement or base expenditure).

This data driven approach to investment strategy creation has led to the formation of the following enhancement activities for flood risk management.

Table 53 Flood risk management in AMP8

Theme	Strategy
Network sensors and monitoring	Install in sewer monitors linked to weather data to provide real time information on sewer capacity and allow proactive interaction when a change in sewer level predicts a blockage.
Surface Water Management	Use DWMP to inform our highest risk location for future hydraulic flood risk. Work with third partners to establish common risk locations and seek to resolve the root cause of hydraulic flooding through the removal or attenuation of surface water. Investment strategies include low complexity (ie down pipe disconnection) medium complexity (Surface Water Management at government buildings) and high complexity (named subcatchment within known hydraulic flooding risk).
Sewer enhancements	Includes property level mitigation, through to increasing the storage capacity of the wastewater network.

7.2.2 Cost-benefit appraisal

Option selection has been supported through modelling and cost vs benefit analysis which has included consideration of the level of flood protection (ie a 1 in 20 through to a 1 in 30 plus climate change level of protection)

Prioritisation for hydraulic schemes has been conducted on the full list of flood locations with the highest impact locations prioritised. Cost benefit of each solution has then been assessed with lower levels of protection (ie a 1 in 20 solution) being proposed at some sites to maximise this.

For the majority of the flooding programme, investment strategies have been identified without naming intervention locations. This is driven by a need to respond quickly and flexibly to flooding incidents as they occur during AMP8, and to maximise the opportunity for partnership working.

Where chronic hydraulic flooding risk is identified, that cannot be solved through mitigation, bespoke location specific investment have been created. This applies to the below 13 locations. We have worked closely with partners to identify needs, and through this process used water company generated needs to prioritise the locations for investment. Prioritisation for hydraulic schemes has been conducted on the full list of flood locations with the highest impact prioritised. For scheme where no partner support has been identified we have considered surface water removal and storage solutions.

Table 54 Investments and recommended alternatives

Investment Name	Recommended Alternative
Billericay - Excess flow	Partnership scheme
Thorpe Market, Norwich - Excess flow	Partnership scheme
Lincoln - Excess flow	Partnership scheme
Hundon, Sudbury - Excess flow	Partnership scheme

Investment Name	Recommended Alternative
Wickford - Excess flow	Wickford - SUDS Option 1 in 30+CC
Norwich - Excess flow	Parnership scheme
Weasenham, King's Lynn - Excess flow	Weasenham, King's Lynn - SUDS Option 1 in 30+CC
Benfleet - Excess flow	Partnership scheme
Bedford - Excess flow	Bedford - Storage Option 1 in 30+CC
Thetford - Excess flow	Thetford - Storage Option 1 in 20
Witham - Excess flow	Witham - SUDS Option 1 in 30+CC
Bury St. Edmunds - Excess Flow	Partnership scheme
Vange, Basildon - Excess flow	Vange, Basildon - Storage Option 1 in 30+CC

7.2.3 Environmental and social value

Application of our Value Framework:

Each candidate investment is appraised to establish a baseline position that captures any current or expected impacts to service, customers, the environment, safety etc (and their respected likelihoods) if no action is taken. (For example no. of properties expected to flood and frequency). This is established using modelling data, incident trends, growth data etc and expert judgement.

Each alternative (i.e. option) is appraised to establish a residual position which updates the baseline post solution, with updated impacts and likelihoods. This residual position also considers any additional benefits and disbenefits that may apply as a result of the intervention. These could be permanent (e.g. visual impact) or temporary (traffic disruption during construction) and consider a range of environmental and social measures including both capital and operational carbon.

This information is combined with whole life cost information within our investment optimisation system (Copperleaf) to determine which alternative offers best value, i.e. maximum net benefit for least cost. Investments and alternatives are then optimised to produce a best value plan that meets PC levels.

7.2.4 Investment benefits

Each option is assessed from a benefits perspective using our Value Framework.

A baseline position is established that captures any current or expected impacts to service, customers, the environment, safety etc (and their respected likelihoods).

Each alternative (i.e. option) is appraised to establish a residual position, with updated impacts and likelihoods. This residual position also considers any additional benefits and disbenefits that may apply as a result of the intervention. These could be permanent (e.g. visual impact) or temporary (traffic disruption during construction) and consider a range of environmental and social measures including both capital and operational carbon.

These subsequently provide benefit to the following performance commitments:

- Internal sewer flooding
- External sewer flooding
- Total pollution incidents
- Serious pollution incidents

For internal sewer flooding performance commitments, we expect this investment to create a significant performance benefit. We have accounted for this performance benefit in the PCL ensure our target remains stretching. For pollution incidents, we expect this investment to create some minor performance benefit, which has also been reflected in the PCL. The benefit of this investment for performance commitments is quantified in table CWW15.

7.2.5 Managing uncertainty

The greatest uncertainty lies in the priorities of our external partners changing, often as a result of a significant flood event. This highlights the need for a flexible approach in AMP8. The main uncertainty relating to AW flooding schemes and parcel type work is that UK climate may change across the end of this AMP and the next AMP and is somewhat of an unknown. This can have a vast impact on those impacted by flooding together with the potential for many more localised or wide stretched wet or dry weather events impacting on flooding. For this reason, our approach to flooding risk reduction as focussed on investment strategy identification rather than location specific interventions for all but our 13 highest risk locations in terms of chronic flood risk.

7.2.6 External funding

Working with others is central to this investment proposal - the proposed investments have been built up through conversations with partners, and delivery will be through collaborative working wherever possible as outlines in previous sections.

We have recognised the need for cross party working to reducing hydraulic flood risk and anticipate a significant proportion of our AMP8 flooding risk schemes will be delivered via a partnership with third parties.

The scale of partnership funding is set out below in Development of costs.

7.2.7 Direct procurement

This investment falls short of the £200m threshold for DPC by default, and the value of the individual assets is generally less than the £5-10m set out in Ofwat's guidance. The investment is also not in discrete assets and require a high level of interfacing with existing company assets. Therefore this investment is not appropriate for DPC.

7.2.8 Customer view

We undertook customer engagement on solution types through the DWMP engagement. Engagement with our Online Community in September 2022 found that 78% support use of green solutions where possible, and that customers find green solutions to address flood risk highly appealing. However, whilst customers supported the use of green solutions and agreed this was the best approach for the long term, there is an understanding that grey solutions may have a place in urgent situations.

Our DWMP also recognises a stakeholder preference for solutions that resolve flood risk through surface water removal or attenuation. Our hydraulic flooding programme proposes over 60% of solutions will be address through surface water removal schemes.

7.3 Cost efficiency

7.3.1 Developing costs

The development of the reducing risk from floods costs in our plan follows our cost efficiency 'double lock' approach set out in chapter 7 'Driving cost efficiency' of our business. plan. Through this approach we have ensured that are costs are efficient in their bottom-up build up, and this is cross-checked through external benchmark approaches. This section sets out how we have ensured cost efficiency of our reducing flooding risk investments through step one of our double lock approach. Step 2 is explored in the Benchmarking section below.

We have taken a robust approach to developing our reducing flooding risk costs, building on our experience from delivering similar schemes into the bottom-up development of costs (before external cost benchmarking challenges are applied in step 2 of our 'double-lock' approach). The detail of the cost development approach is set out below, along with a breakdown of costs we provide in table CWW3.

Cost estimation methodology

We follow a common cost development methodology across our enhancement investments in a three phase process:

1. Establish cost and carbon models
2. Input the cost drivers into the model (including location specific factors)
3. Data validation, internal challenge and assurance.

Phase 2; We derived our total cost estimation for each scheme through the following process:

- Assessment using the flood risk register
- Hydraulic modelling of storage required
- Topography and surface types (i.e roads, field, verge)
- site specific requirements
- Infiltration Reduction Plans previously carried out.

The table below provides a breakdown of the costs we have included in our plan for reducing flood risk.

Table 55 Cost and site breakdown of investment

Investment ID	Investment Name	Scope	Capital cost £m AMP8	OPEX cost £m AMP8
I009143	Norwich - Excess flow	4 radar level monitors	27	-
I009165	Benfleet - Excess flow	4 radar level monitors	27	-
I009167	Lincoln - Excess flow	4 radar level monitors	27	-

Investment ID	Investment Name	Scope	Capital cost £m AMP8	OPEX cost £m AMP8
I009269	Bury St Edmunds - Excess flow	4 radar level monitors	27	-
I009292	Thorpe Market, Norwich - Excess flow	4 radar level monitors	27	-
I009354	Hundon, Sudbury - Excess flow	4 radar level monitors	27	-
I009395	Billericay - Excess flow	4 radar level monitors	27	-
I009296	Vange, Basildon - Excess flow	*Gravity sewer	88	-
I009358	Wickford - Excess flow	*SuDS 38 Wet Swale 9.188m3 17 Wet Swale 30,674m3 *458m3 Offline Storage *Interconnecting Gravity sewers and Rising main *Ancillaries (road, fence, telemetry)	1,592	1
I009462	Weasenham, Kings Lynn - Excess flow	*Multiples SuDS incl permeable pavement, filter drain, attenuating raingardens, soakaway * 77m3 Offline Storage *Interconnecting gravity sewers and rising main *ancillaries (road, fence, telemetry)	1,049	2
I009300	Witham - Excess flow	*Multiple SuDS incl filter drain, raingardens, wet swales *13m3 Offline storage *Interconnecting gravity sewers and Rising main *Ancillaries (road, fence, telemetry)	728	2
I009411	Bedford - Excess flow	*254m3 Offline storage *Interconnecting Gravity sewers and Rising main *Ancillaries (road, fence, telemetry)	909	2
I009747	Thetford - Excess flow	*53 and 208m3 Offline storage *Interconnecting gravity sewers and rising main *Ancillaries (road, fence, telemetry)	1,733	3

Investment ID	Investment Name	Scope	Capital cost £m AMP8	OPEX cost £m AMP8
I038889	AMP8 Surface Water for IRPs	The investigations will include the following elements: Ground truthing (CAS survey) and CCTV The mitigation will include: Correcting misconnections. Installation of soakaways	5,080	-
I038897	AMP8 Flood mitigation	The scope of this alternative covers both simple mitigation and more complex solutions. Simple mitigation - the installation of non return valves (push fit) into the existing customer pipework. Simple mitigation - replacement of sewers and manholes connections	4,483	107
Various	Inceptor risk mitigation	2525 Inceptors removals	6,910	-
Various	Office Gov Properties SWM	The mitigation will include: Ground truthing (CAS survey), SI inc infiltration and Topo. Installation of SuDS features including soakaways. Correcting misconnections, installing short lengths of sewer, constructing manholes.	3,274	-
Various	Community Assistance Funding	Low value Community Assistance Opportunities	-	250
Various	Local Partnership Funding	Community partnership collaboration	1,150	-
Various	Partnership Funding	Community partnership collaboration	5,580	-
Various	Consolidated level monitoring	17,259 sewer monitors	10,471	13,115
I038903	AMP8 Modelling Flooding Investigations	Investigations and modelling	1,221	-
I039335/ I041261	WR modelling strategy implementation	Adaptive modelling, risk modelling, coding costs, investigation of new modelling software, linking hydraulic models to live monitoring data, WRC hydraulic models	342	1,920
I038882	AMP8 Pluvial and Fluvial Flood Resilience		3,412	-
		Total	45,108	15,401

7.3.2 Benchmarking

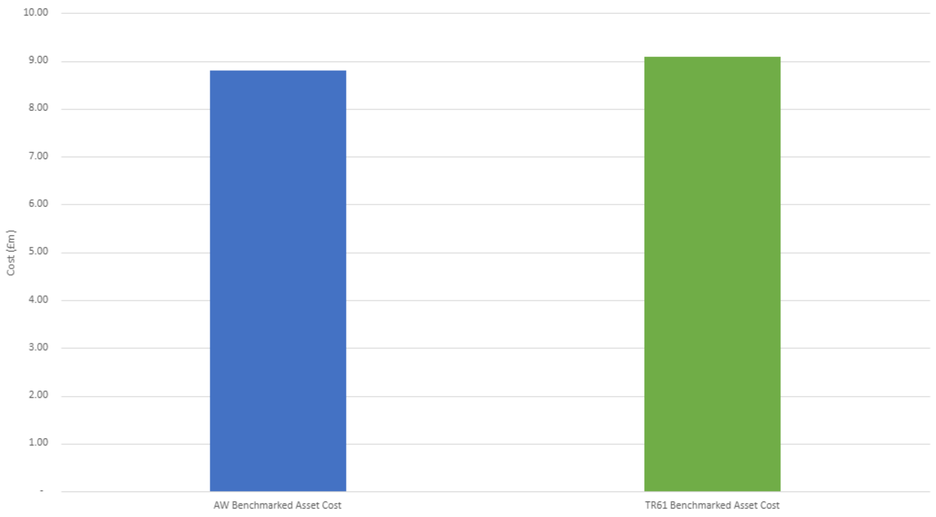
Scheme outturn costs

We have continuously captured outturn costs data of all projects delivered in our capital investments including granular cost components such as offline storage, interceptors, pumps, gravity sewers, sewer monitors, on costs, etc. These outturn costs have been the inputs to the cost models to each specific assets. Building outturn costs into our cost assumptions in this way builds cost efficiency into the build up of costs.

Industry cost models from TR61

We have looked to benchmark our direct asset costs against the cost models built by WRCs TR61. Overall 57% of the programme costs are built from SUDS, offline storage and sewers assets. The combination of this assets show that our direct cost are 8% higher than WRCs TR61 parametric models, this is due to our historically installation of tank on the East of England region proven to required more civil works due to ground instability and high-water table.

Figure 34 Reducing flooding risk - direct cost of asset only benchmarked to industry data WRC TR61



Note : The direct cost benchmark figures include for all direct cost to install the assets, excluded any location factors and on cost, so these figures will not match the Total cost table presented in the Developing cost section.

7.3.3 Assurance

The costs developed using our costs estimation tool (C55) have been independently assured by Jacobs.

7.4 Customer protection

Customers are protected against the cancellation, delay, or reduction in scope of this investment through the flooding performance commitments (internal and external sewer flooding). This enhancement investment is crucial for us meeting our target to reduce internal sewer flooding by 21% between 2024/25 and 2029/30. As our PCL has been calibrated based on the acceptance of this enhancement case in full, should any of our investments to reduce flooding risk not be delivered, this would increase the instances of sewer flooding taking place and this lead to a greater underperformance penalty (or a smaller overperformance reward) than if the investment had been delivered. In addition to this, customers are protected against the non-delivery of wider benefits through other ODIs including total pollution incidents and serious pollution incidents.

8 Resilience (water)

Overview

Creating a resilient business is a key strategic priority for us and our customers. Our customers have the right to always expect water whenever they turn on the tap, so ensuring we are able to provide safe, clean drinking water 24/7 365 days a year is vital. As part of our AMP8 investment plan and Long Term Delivery Strategy, we have set out an ambitious plan to help us mitigate the impacts of climate change, asset flooding, and single points of failure.

Climate Vulnerable Mains (CVMs)

To mitigate for the impacts of climate change upon the East of England, we are proposing to invest £1.64bn by 2060 in mitigating the premature failure of our climate vulnerable mains, £184m of that being invested within AMP8. This will renew 668km in AMP8 as part of a multi-AMP programme of removing 75% of our 8241km of climate vulnerable main by 2060. This investment builds on the leading academic work of Dr Timothy Farewell and Cranfield university who we have partnered with since 2014, and the development of our sector leading WISPA climate modelling tool.

Single points of failure

We are proposing to invest £28.1m in AMP8 as part of our long-standing, multi-AMP programme to address single points of failure across our water network. This includes where distribution water mains cross over, under and through pieces of critical national infrastructure such as motorways, high speed rail lines and bridges where the impact of failure is particularly severe. This work provides significant resilience for our customers to the potential consequences of high impact/low likelihood critical asset failure.

Surface water flooding

We are investing £4.2m to mitigate against the impacts of surface water flooding at 13 key water production assets including boreholes which are highly susceptible to flooding. This is to ensure that the impacts of heavy rainfall and sea level rise, both attributed to climate change, will be mitigated from in the medium to long term, ensuring we can provide a resilient supply of clean, safe drinking water to our customers.

Table 56 Investment Summary

PR24 costs (£m)	
Capex	238.0
Opex	0.3
Totex	238.3
Benchmarking	
Method	Scheme outturn costs Asset level cost comparison with other companies Industry cost models from TR61
Findings	The cost in our plan were found to be lower than the industry benchmark both for asset level cost comparison and industry cost models from TR61.
Customer Protection	
Price Control Deliverable	Climate Vulnerable Mains
Ofwat data table	
CW3.118-CW3.120	Resilience

8.0.1 Investment context

Our resilience enhancement plan for AMP8 is fully aligned with our resilience framework, outlined in section 7 of our main business plan. At PR19 we benchmarked our approach to resilience in the round and developed a resilience action plan to focus our capability development to ensure we can make important steps to mitigate key resilience risks to our customers the environment and our organisation. Defra, Ofwat, DWI and other independent bodies including the National Infrastructure Commission (NIC) and the Competition and Markets Authority (CMA) all recognise the need for infrastructure owners to carefully consider resilience risks and support forward looking risk assessments.

Our resilience investments address risks identified in our risk assessment process that are not adequately mitigated by the other areas of the plan. This explicitly focussed on areas we understand at this time that have exogenous factors that will impact on our ability to deliver value for our customers. As one of the few areas of our enhancement plan that does not have explicit statutory investment drivers, we have taken great care to consider resilience in the round and the interdependency of operational, financial and corporate resilience requirements. Accordingly, we have considered in the approach the appropriate scale and timing of resilience investments to tackle both short and long term risks, the levels of uncertainty and how adaptive planning will be governed effectively. This is fully integrated into our LTDS approach. Through our robust business model process we ensure that resilience is considered in all areas of our plan including botex, and also in enhancement investment areas such as WRMP and DWMP.

Our resilience framework continues to be improved since PR19. It enables us to develop optimal plans for the mitigation of the shocks and stresses we identify through our horizon scanning, risk management process and governance processes. Already in AMP7 we have had our resilience capacity tested by a number of shocks and stresses identified in our resilience plan (pandemic, drought, extreme temperatures, global unrest and cost shocks in the energy market to name a few). Due our preparedness and forward-looking approach to resilience investment, we are pleased to be able to say that the impact to our customers of these challenges has been minimal. For example, we maintained almost seamless operations throughout the freeze-thaw event in December 2022.

We use our resilience in the round approach to ensure that our responses are balanced across the 4 Rs (Resistance, Reliability, Redundancy and Response and recovery), learning from these real world events to further develop our resilience planning. With the standardised industry approach of long-term adaptive planning though the LTDS we can present our plans in a consistent way to the regulator. The case for investments that are required to be continued or started now to mitigate risks for customers, the environment and maintain a financially resilient business is compelling. Using our improved value tools that now include "6 Capitals" we can consider the broader value we can create with our proposed investment. We also ensure that the optimal balance is provided though considering the best balance between the "4 Rs", for today and how that needs to evolve over future AMP periods. Importantly we have aimed to design an adaptive plan that will allow innovations in the future to be exploited so these proposals are low regrets investments.

The key risks that we are seeking to mitigate as part of our resilience enhancement investment during AMP8 are summarised in the table below. They represent either an immediate resilience risk to customers or an escalating risk that we need to start addressing now to avoid unacceptable service failures and costs in future AMPs:

Table 57 Key risks requiring mitigation in AMP8

Risks	Description
Climate change	Resilience to many aspects of climate change are addressed by our WRMP such as the impact of growth, drought and the impact on supply and demand. However the increasing risk of interruptions and service impacts in communities from premature asset failure due to extreme heat and drought as well as flooding of our assets at specific locations vulnerable to fluvial and pluvial flooding are not addressed. Investments in this portfolio address these risks.
Critical single points of failure	Single point of failure - Continuing to eliminate the risk, for isolated communities, from having to rely on a single source of water supply has been a resilience focus for a number of AMP periods. High risk crossings -We adopted a system level approach to expand this focus in AMP7 to include the risk of single points of failure in the network. We have specifically focussed our the risk of single points of failure for critical infrastructure crossings (dualling mains under/over critical crossings of third-party infrastructure like roads, rail and watercourses). These not only create a service risk to our customers but have a consequential impact on other UK infrastructure. We also include investments for reducing the risk of inundation in the event of reservoir structural failure. This is due to the expanded scope of the Reservoir Act to cover more sites.

We have considered the interdependencies of these risks with other areas of the plan. The mitigation of a number of these risks are assessed in other enhancement areas so the following are not addressed here:

- Water Resource Management Plan (WRMP) - the impact of the above risks on resilient water supplies are addressed in our revised draft WRMP24 and associated enhancement areas
- Security - the approach to cyber and physical security threats are addressed in the security enhancement area.

Taking into account the risks mitigated through the above enhancement areas, plus those mitigated by base expenditure, our risk assessment identified three key areas of resilience risk requiring further mitigation. The key risks which require further mitigation by investments specifically focussed on resilience (in this chapter) are climate change and catastrophic asset failure:

Table 58 Links between risk and investment

Exogenous risk mitigated	Investment areas
Climate change	Asset Climate vulnerability
Climate change	Asset flood resilience
Critical single points of failure	Single source of supply High risk crossings

Underpinning our risk analysis are some leading asset management approaches. These include:

- the comprehensive understanding of our asset health through extensive deterioration modelling embedded in our use of Copperleaf C55 tool. This tool supports our long term investment planning by being able to model across our asset base and run multiple plausible future scenarios;
- the Water Infrastructure Serviceability Performance Assessment (WISPA) has been developed in collaboration with world leading climate academic Dr Timothy Farewell and his wider climatic infrastructure consultancy, Maplesky which allows us to use historic climate and asset data to predict future climate related failure;
- a predictive analytics optimiser, allowing us to optimise our investments against multiple drivers;
- our Value Framework now incorporating the 6 capitals approach to value that is embedded in our Copperleaf C55 investment planning tool;
- real world validation of modelling outputs using data from past events;
- interdependency through our benefits mapping process.

Pilots in progress to be exploited in the future:

- Our work with others - e.g. CReDo has been delivered through a first-of-its-kind collaboration between academia, utilities networks and government. The Connected Places Catapult is working with Anglian Water, UK Power Networks and BT to develop the Climate Resilience Demonstrator (CReDo). CReDo aims to be a connected digital twin of critical infrastructure that helps the cross-sectoral infrastructure network adapt to climate change and improve climate resilience.
- Place based interdependency mapping.

8.1 Asset climate vulnerability

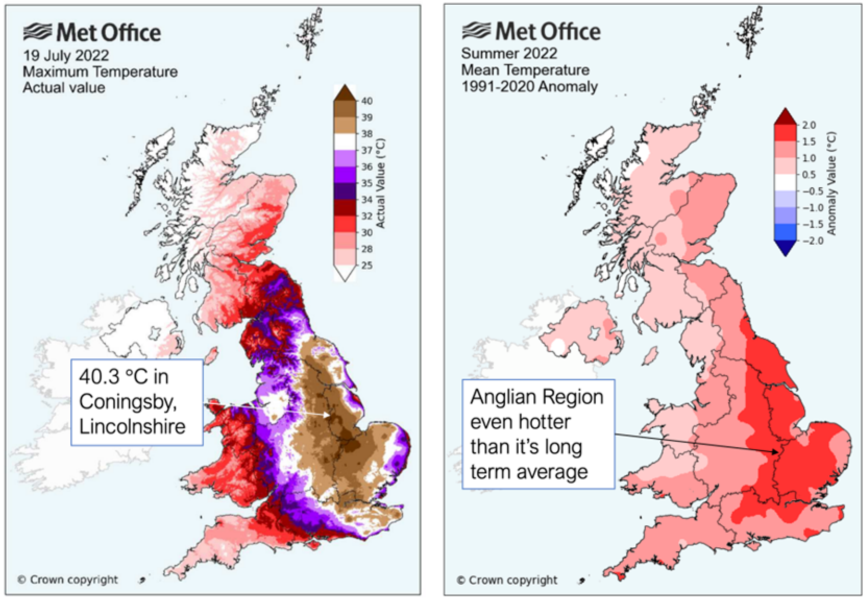
8.1.1 Delivering for the long term

Investment context

As part of our Climate Adaptation Report 2020[19] we set out the risks we face from climate change, and explained that we were improving our understanding of the risks to water networks associated with high temperatures, looking ahead to the adverse common reference scenario and using a less optimistic scenario of a potential 4°C rise in global temperatures (#fitforfour). The UK Government's subsequent climate change risk assessment 2022 [20] identified increasing risk to water infrastructure as an area of concern, and other infrastructure owners have conducted their own research including network rail who recently announced a review of their readiness for extreme heat. In the summer of 2022 we experienced extreme weather of exactly the nature forecast to occur more frequently as climate change progresses, with Coningsby, Lincolnshire in our area setting a new UK temperature record of 40.3C, directly leading to record soil moisture deficits. Historic analysis and independent academic research has shown that smaller diameter Asbestos Cement, Cast Iron and PVC distribution mains have a higher risk profile when in high shrink swell soil types during periods of high soil moisture deficit. The summer of 2022 and exceptional climatic events had the resultant outcome predicted by our modelling, with levels of water mains bursts in excess of those seen during the 'Beast from the East'. Since then we have seen record temperatures at a global scale and extreme heatwaves in Europe.

19 Climate Change Adaptation Report 2020
20 UK Climate Change Risk Assessment 2022

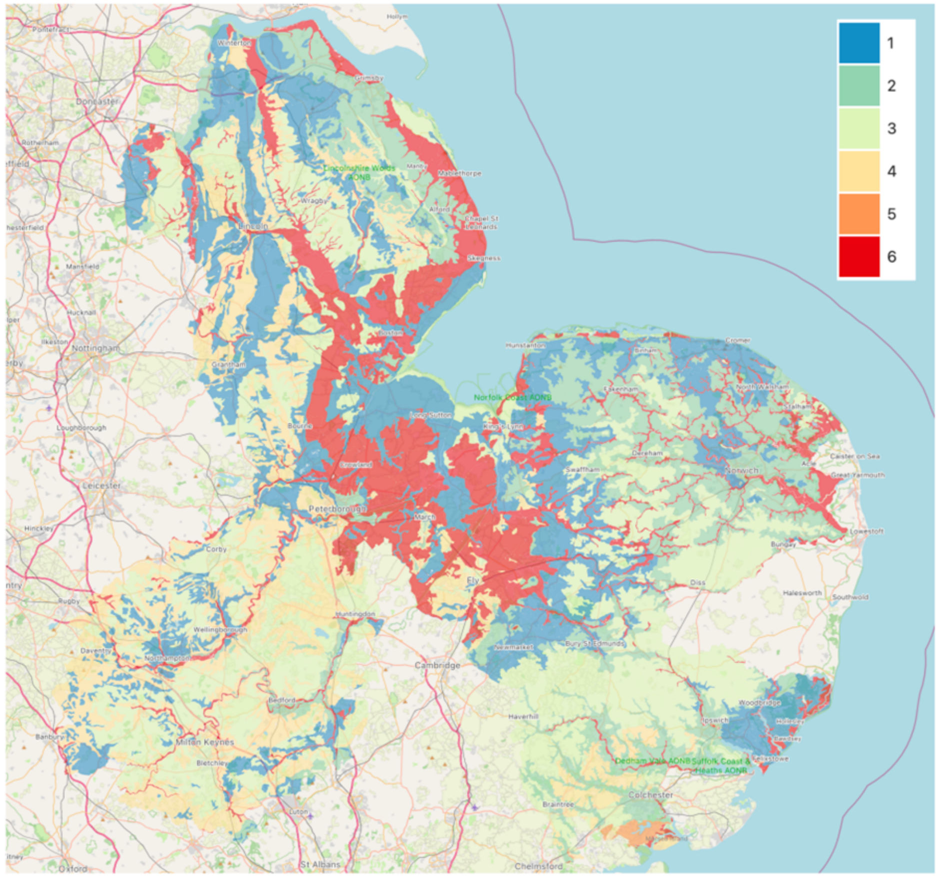
Figure 35 Met Office 2022 UK Temperatures



In keeping with the 'forward looking' risk assessments called for by the National Infrastructure Commission (NIC) and Competition and Markets Authority (CMA)'s support for a forward-looking approach to capital maintenance [21], we have used our industry leading WISPA climate modelling tools to identify high risk water main assets in our region that are vulnerable to these changing climate conditions (Climate Vulnerable Mains, CVM). These are water mains of a smaller diameter, made of various rigid materials with socket type joints, and located in shrinkable soil types susceptible to climate induced ground movement. These high shrink swell, class 4, 5 and 6, soil types are prevalent in large parts of our operating area making this a particular acute problem for Anglian Water as demonstrated by the image below. This is exacerbated within the Anglian Region due to major centres of population e.g. Peterborough, Milton Keynes etc. being directly within class 6 soil areas. The majority of the remaining class 6 soil types within the UK are located within remote upland areas e.g. Lake District, Yorkshire, and the peak district. Our modelling, supported by a number of recent real life examples, shows a significant proportion of our network is vulnerable to this failure mode which will increase in frequency over the coming decades due to climate change. The UKPC18 climate predictions show that summers will become hotter and drier, leading to increase in soil moisture deficit and also potential spikes in demand from customers during climatic events as was demonstrated in 2022.

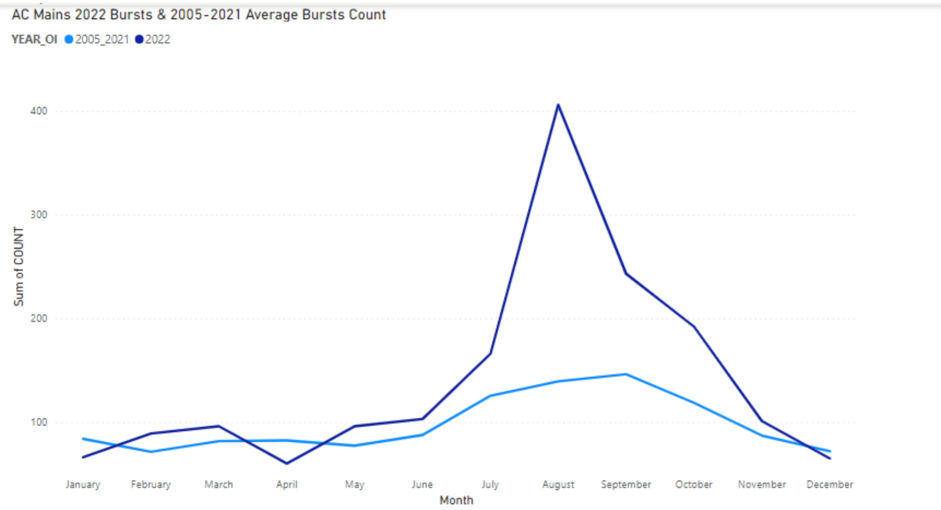
21 https://assets.publishing.service.gov.uk/media/60702370e90e076f5589bb8f/Final_Report_---_web_version_-_CMA.pdf

Figure 36 Anglian soil types by category



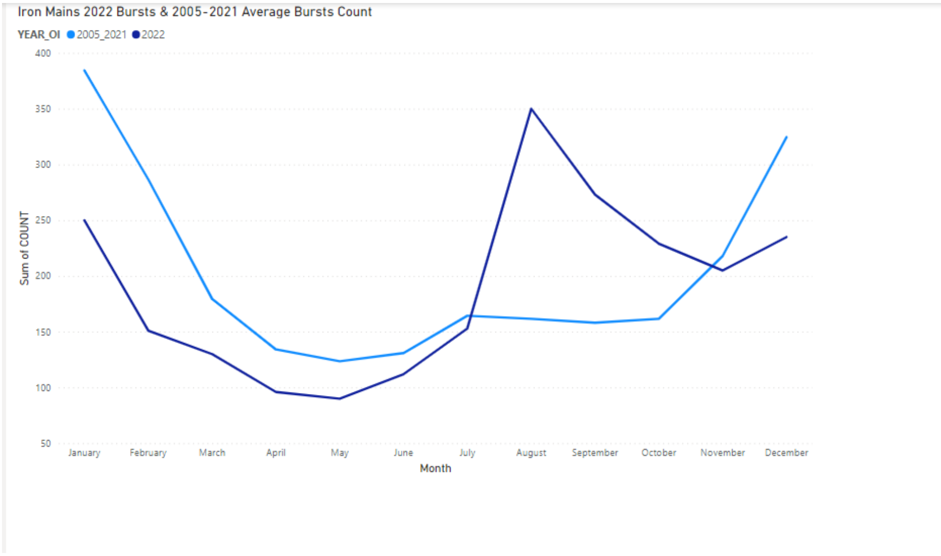
It is also clear that Climate Change and soil type is explicitly affecting a certain subset of distribution assets which we are deeming as climate vulnerable. As you can see from the graphs below, there is a stark increase in the failures of climate vulnerable materials, Asbestos Cement, Iron and PVC during high soil moisture deficit periods such as summer 2022. This demonstrates how climate has a direct impact upon those assets and soils over and above the rest of the Anglian Water distribution network or wider country as a whole.

Figure 37 AC bursts during high soil moisture periods



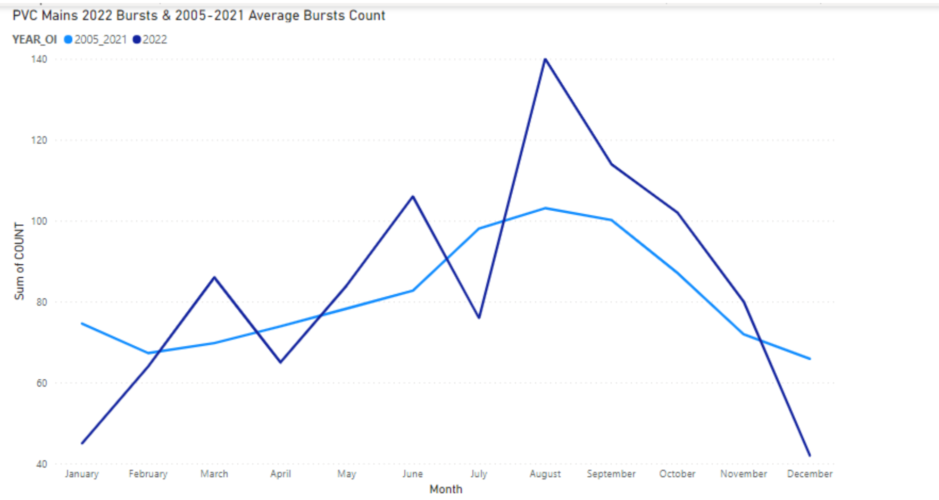
The above graph shows a distinct peak in AC mains bursts in July and August 2022, during the peak of the climactic event and when soil moisture deficit was at its highest.

Figure 38 Iron mains bursts uring high soil moisture periods



A similar trend can be seen above for Iron mains with a summer peak as an outlier to the previous 17 year average.

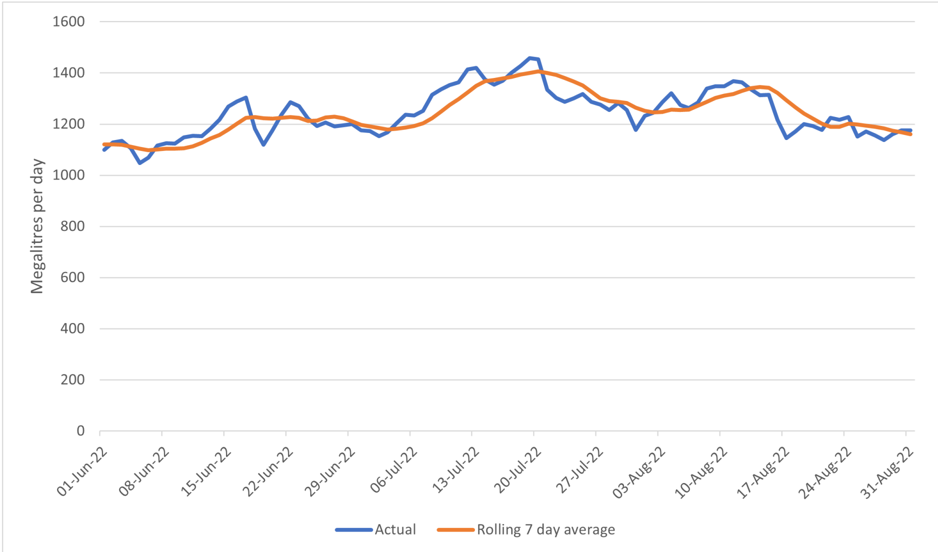
Figure 39 PV mains during high soil moisture periods



Finally, a similar trend can be seen above for PVC mains with a summer August peak in 2022 during the exceptional hot weather as an outlier to the previous 17 year average.

As these climactic events become more frequent and more severe due to climate change, the severity of these peaks will also increase and will result in a significant challenge to maintaining supplies to customers. During the summer of 2022, we saw a prolonged period of hot dry weather. This caused us to experience exceptionally low levels of soil moisture within our region leading to a dramatic increase in the failure of our climate vulnerable assets. The impact of the increase in asset failure drove a record spike in demand and production requirements due to an increase in climate vulnerable leakage. This can be seen in the graph below showing Anglian Water hitting a record daily production output of 1458.5 Ml/d on 19th July 2022. During this period we also hit a record 7 day rolling daily production output record of 1405.4 Ml/d. This exceptionally high level of production demonstrates the stress that climate induced asset failure puts upon our production assets, but also the resilient nature of Anglian Water's asset base. If the levels of climate vulnerable main failure were to increase, as projections currently show, the challenge of meeting the additional production requirements would put unsustainable level stress on our production assets, and ultimately lead to us being unable to meet peak demand during climate events. This can be mitigated by proactively reducing our proportion of climate vulnerable mains across our company. We need to remain ahead of the point at which these impacts become unmanageable. The scale of the problem requires a multi-AMP strategy and we need to be able to ramp-up be able to deliver it the volume of activity that will be required.

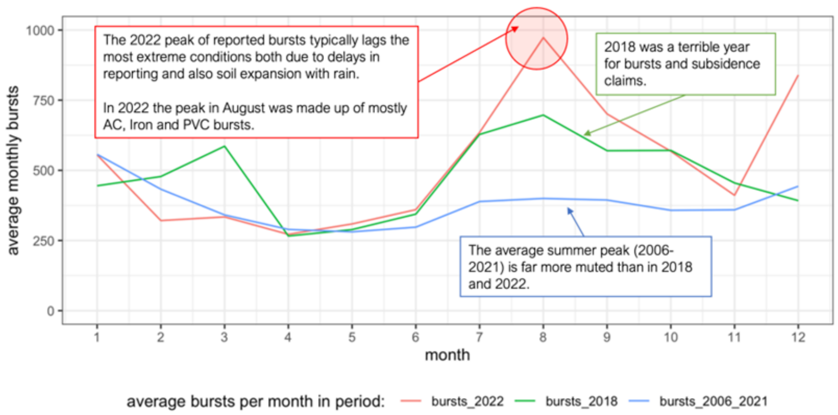
Figure 40 Anglian Water Distribution Input for June - August 2022



In addition to climate failure driving up demand, we also experienced high levels of resourcing required to be able to repair climate vulnerable main failure. Our repair teams were required to deal with 208% more bursts during August alone, and 150% more bursts than a traditional summer. This is demonstrated in the below image which demonstrates summer 2022 was far worse than previous summers or other climactic events like the 2018 Beast from the East.

This additional level of reactive bursts caused exceptional pressure on our repair resource, even with our flexible ways of resourcing and alliancing practices, meaning that the average time to fix increased and bursts ran for longer, putting additional demand stress on our network. This was as a direct result of climatic events impacting our climate vulnerable mains. The below graph also demonstrates why it is not appropriate to resource to levels required during the summer of 2022, and that even with flexible resourcing models, certain climatic events will always overwhelm resources. A proactive method of mitigation is therefore required rather to ensure service and supply is maintained for our customers.

Figure 41 Average bursts per month vs average monthly



The additional stress that climate driven bursts and high demand can place upon an area was clearly demonstrated in Haddenham in the summer of 2022. As a result of a burst of a climate vulnerable main during a period of high soil moisture deficit, the Haddenham network depressurised. To be able to recharge the local network, we were required to recharge Haddenham Tower to provide satisfactory pressure to downstream customers. However, due to high demand in the local vicinity and further secondary bursts of climate vulnerable mains within the Haddenham area, the recharge of the tower took much longer than usual, leaving 3,500 customers without water for 20 hours (a 25.49 second interruption to supply). Further information on the impact that climate change has upon our sub-terranean assets during the summer of 2022 can be found in "The Exceptional Summer of 2022" in Annex ANH68.

For this reason we are including in our Long Term Delivery Strategy core pathway a multi-AMP programme to improve the resilience of our network by renewing 6,000km of our 8,241km of our distribution main that is deemed to be climate vulnerable, approximately 75%. In our APR23 we reported our total mains distribution length as 39,248km, meaning that 20.99% of our total distribution mains are deemed as climate vulnerable. This is profiled to achieve deliverability and affordability across our SDS horizon. Were enhancement investment not to be made in this and subsequent AMPs, we would see high reactive costs and high disruption to customers from peak climatic event related failures. Costs and disruption would be driven by both the need to undertake significant additional reactive asset renewals and from summer failures exceeding the resource availability to address mains bursts. This would be exacerbated by these events occurring at peak demand times, therefore having a greater likelihood of causing supply interruptions to customers. The investments have been profiled to acknowledge the affordability issue our AMP8 plan presents and also to allow time for the delivery capability and capacity to develop in the supply chain. This is coupled with investments to improve in situ monitoring and condition assessment of our network and a focus on innovation to develop less intrusive methods of dealing with this risk.

During AMP7 we have significantly developed our capabilities in data and analytics

In our efforts to understand the challenge from climate change on our assets we realised that there were limited effective modelling techniques that would be able to convincingly inform investment decisions. To fill this gap we have developed a world leading climate modelling tool (WISPA) in partnership with world leading climate academic Dr Timothy Farewell. His wider climatic infrastructure consultancy, Maplesky and Cranfield university are now helping us to better understand the impacts of climate change on our subterranean distribution assets. Since its inception in 2014, WISPA has taken previous climate data from our region, and national climatic trends, as well as historical pipe by pipe burst data, to highlight the future potential of risk.

For example, where there have been multiple mild summers and winters, WISPA helps us to highlight the potential threat of increased climate vulnerability due to the clear through effect of a climate event and the weakest assets failing, which is well documented in scientific literature.

These tools have allowed us to highlight our climate vulnerable mains, help us to predict hotspot areas to better resource during climatic events, and promote investment into key areas of climate vulnerability and network risk, delivering the best holistic investment for our customers. WISPA uses three different climatic statistical models; winter optimised, summer optimised, and yearly annual model, to allow us to identify trends and highlight risk at a pipe by pipe level, unlike previous approaches which have been at DMA or regional level.

Over a number of years, we have been using WISPA as a tactical tool, allowing us to prioritise resource, plant, materials and restoration tankers in high risk areas, as well as providing high and critical risk assets which we have proactively contingency planned for to help reduce the impact of asset failure.

Alongside WISPA, we have used our industry leading asset optimisation tool, Predictive Analytics, as part of the Copperleaf suite of solutions to help model the impact of climate across a longer time horizon using real world asset data. Further information on our predictive analytics tool and how it has been used across our PR24 investment programme can be found in the ASRAP document page 11 (above diagram)

In addition to the effects of extreme heat on our network assets we have also investigated the resilience of our above ground assets to extreme heat. During the summer of 2022, we had to bring in temporary air conditioning and ventilation assets to support key pumping systems and prevent overheating that could have caused interruptions to thousands of customers. This overheating of assets was primarily due to the record 1,496 Mld which we were pumping into our distribution network at peak, combined with record air temperatures across the UK but specifically in the East of England. We have included in our plan measures at 18 sites to install improved ventilation, air conditioning and increased shading from trees and hedges to mitigate the risk for future periods of extreme heat.

Scale and timing

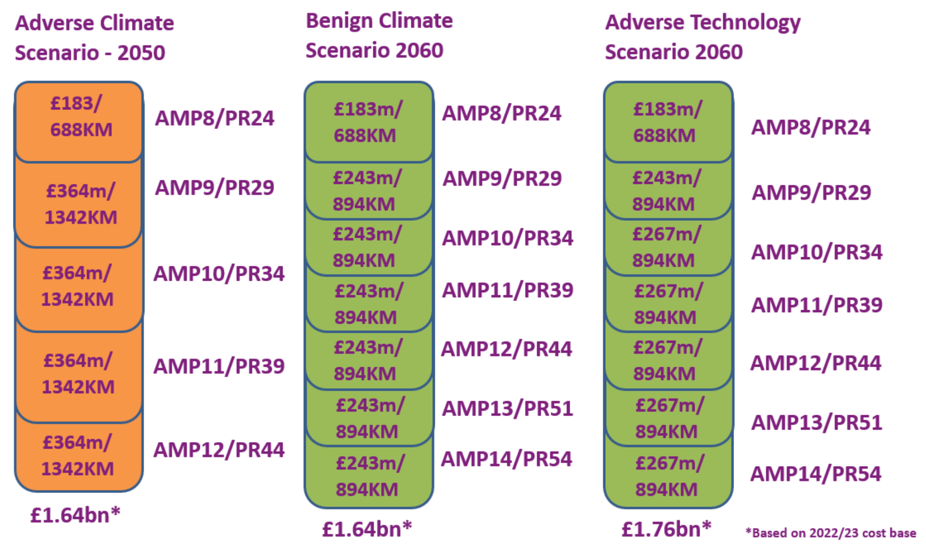
Unlike most areas of our PR24 enhancement programme, these resilience enhancements are not directly driven by statutory drivers with an AMP8 obligation date. This allows us to ensure that resilience investments across our LTDS timeframe are made at the right scale and at the right time, informed by a long-term view of affordability and deliverability.

Our resilience to climate vulnerability is a key part of our long-term resilience strategy and so the scale and timing of the investment we are putting forward for PR24 is heavily driven by this long-term need. We have identified that 20.99/8,241km of our distribution mains are deemed as climate vulnerable and we have therefore phased investments to remove c.75% of our climate vulnerable assets over a seven AMP period (this timescale has been used as it delivers investment before the critical point of climate related failure indicated by our WISPA and Predictive analytics modelling). One of the key drivers for tackling the problem of climate vulnerability across multi-AMP is customer affordability. By spreading the investment over multiple AMPs prior to the height of the impact being felt, in AMP customer bills are reduced and the investment can be spread across multiple generations following the policy of intergenerational equity in funding resilience to the impacts of climate change.

Given the acute affordability and deliverability challenges inherent within the scale of our statutory PR24 programme, we have recognised that the discretionary and scalable nature of this investment allows us to defer some investment into future AMPs. With these concerns in mind, we have proposed to start the climate vulnerable mains programme at a slower pace in AMP8, whilst starting work in AMP8 in order to avoid a major affordability and deliverability challenge in AMP9 and beyond. Whilst AMP8 is lower than future AMPs, the step up from no activity in AMP7 is very large which requires an increase in capacity and capability in the supply chain alongside existing capital maintenance and enhancement mains renewal programmes to meet our WRMP leakage targets which will also need to increase significantly in AMP9 and beyond.

The image below sets out the assumed level of investment required under adverse climate, benign climate & adverse technology scenarios within our Long Term Delivery Strategy. The benign climate scenario represents our core pathway.

Figure 42 LTDS scenarios and Long Term investment impact



To support this and enhance our response and recovery capabilities in the short term, we have included investments in condition assessment and in situ monitoring to allow us to better manage the short term impacts of the failure of climate vulnerable assets. This level of asset monitoring builds on our AMP7 deployment of our industry leading Enhanced Pressure monitoring programme bringing high-speed pressure monitoring to our network. Our asset management maturity (as highlighted in Ofwat's AMMA) puts us in a good place in the industry begin delivering on this uptick of investment. For example, during AMP7, construction of our Strategic Interconnector Programme has given us great learning around the construction and commissioning of large volumes of water mains. This will aid our efficient delivery of Climate Vulnerable Mains in AMP8.

The multi-year Climate-Vulnerable Mains programme we have proposed is sizeable, even though it only addresses 75% of the mains we deem at risk from climate change. Were it to be too back-end loaded through AMPs 9 - 12, there would be both increased risks to customers as climate change accelerates as anticipated, and increased challenge in working with suppliers to deliver the scale of the programme, not least as other companies are also likely to be increasing their demands from this supply chain. The potential customer disruption from widescale intensive activity in the highway is also a key consideration. We judge therefore that the least regret approach is to make an immediate start, with the scope to calibrate the rest of the programme based on our AMP8 experience and developing knowledge of climate change risks. We have ruled out the most ambitious end of the scenarios we tested as posing too great a deliverability challenge but have settled on a significant programme of 688km within AMP8 which means that our water mains replacement overall will be a 392% increase (994km total AMP8 renewal) on the AMP7 run rate (202km).This will be challenging, but upfront discussions with our alliance delivery partners have given us confidence that this level of ambition is achievable.

Interaction with base expenditure

We have taken careful consideration of the activities which should be considered as base activities and those which represent enhancement. In this assessment, we have considered investments to be base maintenance where investment is made to address existing risks from hazards. We have considered investments to be enhancement where they are required to manage risks from hazards that are increasing and are outside of management control.

However, we recognise Ofwat's concerns to ensure customers are not asked to pay twice from both base and enhancement for the same activities. In AMP7 we have delivered less mains renewal than we anticipated in our PR19 business plan, with a corresponding increase in other maintenance activities. In recognition of the potential overlap between base and enhancement in this area, prior to the submission of our business plan we have challenged ourselves by removing £23m from our view of the efficient cost of delivery for our enhancement programme whilst still delivering the same benefit for customers in terms of Climate vulnerable mains length mitigated.

We believe this £23m of capex is equivalent to the cost sharing component of the difference in length of rehabilitation between our AMP7 forecasts and PR19 business plan. By challenging ourselves to achieve this additional stretching level of efficiency in AMP8, we are ensuring there is no risk that customers have been asked to pay twice for the same activity.

We project to continue our base mains renewal rate in AMP8 at the average of our AMP 7 renewal rate. We will continue to invest in network sensors and system optimisation and envisage that the capabilities resulting from our Ofwat Innovation project, "Safe, smart systems" will ensure that the constrained levels of base expenditure can be targeted in the most effective way. To support this and provide protection to our customers we have proposed a stretching improvement in our mains burst performance commitment (for more detail, please refer to the OUT1-7 data table commentary.

Table 59 Mains renewal activities split by base and enhancement expenditure

Base	Enhancement
PLC replacement	Mains renewal in response to catastrophic impacts of climate change
Mains renewal for deterioration	
ULB supply chain resilience. Some of the disinfection systems within Anglian Water rely on Hypochlorite liquid as a chlorine source. For some of these processes Bromates are a critical parameter that requires management. To do this Ultra Low Bromate Hypochlorite is used. The supply chain for this chemical is vulnerable to disruption and this investment would fund Anglian Waters part in the industry level response to this risk.	Investment to address increasing risk of asset flooding and raw water contamination that is an increasing risk with climate change.
Failures that are within management control	
Investment to address persistent issues	
Site emergency plans	
Maintenance of assets	
Risk assessments	

Base	Enhancement
Analytical improvements	

Long term context (historic)

Enhancement allowances have not previously been requested for the resilience of our mains network to climate change so there is no overlap or duplication of enhancement expenditure from previous price reviews. The requested funding for CVM is not related to their age, which would be base expenditure - the definition of climate vulnerable assets is taken from recently published independent academic research and is based on response to climatic shift and linked to soil type, material and diameter. This means that a main that was installed within the previous at any time with those characteristics would be climate vulnerable. In practice, we have updated our internal design standards to prevent the installation of any new water mains that would meet these criteria and only 0.15% of climate vulnerable mains are less than 30 years old. Therefore this enhancement case is not related to asset condition or deterioration, but on forward looking risk.

Long term context (future)

As identified in our Strategic Direction Statement, we are committed to making the East of England resilient to the risk of flooding and drought. Building on our SDS ambitions, the Resilience sub strategy in our LTDS sets out a long term strategy for enhancing customer resilience in all three identified investment areas, climate vulnerable mains, flooding and single point of failure. This is complemented by investments in our WRMP which continue to mitigate other resilience risks such as drought, growth and supply demand imbalances.

For climate vulnerable mains, our LTDS sets out a stepped profile for renewal, helping to aid affordability within AMP8 due to statutory environmental investments. Our LTDS sets out how we increase expenditure within AMPs 9 - 12, allowing us to mitigate the climate risk which is expected to be severe by 2060. We have also included additional scenarios around adverse climate and technology which will allow us to pivot our expected expenditure to meet emergent needs. Our AMP8 investment is low regret as it places us on the right trajectory to achieve our ambition in all tested scenarios. [22]

Customer support

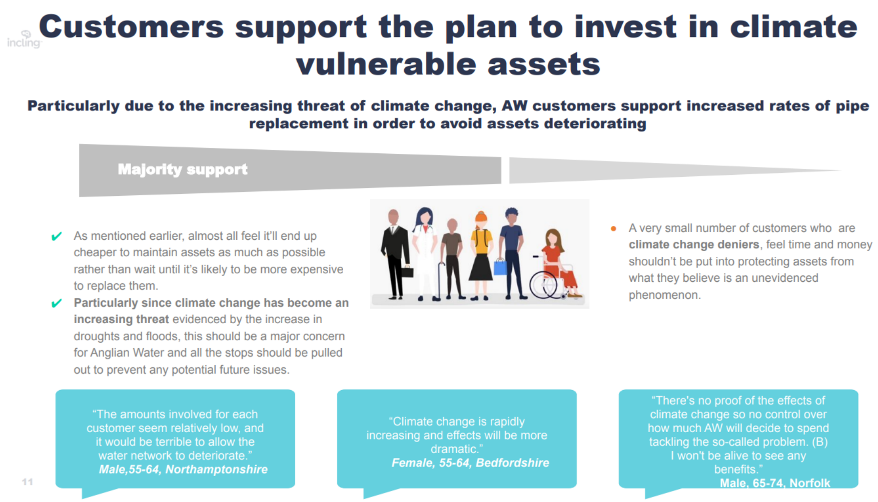
The resilience portfolio has been constructed with three main outcomes in mind, these are to protect the supply to the customers in terms of volume and reliability, to protect the quality of the water that is provided and to ensure that the first two outcomes are resilient to climate change. Indication from Anglian Waters customer engagement is that customers rate safe, high quality drinking water as the most important service that Anglian Water provides. Making the region resilient to flooding is within the customers top ten priorities. When asked where customers want Anglian Water to invest more Ensuring safe, high quality drinking water ranked 6th. Unplanned interruptions ranked 3rd in customers investment priorities.

Our customer engagement consistently shows customer support for the long-term and proactive view we are taking on the enhancement of climate vulnerable assets, ahead of their anticipated vulnerability to increasing threats from climate change. We have considered it particularly important to ensure that customer views inform the scale and timing of this investment.

We have engaged with customers at several levels on the need, scale and timing of investment on climate vulnerability.

We engaged with our Love Every drop online community about our approach to investing in climate vulnerable assets (See 96. Asset Health, conducted by Incling in our Customer Synthesis Report reference list for more detail). The image below show some of the key highlights from this research, in which customers highlighted that - particularly due to the increasing threat of climate change - they support increased rates of pipe renewal to avoid assets failing.

Figure 43 Online Community PR24 Asset Health research findings on climate vulnerable assets



22 For more detail, please refer to Section 2.2.4 'Resilience' in our LTDS.

Our Customer Board

Our Customer Board is a smaller, well-informed group of customers which have provided feedback on multiple areas of our plan. The image below shows the quantitative and qualitative feedback from this group on the pace of activity over the next 40 years, showing overall support for increasing the rate of renewal to allow this work to take place at a steady rate over this time period, rather than waiting until closer to the point at which issues will arise[23].

Figure 44 Extract from Customer Board survey July 2023

Comments included:

"Again it's never good putting off things. If there's a replacement program in place then carry it out"

"It's better to replace them now as if waiting who know more vulnerable mains could be found. Constant improvements are necessary"

"Again can this be done is a happy medium. Of course pipes need replacing and no-one wants leaks but both options sounds expensive in different ways. Can AW make a small increase to bills and keep replacing pipes but at a steadier rate?"

"We must do this, it seems a no brainer. It almost feels we should not be in this position and we should always have been doing this and not be facing this question"

Cost control

All of the resilience enhancement investments are driven by external risks which are outside of management control (climate change and resilience to single points of asset failure).

On CVM, the driver for investment is a combination of the impacts of climate change, the nature of the soils in our region and existing pipe materials. The pipe material installed would have been within management control when originally installed in line with best practice given available information at the time, but this was well before the potential impact of climate change on these soils was known. Our initial work on with WISPA and climate impacts of mains materials began in 2010 after partnering with world leading climate academic Dr Timothy Farewell and his wider climatic infrastructure consultancy, Maplesky and Cranfield University. However, the potential impacts only began to come to light within AMP6 however this was very much still theory. AMP7 has brought home the reality of these material types within class 5 & 6 soil types, and has exposed Anglian Water to significant climate related failure which has now prompted this investment.

We have followed all other water companies in its move from Cast Iron & Asbestos Cement distribution mains, to PVC and now to PE mains following best practice at the time of installation.

It is important to note, that all best scientific evidence suggests that the material properties of PE pipe installed as part of our approved installation methodology will help to mitigate the majority of climate vulnerability.

8.1.2 Unlocking greater value for customers, communities and the environment

Option consideration

Across our resilience investments we have sought to take a broad view of the potential options that could be delivered, factoring in the four R's of resistance, reliability, redundancy and response and recovery.

The range of options that we have considered for resilience investment has been informed by the approach we have taken to identifying the key risks facing our customers and the options we have available to address these risks. Our optioneering process has six capitals embedded as part of the process and therefore takes a holistic view of the benefits of all options available.

23 Survey undertaken 7 July 2023 reported in Synthesis v10 report 112.

Through this process we have identified a wide range of potential options which could be pursued. The tables below set out the options we have considered to addressing the risks identified in earlier sections:

Table 60 Options considered to address climate vulnerable assets

Climatic vulnerability	
Options considered	**Sub-options/ alternative scopes considered**
Upgrading existing mains within climate vulnerable soils to be more resilient.	Changing of diameters, changing of routes to exclude climate vulnerable routes, change of main material, Relining of sub-terranean climate vulnerable assets with structural liners (note: Due to technical & regulatory constraints, we expect to be able to utilise some of our innovative relining technologies at scale in the future. Our current plan is that this will form a core option from AMP9 onwards and has been factored into our LTDS[GH3]).
Increase of our I2S reactive restoration resource due to the short term and fast moving impacts of climate related events thus being reactive over proactive.	Increase in restoration resource & equipment, Increase in repair gang resource, additional distribution centers including critical spares.
Continuing to develop the industry understanding around climate vulnerability and sub-terranean water distribution assets including improving the predictability of failure and failure modes using the industry leading WISPA tool.	
An increase in pressure management due to the short term benefits of the investment in mitigating the impact of failure and extends the asset life.	

Cost-benefit appraisal

Our option consideration process identified a wide range of potential interventions which would help to mitigate the risks that we have identified as needing specific enhancement intervention. From these options we followed a robust cost-benefit appraisal process to arrive at the solutions we have assumed in our PR24 plan. This process takes into account the long-term resilience needs of the region, and also factors in the affordability and deliverability of the PR24 plan in the round , particularly in light of the significant scale of investment required for statutory schemes such as WRMP and WINEP. Below we set out the process that we have followed for each risk area.

Following in-depth analysis and optioneering, the only feasible option for removing the risk of climate on sub-terranean assets was mains renewal. As part of our investment optimisation process we have chosen an investment which provides significant benefit for our customers in AMP and also matches our AMP8 affordability challenge with WRMP & WINEP pressures. Further analysis and longer term timelines for CVM renewal can be found as part of our LTDS.

Environmental and social value

We have considered the environmental and social value of our Climate Vulnerable Mains investments as part of our options consideration process. In selecting options, we have considered the social and economic impact of repeat or prolonged service disruptions, environmental impact of flooding and the social impact of repeat traffic disruption.

We have developed a Value Framework, structured by the Six Capitals, which allows us to express benefits and disbenefits in a common language (£) for use in cost-benefit analysis and to inform our investment decisions. [24]

24 For more information on our value framework see chapter 7 Driving cost efficiency in our plan 2025-2030

The impact values within our Value Framework are made up of both private costs (e.g. costs to resolve an incident) and societal costs. Societal costs are derived through a robust Societal Valuation Programme considering a broad range of sources where customers' views, preferences and priorities are canvassed, analysed and incorporated into the values through a triangulation process.[25]

Investment benefits

Our climate vulnerable mains programme delivers benefits through avoided supply interruptions and leakage increases that would otherwise occur as a result of climate change. As it will take multiple AMPs to replace the majority of the vulnerable mains, attempting to stay ahead of the impact that would otherwise be felt, there is no net performance improvement for supply interruptions and only a minor benefit to leakage in AMP8 as a result of AMP8 investment.

We anticipate our climate vulnerable mains programme will deliver the majority of performance improvements in AMP8 against the Mains Repairs performance commitment. The benefits of this investment for PC performance is quantified in table CW15. The majority of the benefit of this investment is to offset adverse impacts of climate change and prevent a performance deterioration. Our PCL has been calibrated to account for the benefits delivered from enhancement, therefore reaching this target is dependent on this investment being granted in full.

Managing Uncertainty

We have given significant attention to the uncertainties relating to both cost and benefits delivery given the uncertainties that have been experienced during AMP7.

For climate vulnerable mains, there is an amount of cost uncertainty risk due to the scale of mains renewal we are looking to undertake in AMP8. For the first time, we are proposing large scale investment across both rural and urbanised environments. We are aware that dramatically increasing our mains renewal programme across our entire enhancement programme (CVM & Leakage) will provide a challenge in terms of deliverability to our alliance partners, especially against a potential backdrop of increased mains renewal rates from other UK water companies. Therefore, we are already in advanced discussions with our alliance partners around how to deliver the scale of investment required within AMP8. To aid affordability for our customers with the backdrop of the level of environmental investment required within our WINEP & WRMP, the reduced programme in AMP8 compared to future AMPs will enable a phased start for delivery alliances allowing them to ramp up to meet the delivery challenges of AMP8 and the aspirations set in our LTDS.

We have high certainty of the benefits of the climate resilient mains we propose to renew. Evidence shows that we have not seen failures due to climate in the PE pipe materials that we are replacing with. Our industry leading deterioration modelling has shown high correlation to actual asset failure and demonstrates that within the next 40 years, there is a high degree of certainty that these mains will need to be renewed or they will be experience premature failure due to the impacts of the changing climate directly impacting our customers through interruptions to supply and potential water quality impacts.

Our combined WISPA and Predictive analytics tools predict that there will be 3,200 bursts on climate vulnerable mains by 2060 if no proactive action is taken. As part of our LTDS, we have a multi-AMP strategy for this investment, this modular approach ensures that we are able to profile the financial impact upon customers whilst renewing the distribution mains which we believe will be first to fail.

External funding

Given that the investments we are proposing relate to Anglian Water assets and addressing the resilience needs of these to our customers, no third-party funding is assumed for this investment area.

Direct procurement

We have considered the suitability of each of our resilience investments for delivery through DPC, following Ofwat's guidance including the most recent guidance relating to Technical Discreteness. The single source of supply and asset flood resilience falls below the whole life cost threshold for DPC by default, and there is no opportunity for project bundling.

The climate vulnerability investment is a multi-AMP programme with a whole life cost which significantly exceeds the DPC-by-default threshold. However, as these are mains which are heavily integrated into our water supply network, and individual work packages fall below the above new test for project bundling, we have considered that the installation and/or operation of these mains would not be suitable for delivery through DPC.

Customer view

Options have been assessed according to feasibility and cost-benefit which includes customer valuations of the benefits provided by each alternative. As stated above, our customers support taking a proactive approach to managing risks to supplies such as those presented by climate vulnerable mains. As the solution options are limited, we've focussed mainly on timing and scale of investment.

25 For more information on customer insight see chapter 3 Customer engagement in our plan 2025-2030

[redacted]

[redacted]

[redacted]

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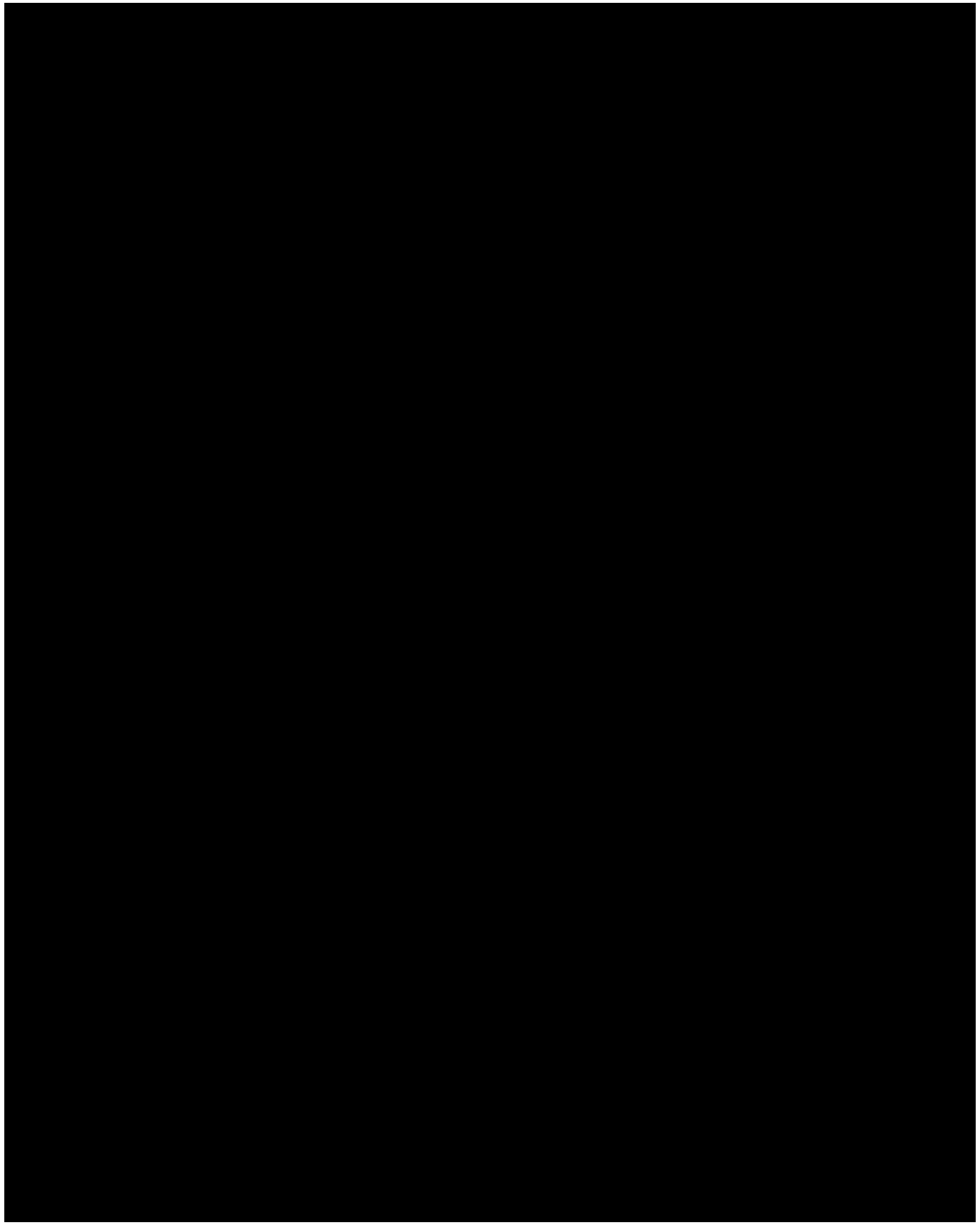
[redacted]



8.3 Asset flood resilience

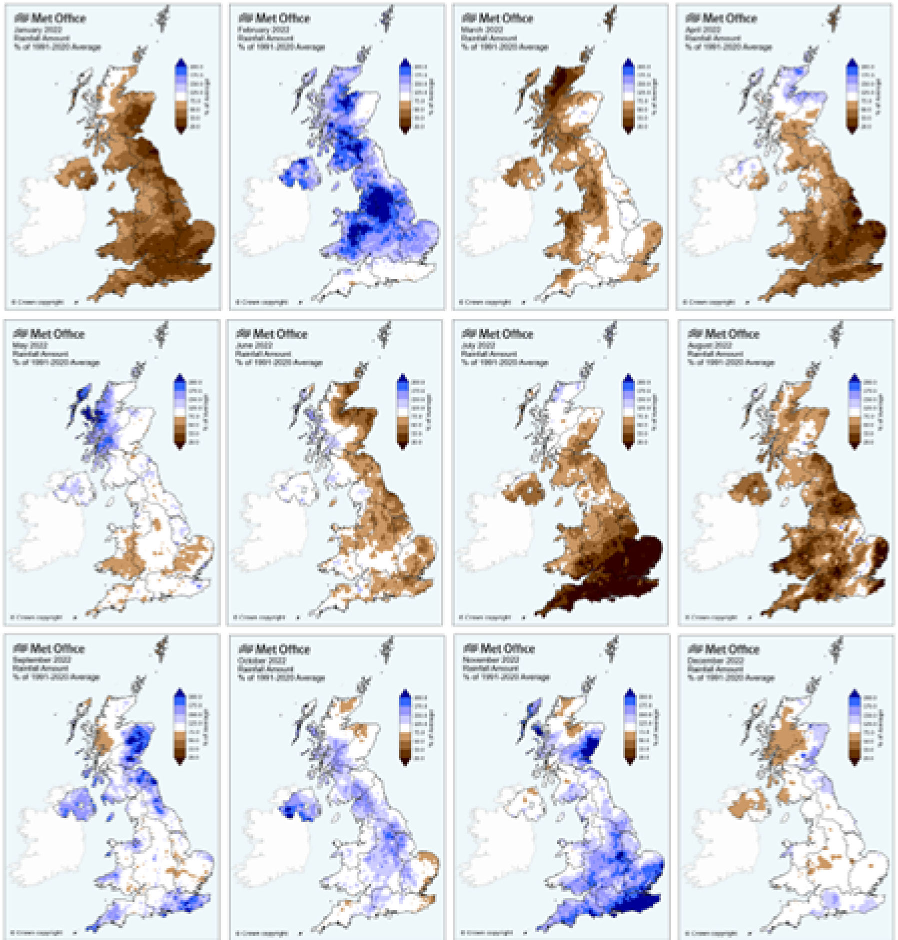
8.3.1 Delivering for the long term

Investment context

Enhancing asset flood resilience has been a key feature of our investment plans for PR14 and PR19 and needs to continue into the future as climate change understanding continues to improve. We have continued to explore the risks of pluvial and fluvial flood risk using the latest research.

The International Journal of Climatology (Volume 23 July 2023) indicates that the variability of the UK climate is increasing. As an example, 2022 included the wettest February on record but the remaining months of that year were particularly dry, with the driest summer since 1995. Over the period 2013-2022 winters have been 10% wetter than between 1991 and 2020 and 25% wetter than between 1961 and 1990. While the Anglian Region is a water stressed area there were two months (February and November) within 2022 where the monthly rainfall figures were well above the average calculated between 1991 and 2020. The Anglian Region experienced between 125% and 200% of those average rainfall figures. The remainder of that year presented rainfall figures that were between 20% and 100% of that average value.

Figure 48 Met Office rainfall variation between months



The variability of the climate is increasing with both hot dry spells and times of high precipitation. It is against this background that the investments within the water industry must be made. Not only is there a need to increase resilience to hot dry weather but also to shorter periods of unusually high precipitation.

As part of our resilience strategy, we have considered flooding investments that are designed to be low regret investments which remove the hazard of flooding under extremes of precipitation, that are becoming an increased risk, requiring enhanced levels of protection. Specifically, we need to ensure the security of our groundwater assets to prevent contamination of raw water resources for which we have a longstanding process in place of Catchment Risk Assessments for Groundwater Sources (CRAGS). This process identifies potential ingress of surface water into aquifers often via the borehole headworks and classifies each source according to the level of risk. Failing to protect these assets would lead to non-compliance with the Water Supply (Water Quality) Regulations 2000. Additional investment is required in 13 assets to ensure that they do not provide a pathway for contaminants to enter the groundwater system. This will reduce the risk of raw water contamination incidents. These boreholes have headplates that require raising to prevent a risk of ingress during flooding incidents. We have checked that these sites are not at risk of sustainability reductions in the future to ensure the investment is low regret.

Scale and timing

Unlike most areas of our PR24 enhancement programme, these resilience enhancements are not directly driven by statutory drivers with an AMP8 obligation date. This allows us to ensure that resilience investments across our LTDS timeframe are made at the right scale and at the right time, informed by a long-term view of affordability and deliverability.

The investments to mitigate the risk of flooding compromising aquifer quality, are relatively small in terms of cost but deliver huge benefits in preventing water quality incidents in the water supply. Safe, clean and reliable water supply is recorded as the primary concern of Anglian Waters customers and as such they are fully supportive of delivering this program in a timely manner within AMP8.

Interaction with base expenditure

We have taken careful consideration of the activities which should be considered as base activities and those which represent enhancement. In this assessment, we have considered investments to be base maintenance where investment is made to address existing risks from hazards. We have considered investments to be enhancement where they are required to manage risks from hazards that are increasing and are outside of management control.

Table 63 Wider resilience: base and enhancement activities

Base	Enhancement
PLC replacement	Mains renewal in response to catastrophic impacts of climate change

Base	Enhancement
Mains renewal for deterioration (rate of 0.13%)	
ULB supply chain resilience. Some of the disinfection systems within Anglian Water rely on Hypochlorite liquid as a chlorine source. For some of these processes Bromates are a critical parameter that requires management. To do this Ultra Low Bromate Hypochlorite is used. The supply chain for this chemical is vulnerable to disruption and this investment would fund Anglian Waters part in the industry level response to this risk.	Investment to address increasing risk of asset flooding and raw water contamination that is an increasing risk with climate change.
Failures that are within management control	
Investment to address persistent issues	
Site emergency plans	
Maintenance of assets	
Risk assessments	
Analytical improvements	

Long term context (historic)

During AMP7 we have a programme of work to reduce pluvial and fluvial flood risk which is increasing due to climate change. The investments included in our PR24 plan are in response to new risks which were not included in our PR19 Final Determination or any previous determinations so are not part of the historic base allowances.

Long term context (future)

The core adaptive pathway in our LTDS 'Resilience' sub strategy sets out a long term strategy for enhancing customer resilience related to asset flood protection. This is complemented by investments in our WRMP which continue to mitigate other resilience risks such as drought, growth and supply demand imbalances. [30]

Customer support

The resilience portfolio has been constructed with three main outcomes in mind, these are to protect the supply to the customers in terms of volume and reliability, to protect the quality of the water that is provided and to ensure that the first two outcomes are resilient to climate change. Indication from Anglian Waters customer engagement is that customers rate safe, high quality drinking water as the most important service that Anglian Water provides. Making the region resilient to flooding is within the customers top ten priorities. When asked where customers want Anglian Water to invest more Ensuring safe, high quality drinking water ranked 6th. Unplanned interruptions ranked 3rd in customers investment priorities.

Cost control

All of the resilience enhancement investments are driven by external risks which are outside of management control (climate change and resilience to single points of asset failure).

On asset flood risk, over many AMP cycles Anglian Water has assessed and remediated the risk of flooding from unusual weather patterns. In the past this work has included full site protection and has proved to be prudent investments for the prevailing climatic conditions. As the level of climate disturbance progresses however there is a greater need to ensure that any remaining vulnerable assets are protected and in AMP 8 it is proposed that this should take the form of flood protection for borehole. This approach is in line with our customer consultation results as it proactively protects both water quality and availability for the customer base mitigating the impacts of extreme and unpredictable weather events.

8.3.2 Unlocking greater value for customers, communities and the environment

Option consideration

Across our resilience investments we have sought to take a broad view of the potential options that could be delivered, factoring in the four R's of resistance, reliability, redundancy and response and recovery.

The range of options that we have considered for resilience investment has been informed by the approach we have taken to identifying the key risks facing our customers and the options we have available to address these risks. Our optioneering process has six capitals embedded as part of the process and therefore takes a holistic view of the benefits of all options available.

30 For more detail, please refer to section 2.2.4 'Resilience' in our LTDS

Through this process we have identified a wide range of potential options which could be pursued. The tables below set out the options we have considered to addressing the risks identified in earlier sections:

Table 64 Options assessment

Asset flood resilience	
Options considered	**Sub-options/ alternative scopes considered**
Do Nothing	No action taken on site to reduce the risk of flooding. Discounted as it does not reduce the risk to the customers water supply.
Raise the headworks	This is the selected alternative as it manages the risk to an acceptable level while exercising prudent financial control. It delivers the best benefit for the least expenditure of all the options
Replace the boreholes	While this would be an acceptable way of reducing the risk to the water supply it is a great deal more expensive and carbon hungry as a mitigation method. For most sites it was not a selected option due to this unjustified cost. The exception to this is Swaton where working on the existing bore poses a significant risk to safety and the decision was taken to drill and equip a new bore.

Cost-benefit appraisal

Our option consideration process identified a wide range of potential interventions which would help to mitigate the risks that we have identified as needing specific enhancement intervention. From these options we followed a robust cost-benefit appraisal process to arrive at the solutions we have assumed in our PR24 plan. This process takes into account the long-term resilience needs of the region, and also factors in the affordability and deliverability of the PR24 plan in the round , particularly in light of the significant scale of investment required for statutory schemes such as WRMP and WINEP. Below we set out the process that we have followed for each risk area.

There are two main ways of protecting an aquifer from contamination by flood water through below or at ground level headplates. The first is to raise the headplate above the potential flood level and the second is to drill and commission a new bore that meets all the current design standards and as such would be more flood resistant.

Raising the headplates is cheaper than drilling and commissioning new boreholes. It makes use of an existing asset while providing a good risk reduction. Headworks raising is lower in carbon than drilling and commissioning new bores and has the added advantage of maintaining the understood water quality of the production bore. Any new borehole that is drilled has a significant risk of vastly different raw water quality that could necessitate increased treatment interventions to comply with the required final water quality from the site.

Where a replacement bore is drilled it would require that the existing asset is decommissioned and backfilled and this will place an additional cost on the program.

For this program of work the option to raise the headworks has been selected where appropriate. The only exception to this is the resolution of the risk at Swaton. The current bore sits in the middle of a dual carriageway road and as such prolonged construction activity on site is not a safe option. For this reason, the option to construct a new bore outside of this area has been chosen at this site.

Environmental and social value

We have considered the environmental and social value of our asset flood resilience investments as part of our options consideration process.

We have developed a Value Framework, structured by the Six Capitals, which allows us to express benefits and disbenefits in a common language (£) for use in cost-benefit analysis and to inform our investment decisions.[31]

The impact values within our Value Framework are made up of both private costs (e.g. costs to resolve an incident) and societal costs. Societal costs are derived through a robust Societal Valuation Programme considering a broad range of sources where customers' views, preferences and priorities are canvassed, analysed and incorporated into the values through a triangulation process.[32]

31 For more information on our value framework see chapter 7 Driving cost efficiency in our plan 2025-2030
32 For more information on customer insight see chapter 3 Customer engagement in our plan 2025-2030

Investment benefits

This investment will support the mitigation against the impacts of surface flooding at 13 key water production assets including boreholes which are highly susceptible to flooding. This is to ensure that the impacts of heavy rainfall and sea level rise, both attributed to climate change, will be mitigated from in the medium to long term, ensuring we can provide a resilient supply of clean, safe drinking water to our customers.

Managing Uncertainty

We have given significant attention to the uncertainties relating to both cost and benefits delivery given the uncertainties that have been experienced during AMP7.

We have relatively high-cost certainty for those investments related to asset flood resilience. This is because the solution that we are proposing are both mature in terms of the technical competence, and have been delivered previously in prior AMPS. This allows us to have a high confidence in the cost & benefits attributed to these investments.

External funding

Given that the investments we are proposing relate to Anglian Water assets and addressing the resilience needs of these to our customers, no third-party funding is assumed for this investment area.

Direct procurement

We have considered the suitability of each of our resilience investments for delivery through DPC, following Ofwat's guidance including the most recent guidance relating to Technical Discreteness. The single source of supply and asset flood resilience falls below the whole life cost threshold for DPC by default, and there is no opportunity for project bundling.

Customer view

Options have been assessed according to feasibility and cost-benefit which includes customer valuations of the benefits provided by each alternative.

8.4 Cost efficiency

8.4.1 Developing costs

The development of the resilience costs in our plan follows our cost efficiency 'double lock' approach set out in chapter 7 Driving cost efficiencyof our business. plan. Through this approach we have ensured that are costs are efficient in their bottom-up build up, and this is cross-checked through external benchmark approaches. This section sets out how we have ensured cost efficiency of our resilience investments through step one of our double lock approach. Step 2 is explored in the benchmarking section 7.1 of chapter 7 of our Plan.

We have taken a robust approach to developing our resilience, building on our experience from delivering similar schemes into the bottom-up development of costs (before external cost benchmarking challenges are applied in step 2 of our 'double-lock' approach). The detail of the cost development approach is set out below, along with a breakdown of costs we provide in table CW3.

We derived our costs for each scheme by gathering on site by site data which influence the cost estimates for each site, including

- current operability
- Boreholes characteristics,
- Topography and surface types (i.e. roads, field, verge)
- Number of Crossing to major infrastructures (Railways, Rivers, Ditch)
- Construction techniques and applicable Materials
- Operability and connection to existing assets
- site specific requirements and
- assessment of construction constraints such as SSSI areas.

The outputs of Predictive Analytics allows us to ensure that cost estimates for CVM are based on realistic lengths and allows us to build cost based on virtual schemes of work rather than requiring specific schemes of work to be created as part of the PR24 process. This allows us flexibility within delivery to prioritise the most impactful mains for our customers and also be agile to emergent needs within the AMP that may arise from climactic events.

The key cost assumptions and estimations have been built using both the parametric models applicable to each asset and the on-site design information to inform our cost estimation for PR24.

We have continuously captured outturn costs data of all projects delivered in our capital investments including granular cost components such pumps, borehole , etc. These outturn costs have been the inputs to the parametric models to each specific assets. Building outturn costs into our cost assumptions in this way builds cost efficiency into the build up of costs.

The table below provides a breakdown of the Resilience costs provided in data table lines.

Table 65 AMP8 Investment overview

Investment ID	Project Name	Scope	Capital Cost £k	OPEX Cost (25-30) £000
I010479	Bramford no.1 Flooding	*Borehole Head raise Site specific *Replacement of flow meters, * pressure monitors and *sampling arrangements * Kiosk is required as the borehole is currently below ground level and will be exposed when raised	333	110
I010481	Bramford no.2 Flooding		215	
I010494	Westerfield BH 2 Flooding		129	
I010498	West Bradenham 2 Flooding		128	
I010504	Wellington A Flooding		245	
I019070	Beck Row Flooding		195	
I023214	Denton Lodge Borehole Flooding		348	
I040459	Hillington Chalk 1 Flooding		98	
I040461	Hillington Chalk 2 Flooding		215	
I040474	Southfields Bore 2 Flooding		25	
I040759	Wellington Plantation B Flooding		232	-3
I040761	Wellington Plantation D Flooding		232	-3
I018463	Swaton no.1 Borehole Flooding	Borehole Relocation *Pump (66kW) *Borehole shaft (depth 94.5 m) *Headworks and instruments *Kiosk to in house it *Water main connection; length 250m , diameter 100mm *Ancillaries (access road/path, landscaping, fence, telemetry relocation) *Decommission od existing borehole (Backfilling and make safe)	2,007	47
I010677	Cadney to Elsham Raw Water Main Resilience	339 m of Directional drilling at 4 locations - Diam 900mm	797	
I023085	Wicken Resilience (Ely)	3.5 km of water main - Diam 200mm	1,618	

[redacted]

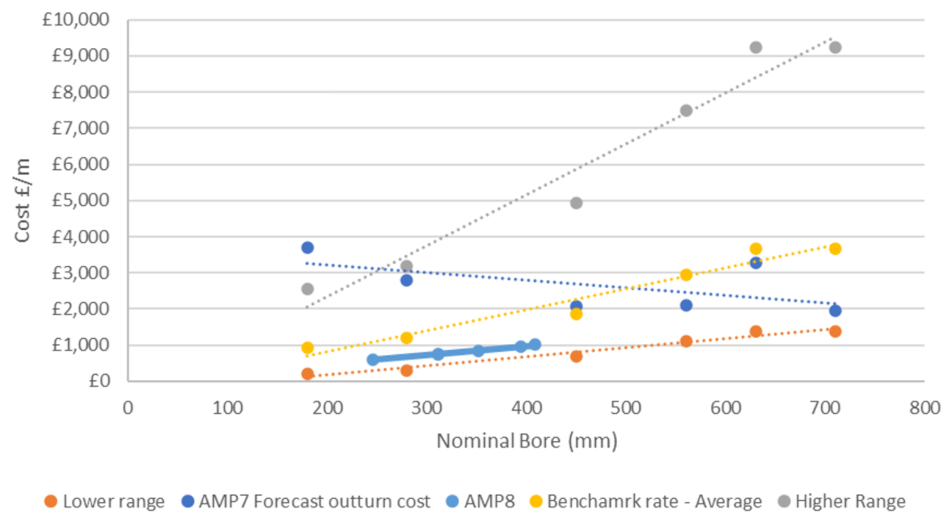
Investment ID	Project Name	Scope	Capital Cost £k	OPEX Cost (25-30) £000
I027411	Elsham WTW Cadney Intake Resilience	Replacement Weed Rake screen and associated valves	578	-4
I028139	Stuntney WR to Haddenham WT (Ely) Resilience	*Pumping Station 160 kW *9.5 km water main and fittings , diam 275mm *Ancillaries(access road, landscaping, fencing, telemetry)	6,883	55
I038864	East Harling WTW Resilience	*Pumping Station 34 kW *Standby generator *Surge protection *Ancillaries(access road, fencing, landscaping, telemetry)	2,192	5
I038865	PR24 Resilience - Bunwell WTW	*Pumping Station 52 kW *Standby generator *Surge protection *Ancillaries(access road, fencing, landscaping, telemetry)	2,850	24
I038860	West Bradenham WTW Resilience	*Pumping Station 12 kW *Standby generator *pipework and fitting to connect Water reservoir to Treated water main *upgraded of PLC, telecoms to enable control of connectivity *Ancillaries(access road, fencing, landscaping, telemetry)	3,704	9
I034533	Condition Monitoring-Resilience 2025-30	50 Pump condition monitors	208	-104
I034737	Critical Infra Xings Dual Mains-2025-30	6 Pressures loggers 1165 m of Directional drilling at 9 locations - Diam 300-500mm	1,553	1
I039346	CV - Incr Pressure Monitoring	1033 Pressure loggers	3,614	
I040210	CV Regional Overheating Protection RW	20 Fans, vents, PLC, Temperature Monitor	1,149	45
I040278	CV - Reg Temp Related Asset Failure WTW	8 Fans, vents, PLC, Temperature Monitor	711	19
I040279	CV - Region Temp Related Asset Failure TWD	24 Fans, vents, PLC, Temperature Monitor	955	104
I040378	CV - Climate Vulnerable Mains	*623 km of Water main and fittings *311 Hi-Speed 1 Second Logger installed every 2km of renewal *623 Hydrophone installed every KM of renewal	182,338	
I039050	CV-Condition & Criticality Investigation Water		1,651	
I039350	CV - Modelling Vulnerable Mains		2,020	

Investment ID	Project Name	Scope	Capital Cost £k	OPEX Cost (25-30) £000
I010670	Raw Water Cloves Bridge **Multidriver scheme 50% allocated in Water WINEP** NOTE: Total value £20,121k is expected to be start design at the end of AMP8	*UV unit 63MLD *5.5 km water main 900mm NB *Pumps, pipes, valves upgrades *Building *Standby generator	971	
I039039	AW Raw Water End to End Metering		1,780	
		Total	**238,012**	**305**

8.4.2 Benchmarking

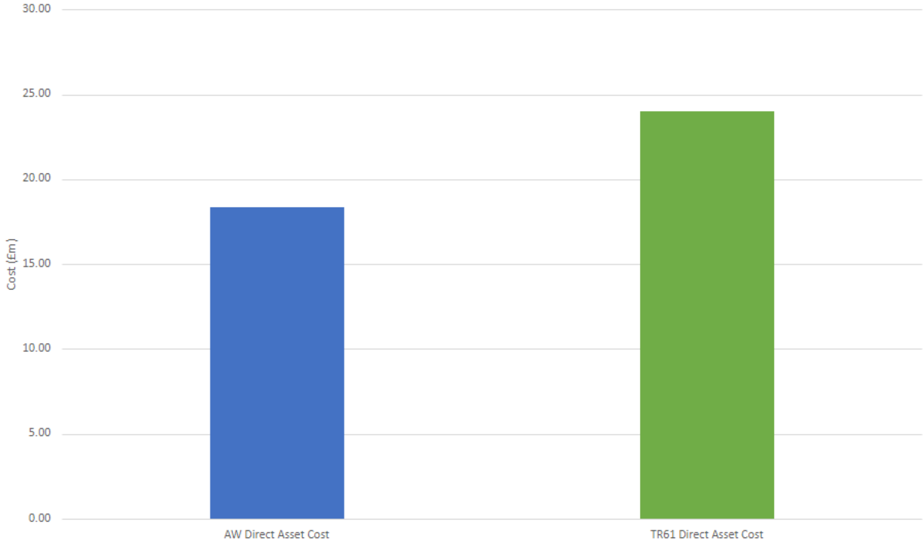
Water main accounts for 91% of the direct asset costs of this programme, the benchmarking findings from our interconnectors investments also provide assurance on the efficiency of our pipes estimated in the Resilience side, as both use the same approach in the build up of the bottom up cost estimates. We have used the analysis of unit rate to benchmark the overall AMP8 unit rate calculated at each scheme in the programme, this can be seen in the graph below.

Figure 49 Overall benchmarking of rates: RPPE



10% of the water main cost is for micro tunnelling alone. This has been benchmarked against the parametric models built by WRCs TR61, *Final Summary of TR61 V15 Infrastructure Model Results (with basic calculator) Locked.xls*. The result of this was Anglian Water's parametric models were 21% below the TR61 models

Figure 50 Water main (all construction techniques) to industry data WRC TR61



In light of the evidence presented above and on account of all the water main schemes scope in these programme are the same nature, we have confidence that the costs we have estimated for our PR24 programme present an efficient rate.

[redacted]

Our costs have been developed using outturn cost data and cost modelling within our C55 system which has been assured by Jacobs.

33 ANX ANH37

8.5 Customer protection

Our plan includes a price control deliverable on Climate Vulnerable Mains which is explicitly linked to the climate vulnerability enhancement investments highlighted above. The PCD relates to the percentage of our potable water supply network classed as climate vulnerable.

Our asset flood resilience and single source of supply investments fall below the cost materiality threshold for PCD consideration, and so we have not included a PCD to cover these investments.

For more detail on our Climate Vulnerable Mains PCD, please refer to the appendix 'Price Control Deliverables'[33]

9 Odour and resilience (water recycling)

Overview

- This investment is targeted at addressing customer dissatisfaction with odours arising from our operations at Water Recycling Centres.
- We also will invest to improve the resilience of our water recycling assets to pluvial and fluvial flooding.
- This investment will deliver improvements at locations identified by WATS (Wastewater Aerobic/Anaerobic Transformations in Sewers) modelling during AMP7 in addition to those identified through AMP8 modelling, supported by investment in catchment septicity monitoring. In addition, we include investment for low/medium complexity odour control solutions at a variety of locations and settings.
- Options are severely limited in odour and septicity reduction . The primary options are bioaeration or chemical dosing. There are some alternative options such as air injection or iron dosing, but as these are still under assessment or not feasible under all circumstances therefore these have not been proposed as part of the baseline submission.

Table 66 Investment Summary

PR24 costs (£m)	
Capex	13.5
Opex	1.4
Totex	14.9
Benchmarking	
Method	Scheme outturn costs
Findings	Odour costs have reduced by 24% since PR19, and savings through economies of scale have been identified for water recycling resilience.
Customer Protection	
CMEX	
Ofwat data table	
CWW3.165-CWW3.167	Odour and other nuisance
CWW3.168-CWW1.170	Resilience

9.1 Delivering for the long term

9.1.1 Investment context

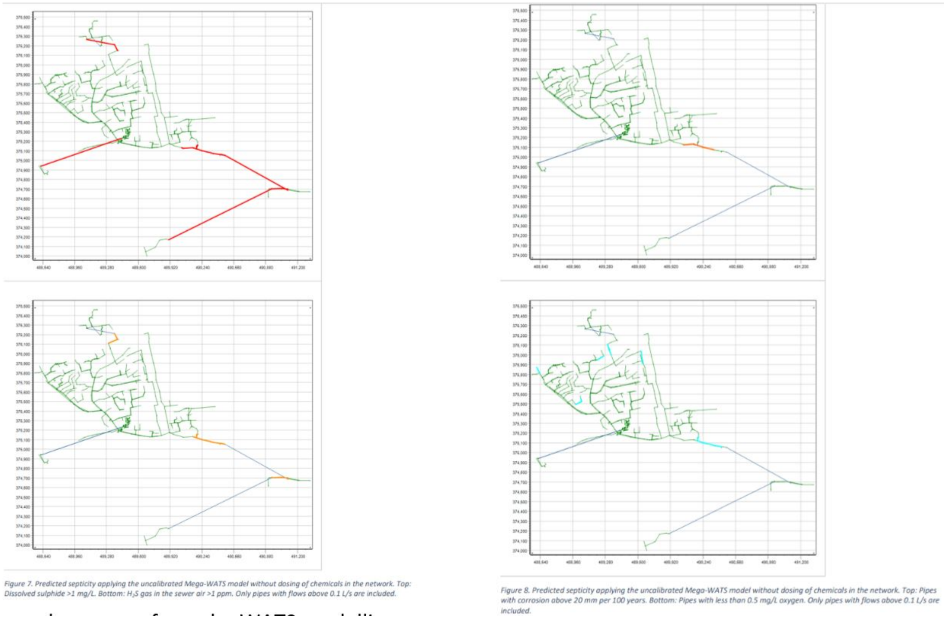
This investment is targeted at addressing customer dissatisfaction with odours arising from our operations at Water Recycling Centres. As a measure of customer dissatisfaction, we aim to hold the number of odour complaints to the 2023 APR value of 3,603 complaints per year. Despite our stable profile for odour complaints in AMP7, further enhancement expenditure is required in AMP8 to prevent customer dissatisfaction rising as we are expecting these to trend upward over the next few years for reasons including:

- Increased population growth increasing both expected frequency and chance of incidents leading to a complaint
- New build/developments occurring closer to AW sites, closer to where it may impact customers
- Projected impact of climate change: higher average temperatures in the future will result in increased levels of septicity in the network compared to now, which in turn create new odour risk hotspots and require new odour treatment to control
- Overall increasing industry expectations on customer complaints of any nature (of which odour are a part). Our ambition is to be a top performing company and in order to achieve this, high CMEX scores are required. As other water companies will keep improving their performance, this will naturally raise customer expectations surrounding this in an indirect manner as well.

Although there are no legally binding drivers currently associated with odour complaints specifically, our customer insight captured within our Customer Synthesis Report shows that our customers think nuisance from odours is unacceptable. We are held account on this, as the number of complaints is associated with the company's CMEX score , which is a measure Anglian Water are committed to improving in our target to become a 4* EPA rated company.

In AMP7, we have strived to become more efficient and strategic in our approach to odour investment and take a more holistic view of odour control. Septicity & odour issues usually manifest at the Water Recycling Centre (WRC), however the root cause of the issue is often earlier on in the process either in the sewerage network or pumping station. We have enhanced our catchment-based approach to solving septicity and odour issues through the innovative use of WATS modelling (Wastewater Aerobic/Anaerobic Transformations in Sewers) to identify the root causes of septicity and scope out appropriate solutions for the long term protection of assets and control of odour. In AMP8, we will continue this strategy to manage odour and septicity risk.

Figure 51 Example outputs from the WATS modelling uncalibrated simulations highlighting predicted assets at risk of odour



WATS modelling also carries the benefit of identifying best locations to dose in order to achieve maximum possible coverage of network protection. This has had the effect of increasing the efficiency of solutions and minimising the required number of assets to deliver the same required benefit.

To achieve this, in AMP8 we must:

- Improve the monitoring capabilities in particular catchments that are struggling with odour and septicity issues. This will help clarify root causes and better quantify ongoing/new risks
- Deliver improvements to address new odour and septicity issues identified by our WATS modelling in AMP7 and our planned modelling in AMP8
- Deliver improvements on a proactive but demand driven basis as identified through our normal BAU prioritisation process (these risks will be separate to those identified from WATS modelling)

9.1.2 Scale and timing

Our AMP8 odour reduction programme balances the need to invest to address the potential impact on customers living close to WRCs with the affordability of the odour and overall AMP8 enhancement programmes.

This investment will deliver not only improvements at locations identified by WATS modelling during AMP7 but also those identified through AMP8 modelling, supported by investment in catchment septicity monitoring.

In addition, we include investment for low/medium complexity odour control solutions at a variety of locations and settings. This parcel is a reactive response to problems as they emerge and will take its priorities from risks raised by operational teams directly as a result of customer contacts and not via our proactive WATS modelling.

Further enhancement for AMP8 will be required to maintain the current figure of 3,603 complaints per year as mentioned previously, since an upwards trend of complaints is expected without further investment. Currently, there is no option of deferment available without further adversely impacting customers.

All investments submitted have alternative options that allow for a flexible approach/pathway as needed if circumstances surrounding the social, technological or environmental circumstances should change in the next AMP beyond the current baseline.

Our Water Recycling resilience investment is required to provide protection to our Water Recycling assets against pluvial and fluvial flood risk. This investment will increase the resilience of our assets to ensure that they can continue to operate in flood conditions. The selected sites require investment in 2025-30 rather than later point in time as modelling indicates these sites are at high risk of flooding in AMP8. We also propose to invest where required to comply with the expansion of the Reservoir Act.

9.1.3 Interaction with base expenditure

To our knowledge this investment does not interact with base expenditure except to account for some operational expenditure that will be delivered via existing base maintenance arrangements (e.g. new sensors or dosing rig maintenance requirements will be included within the existing operational budgets for pumping stations or WRC receiving these items).

This investment is enhancement expenditure as it delivers improvements to air quality in our region.

Given the exogenous factors outlined in previous sections, it is important to note that this investment only addresses the enhancement portion of the risks and that a maintenance programme for odour and septicity is also expected.

Maintenance options such as replacement of at risk sewers, sacrificial layer relining, adequate vent stack provision and pigging for example can be used to contribute a proportion of the stable odour complaints profile that the business has put forward. These activities delivered from base alone are however, not sufficient in maintaining current levels of customer satisfaction, requiring continued investment at levels similar to our AMP7 programme .

Table 67 Odour activities split between base and enhancement expenditure

Base	Enhancement
Maintenance of assets expected to happen via existing base costs of PS's and WRC's. No separate allowance calculated as impact expected to be minimal.	Catchment odour and septicity risk identification (modelling only)
	Catchment odour and septicity risk controls. New chem dosing/power requirements will become base in AMP9.
	Odour enhancements; (new chem dosing/power/maintenance requirements will become base in AMP9)
	Catchment level septicity monitoring will deliver additional monitoring in the network and not just H2S (ORP, pH etc)

For water recycling resilience investments during AMP7, we have invested in the following sites to improve the resilience of our assets to pluvial and fluvial flooding. There is no overlap between these sites and those included for investment in AMP8.

Table 68 Sites with investment for water recycling resilience in AMP7

AMP7 year	Site where we have invested in AMP7
Y2	Kingscliffe WRC
Y3	St Ives Somersham Road TPS - Fluvial Flood Protection St Ives the Quay SP - Fluvial Flood Protection St Ives the Waits SP - Fluvial Flood Protection Somersham WRC (SOMEST) site flooding from adjacent land and watercourses Anwick flood defence Purleigh STW - kiosk floods in wet weather, no site drainage, electric panels at risk Bletchley Manor Field SP - Wet Well and Overflow Screen Chamber Fluvial Flood Risk Broadholme WRC (BROAST) - Site Flooding - Inlet 1 Control Room Corby WRC (CORBST) - Site Flooding - Workshop and Inlet Pump Station

9.1.4 Long term context (historic)

Our PR24 odour and water recycling resilience investments build upon the investments we have made in AMP7 and address the emerging AMP8 need drivers highlighted in section 9.1.1.

9.1.5 Long term context (future)

All investments submitted have alternative options that allow for a flexible approach/pathway as needed if circumstances surrounding the social, technological or environmental circumstances should change in AMP8 beyond the current projected baseline.

Our current strategy ensures a stable baseline position for AMP9 and no deterioration in the current customer experience. We have forecast the investment required to maintain stable performance from AMP9 onwards in our LTDS .

Should circumstances or legislation change, the company will retain a reasonable position to increase resource focus on this measure. [34]

34 Please refer to Section 2.2.6 'Drainage and water recycling' in our LTDS for more detail.

9.1.6 Customer support

The company posits that customer support is self evident in this area, as customer complaints are a direct measure of customer satisfaction. Since the proposed profile for AMP8 is flat, this would be in line with reasonable expectations from existing customers that the situation does not at least deteriorate over the next 5 years.

Indirectly, the industry standards surrounding CMEX, the 4* EPA rating and our ambitions to become a high performing company, compel us to continue to invest in this area even if customers would personally identify odour as a lower priority compared to other issues. Also, customer expectations are likely to rise indirectly given that other water companies will be incentivised to raise the overall performance bar when it comes to dealing with customer complaints, in order to secure top performing positions.

Lastly, this investment will have wider benefits related to pollution and possibly flooding, by proactively preventing large critical failures in the network, which can again directly benefit customers (and for which, separately, support is expected to be much higher).

9.1.7 Cost control

Only previously proven solutions (e.g. based on AMP7 experience) were put forward as options for the investment programme to reduce cost uncertainty, but also provide the maximum amount of least regret investment possible.

Where possible AMP7 cost/delivery profiles were used to provide the baseline information for the AMP8 profiles and our relatively stable level of investment proposed across all years has been put forward deliberately to reduce potential supplier/logistical complications associated with a start/end heavy spend profile (e.g. market bottlenecks with regards to component/material sourcing, internal resources/timing available to deliver modelling).

In this area, potential cost savings are primarily either modelling/monitoring driven (I.e. savings become identified at a later stage after these additional investments get carried out) or identified via the feasibility process (e.g. specific technologies that may be applicable or become available between draft submission and delivery).

As such, these generally cannot be quantified or accounted for at this stage.

9.2 Unlocking greater value for customers, communities and the environment

9.2.1 Option consideration

Options are severely limited in odour and septicity reduction as although there are some alternative options such as air injection or iron dosing, but as these are still under assessment or not feasible under all circumstances (I.e. no cost model developed, limited use that may not feasible). As such, these have not been proposed as part of the baseline submission. Therefore our remaining options are primarily either bioaeration or chemical dosing.

Generally speaking, we have followed the AMP7 approach as the strategy is based on the same principles just with updated values/numbers.

The following table sets out our unconstrained options (any option available to address odour and septicity) and the feasible options (those that can achieve the required outcome).

Table 69 Summary of feasible options for addressing odour and septicity

No.	Option	Description	Unconstrained	Feasible
1	Bioaeration	Standard proven option	Yes	Yes
2	Nitrate Dosing	Standard proven option	Yes	Yes
3	Monitoring	There are no alternative options to monitoring of specific parameters, but different locations and combination of parameters (e.g. WRC or network) were considered	Yes	Yes
4	WATS modelling	Prescriptive in nature	Yes	Yes
5	Hydrogen peroxide, hypochlorite dosing, chlorine, ozone	Under assessment, not widely applicable may be unfeasible. Significant H&S risks that are too high compared to standard options	Yes	
6	Air Injection	Under assessment, not widely applicable may be unfeasible.	Yes	
7	Iron Dosing	Under assessment, not widely applicable may be unfeasible	Yes	
8	Oxygen injection	Under assessment, not widely applicable may be unfeasible	Yes	

9.2.2 Cost-benefit appraisal

Table 70 Justification for selection of feasible options

No	Option	Feasible?	Justification
1	Bioaeration	Yes	Cost model available in cost estimation tool so there is enough cost capture confidence available. Historic proven success in AMP7.
2	Nitrate dosing	Yes	Cost model available in cost estimation tool so there is enough cost capture confidence available. Historic proven success for the last few AMPs.
3	Monitoring	Yes	Cost models available for most of the parameters in cost estimation tool, so there is enough cost capture confidence available. Quotes used for anything not currently cost captured . Historic proven success.
4	WATS modelling	Yes	Historic proven success in AMP7.

We will prioritise sites on the following criteria:

- The historic number of complaints
- The H2S score of the catchment (overall septicity risk of the catchment)
- Whether the receiving WRC has an odour abatement notice
- The chemical costs of the catchment (opex costs)
- Historical CCTV/survey/failure risk of network/WRC assets (e.g. corrosion damage already occurred, rate of corrosion identified or projected etc)

For investment to improve the resilience of our assets to pluvial and fluvial flooding, we have selected sites based on modelled data combined with observed date on site, prioritising sites where flooding has been experienced previously.

9.2.3 Environmental and social value

The limited number of available feasible options at this early stage precludes a comparison. The best value option and the least cost one are one and the same for all investments proposed.

Baseline carbon figures and operational expenditure associated with the installation of assets proposed have been taken into account either through existing cost models or manual adjustments in C55.

The variation in options/alternatives for this programme is based on estimated required quantities/risk delivered instead of different scoping approaches.

Further comparison will be available approaching feasibility/delivery, where our Risk, Opportunity and Value sessions can help identify alternatives that might be lower in carbon or that might drive additional cost or 6 capital benefits.

9.2.4 Investment benefits

These investments all have trackable benefits and value measures associated with them. This investment will have a positive impact on our performance on the C-MeX performance commitment, which measures customers satisfaction.

Water recycling resilience investment will benefit customers by ensuring we are still able to carry out of water recycling functions at sites experiencing an inundation of water from the coast or rivers.

9.2.5 Managing uncertainty

The uncertainty has been minimised/managed by only promoting known historically successful and feasible options that are similar in scope and numbers to our AMP7 programme.

Modular options for these are not available, as control of odour issues requires ongoing protection/management, rather than one off risk reduction interventions that can be spaced out or easily deferred into future AMPs (deferment in this case will result in further asset deterioration without any tangible benefits, as very often the temporary mitigation involves the same scope of setting up a chem dosing rig to dose as well or the installation of bioaeration etc).

9.2.6 External funding

WE do not expect to receive third part funding for investments in odour and water recycling resilience.

9.2.7 Direct procurement

This investment is below the size and discreetness required to qualify for consideration for DPC.

9.2.8 Customer view

Options have been assessed according to feasibility and cost-benefit which includes customer valuations of the benefits provided by each alternative.

9.3 Cost efficiency

9.3.1 Developing costs

The development of the odour and resilience costs in our plan follows our cost efficiency 'double lock' approach set out in chapter 7 of our business. plan. Through this approach we have ensured that are costs are efficient in their bottom-up build up, and this is cross-checked through external benchmark approaches. This section sets out how we have ensured cost efficiency of our odour and resilience investments through step one of our double lock approach. Step 2 is explored in the Benchmarking section below.

We have taken a robust approach to developing our odour and resilience, building on our experience from delivering similar schemes into the bottom-up development of costs (before external cost benchmarking challenges are applied in step 2 of our 'double-lock' approach). The detail of the cost development approach is set out below, along with a breakdown of costs we provide in table CWW3.

Odour

We derived our total cost estimation for each scheme by gathering on propose location basis data which influence the cost estimates for each scheme, including;

- monitoring of odour related parameters (pH, H2S, temperature, oxidation reduction potential etc)
- existing site capacity and process
- the installation of chem dosing rigs for network protection or bioaeration (bubbletec)
- Operability and connection to existing assets
- existing OCU expansion where relevant or applicable (PS's or WRC's)
- site specific requirements
- modelling of catchments for odour/septicity risk (WATS modelling)

Table 71 AMP8 odour investment summary

Investment ID	Investment Name	Scope	Odour Control Quantity	Capital Cost AMP8 £k	OPEX Cost (25-30) £k
various	Catchment level odour/sept control	Calcium Nitrate Odour Control	25	959	437
various	Catchment level septicity monitoring	*Monitors *telemetry	125	2,216	24
various	Named odour enhancements (simple)	*Bioaeration *Calcium Nitrate Odour Control *Telemetry	25	1,831	662
various	Named odour enhancements (complex)	*Bioaeration *Calcium Nitrate Odour Control *Tank Cover *Fan *Telemetry	10	1,844	312
various	Catchment Odour and septicity risk id	Catchment Odour modelling to understanding Odour & Septicity/Corrosion. WATs modelling on 5 catchments during the AMP.		492	
			Total	**7,342**	**1,435**

Water recycling resilience

For the Expansion of Reservoir Act investments cost estimation was carried out by gathering location based data on cost drivers for each scheme, including:

- using our knowledge of the additional inspection frequencies (labour costs and costs of drain downs)
- additional maintenance needs (arising from these additional inspections)
- safety enhancements (provision and freeing of existing valves to make them safer), we have estimated the additional costs relative to the consequences posed to public safety by these structures x a suitable probability

This has been costed using Anglian Water's parametric cost models.

The Climate Vulnerability investment was scoped to understand the asset health and life of the rising mains. The cost has been built up from supplier quotes as there are no cost models for trial holes and surveys.

Table 72 Water recycling resilience AMP8 investments

Investment ID	Investment Name	Scope	Capital Cost AMP8 £m	OPEX Cost (25-30) £m
I039196	WR Networks - Expansion of Res Act	*upgrading Valve *Embankment enhancements	354	8.25
I039198	Bioresources/Sewage -Expansion of Res Act	*upgrading Valve *Platform & ladder	47	7.33
I039199	Sewage Treatment - Expansion of Res Act	*upgrading Valve *Embankment enhancements	593	4.50

Investment ID	Investment Name	Scope	Capital Cost AMP8 £m	OPEX Cost (25-30) £m
I041181	CV-Condition & Criticality Investigation WR	*10 trial holes Low Resolution surveys and analysis	1,718	-
I038882	AMP8 Pluvial and fluvial flood resilience	Installation of a number of flood protection options which include a range of earth embankment, flood wall, demountable defences	3.412	-
		Total	6,123	20.08

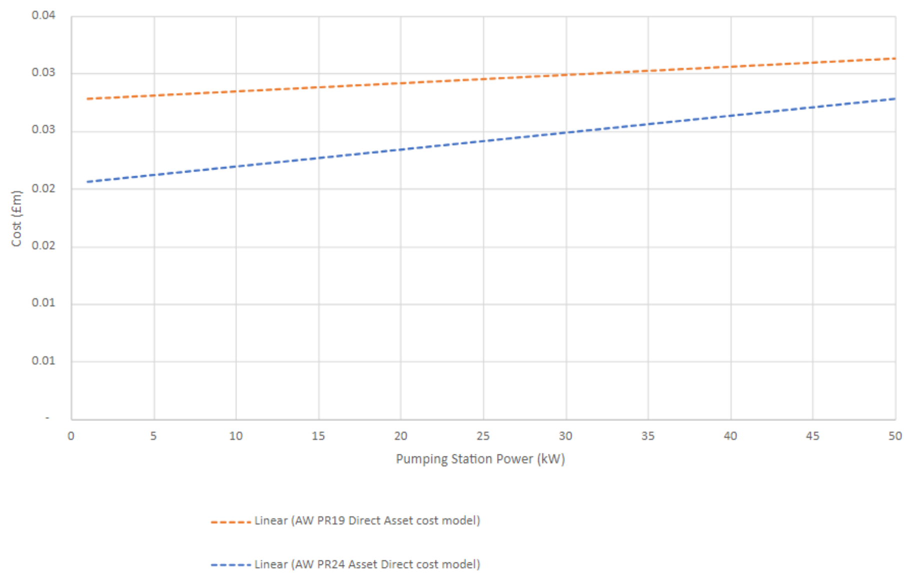
9.3.2 Benchmarking

In stage 2 of our cost efficiency 'double-lock' on Odour and water recycling resilience, we have embedded efficiency into our costs using scheme outturn costs

The Odour investments include assets such as Calcium Nitrate Dosing, monitors, telemetry and Bioaeration units. On these assets, during AMP7 we have been working on strategies that ensure efficiencies are achieved and embedded in our cost model.

The following graph shows the forecast unit rate based on our historic cost compared to our PR19 parametric direct cost for chemical dosing for odour control demonstrates that the costs are reduced by 24%.

Figure 52 Odour control chemical dosing - direct asset costs benchmarking with AW PR19 model



The water recycling resilience investments include enhancements to the reservoir embankments and upgrading valves as well as trial holes and surveys. We have used our cost models to ensure that the economies of scale are achieved through the delivery of these assets in other programmes are embedded in the estimations.

9.3.3 Assurance

The development of our costs within our cost estimation system (C55) have been assured by Jacobs. Our cost estimation process was assured by Arup.

9.4 Customer protection

We have not proposed an additional PCD for this investment as it falls well below the materiality threshold for PCDs. We are in part held account for our performance on odour through the C-MeX measure of customer experience.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

11 Addressing raw water deterioration

Overview

Delivering safe, clean water is the most vital service we offer, therefore we need to protect our customers from increasing nitrate levels in our raw water sources. Our nitrate concentration prediction models indicate that nitrate concentrations in some raw water sources will soon reach a point beyond which current treatment solutions at each site will be unable to ensure compliance with the Drinking Water Inspectorate's nitrate standard of 50 mg/l.

To make sure we continue to comply with this standard, we will invest at 12 new and upgraded water treatment works to protect 730,016 customers from changes in water quality due to rising nitrate levels in raw water

We considered a broad range of options to address nitrates. We select the installation or uprating of ion exchange plants for all sites as this a proven technology for nitrate removal.

We are also working to better understand the potential impact of poly-fluorinated alkyl substances (PFAS) compounds on the environment and health.

As agreed with the DWI, we will invest to upgrade water treatment works to protect customers from the risk of 'forever chemicals' (PFAS) in water and investigate how we can help tackle the issue in the long term.

After considering a range of options, we select replacement of granular activated carbon (GAC) with virgin carbon as our preferred solution as this offers the most robust reduction in risk from PFAS, as found by Cranfield University.

For nitrates, we have sought assurance on the efficiency on the costs of the ion exchange plants through by benchmarking to the models build by WRCs TR61 which has demonstrated that our costs are on average cost lower of 47% lower than the benchmark on a cost/ Ml/d flow rate basis.

Table 82 Investment Summary

PR24 costs (£m)	
Capex	181.0
Opex	6.3
Totex	187.3
Benchmarking	
Method	Scheme outturn costs Industry models from TR61
Findings	In the process of cost benchmarking we identified efficiencies on nitrate removal which resulted in a £21m reduction in our costs. Subsequent benchmarking showed our costs to be efficient.
Customer Protection	
Price Control Deliverable	Water quality (Nitrates) - Number of DWI Reg 28 notices Water quality (PFAS) - Number of DWI Reg 28 notices
Ofwat data table	
CW3.97-CW3.99	(Addressing raw water quality deterioration)
CW3.132-CW3.133	(PFAS)

11.1 Nitrates

11.1.1 Delivering for the long term

Investment context

Our raw water deterioration enhancement programme focusses on reducing the level of nitrates and PFAS in drinking water. The scale and pace of investment is driven by a requirement to meet regulatory standards in the Water Supply (Water Quality) Regulations 2016 (as amended).. We are committed to mitigating risks to delivering safe, clean drinking water from source to tap by addressing emerging challenges through our long-term planning approach. As demonstrated by our collated customer insight captured within our Customer Synthesis Report, (in section 'Customer's priorities - safety vs aesthetics') customers view that delivering safe, clean water is the most vital service we offer, and is one of our ten Strategic Direction Statement (SDS) long-term outcomes.

We have received DWI Letters Of Support (LOS) for all 12 nitrateschemes [36]. Additionally, we have also received a letter of support from the Environment Agency that investment in nitrate treatment is required.

To ensure we continue to provide safe, clean drinking water, we must protect our customers from increasing nitrate levels in our raw water sources through compliance with the drinking water nitrate standard of 50 mg/l. Concentrated nitrates in drinking water poses consequences for human health. The proposed investment is to prevent deterioration of raw water impacting on the potable supply to customers thereby ensuring compliance with this standard at the following twelve sites[1]

- Clay Hill WTW
- Congham WTW
- Houghton St Giles WTW
- Lyng Forge WTW
- Marham WTW
- North Pickenham WTW
- Nunnery Lodge WS / Barnham Cross WTW
- Ringstead WR
- Risby WTW
- Ryston WTW
- Two Mile Bottom WTW
- Twelve Acre Wood WTW

The need for compliance with this standard is due to the long-term emerging needs driven by environmental factors (e.g. due to rising peaks in nitrate concentrations in raw water from intense historical agricultural activity and latterly atypical nitrate values resulting from high rainfall events and aquifer recharge).

Increasing nitrate levels in a number of our groundwater sources continues be a significant risk, showing that the peak nitrate levels within the aquifer have not yet been reached. The impacts of climate change are also being observed as shown by atypical high nitrate values in some of our groundwater sources, for example following heavy rainfall events.

Scale and timing

Our nitrate concentration prediction models indicates that nitrate concentration in some raw water sources will reach a point beyond which we will be unable to ensure compliance with the drinking water nitrate standard of 50 mg/l. This is not due to our blending activities or treatment solutions lagging behind, but instead due to factors outside our control. For instance, we have observed atypical peaks in the levels of nitrates recorded in some aquifers in recent years driven predominately due to run off in periods of high precipitation, with sharp increases observed at a few sites due to two consecutive wet winters in 2019/2020 and 2020/2021. The sustainable abstraction licence reductions also remove the availability of low nitrate raw water blending options at a number of our sources where we currently blend to achieve compliance.

Our AMP7 experiences have reinforced why this investment is required now rather than in later AMPs. This is highlighted in the detail provided below on the impact of heavy rainfall events on a particular aquifer which has high nitrate levels already. The rainfall in this area was unprecedented; with two consecutive record breaking years for winter rainfall in 2019/2020 and again in 2020/2021, which meant the aquifer had no time to recover in terms of nitrate levels in between times. The graph below shows the Effective Precipitation (EP), which is the amount of rain available to go into the ground, once evaporation and soil moisture deficit has been overcome. The graph shows EP significantly exceeding the long-term average (purple line) in this area for two consecutive years. The graph finishes in March 2022 and shows the drier winter.

36 Please refer to Appendix ANH48 'DWI Letters of support'

Figure 54 Example of Effective Precipitation exceeding long-term average

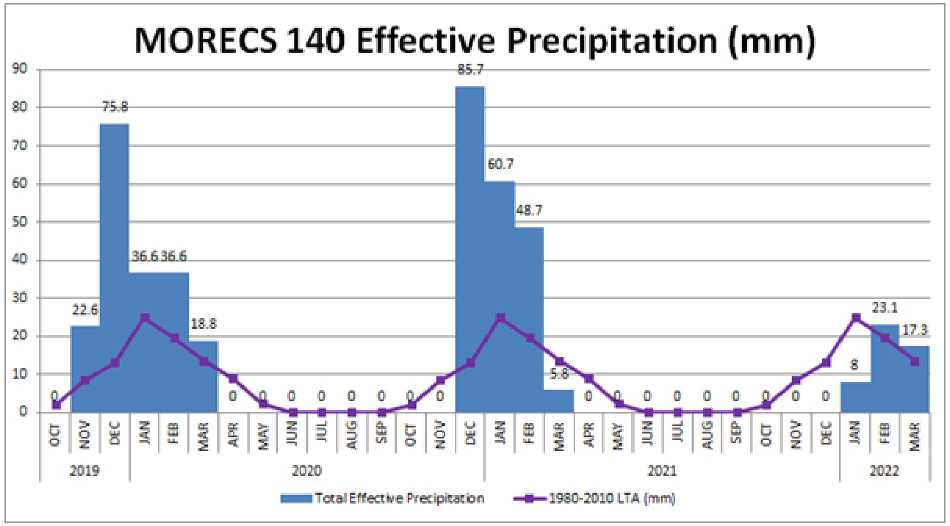
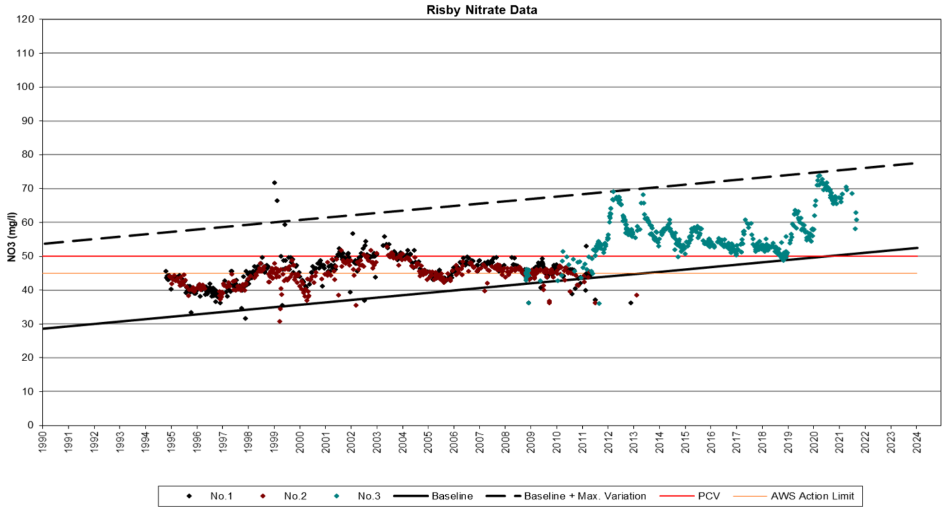


Figure 55 Risby source nitrate data



The nitrate concentration at Risby source went from 56 mg/l on 1/12/20 to 73.7 mg/l on 18/2/21 as shown in the graph below with the sharp increase in nitrate levels in this source clearly evident.

In addition to the atypical nitrate levels observed on a number of our high risk nitrate sources, the abstraction licence reductions which are required under the WFD driver also impact on the current blend capabilities which we have on a number of our sites which use low nitrate sources for blending in order to achieve nitrate compliance. An example below shows the increasing trends in the raw water sources for Barnham Cross and Nunnery Lodge.

For example, Nunnery Lodge WTW has existing ion exchange treatment, but also blends with the historical low nitrate source at Barnham Cross. However, the rising trend at Nunnery Lodge and corresponding increases at Barnham Cross will mean this treatment arrangement will not provide enough mitigation to prevent a nitrate PCV exceedance in the future. Nitrate trends for Nunnery Lodge raw water source and the Barnham Cross raw water source are shown below in the nitrate prediction graphs.

Figure 56 Barnham Cross nitrate data

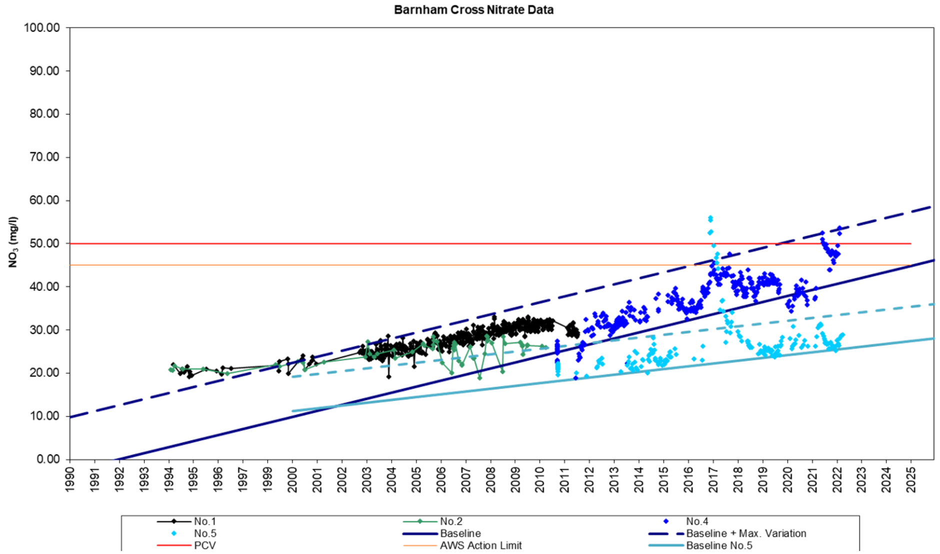
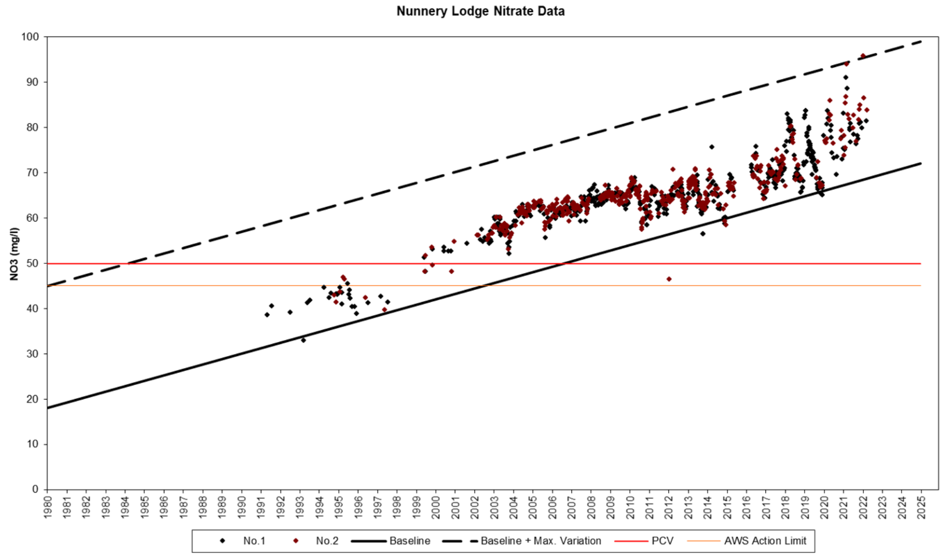


Figure 57 Nunnery Lodge nitrate data



The nitrate prediction charts for each site are included within the DWI Annex B templates for all of the nitrate investments (submitted to DWI 31 March 2023)[37].

In additional to the challenges on raw water quality presented by environmental trends as shown above, as mentioned we are also facing pressure from the loss of abstraction licences from low nitrate boreholes. This is limiting the opportunities to reduce nitrate levels through blending solutions.

The timescale for delivery of nitrate schemes over the coming AMPs has been set to ensure we continue to comply with our nitrate compliance standards as informed by the concentration prediction models whilst incorporating abstraction reductions and source vulnerability to seasonal peaks in nitrates.

Alongside the treatment solutions that are required to meet water quality standards in this AMP, we will continue our catchment management activities for nitrates, working with key stakeholders to continue our catchment management strategies. All catchment strategies will be carried out from base expenditure. We have a WINEP submitted to the EA under the WINEP driver for DrWPA for our Denton Lodge source which introduces catchment management activities for AMP8. There is a considerable lag time to realise the benefits of any catchment management activities for nitrate levels in raw water, therefore, end-of-pipe

37 Please refer to Annex ANH48

treatment is required within the short to medium term to protect water supplies at sites where catchment management opportunities have been exhausted, as recognised by the letter of support we have received from the EA. This letter of support was required as part of our DWI Annex - B submissions for any nitrate reduction scheme proposals, with the DWI stipulating they would not accept any nitrate submission without the EA support.

Interaction with base expenditure

The proposed investments are enhancement (rather than base) expenditure as they relate to the enhancement of the quality of drinking water supplies beyond that covered by base activities. The upgraded treatment schemes or installation of treatment capacity outlined in this investment will help ensure we do not exceed the drinking water standard of 50 mg/l for nitrate and as specified by the DWI.

The table below sets out the activities which we have not included in this enhancement plan (base) and those which are included in the plan as enhancement investments (enhancement).

Table 83 Base and enhancement activities

Base	Enhancement
Existing treatment for nitrate compliance (to include ion exchange or blending for nitrate reduction).	Additional treatment to meet existing nitrate standards or new DWI PFAS requirements, based upon raw water deterioration risk.
Existing maintenance and operational activities to manage the operational risk of nitrate and PFAS.	Additional operational activities to manage the operational risk of nitrate and PFAS as a direct result of the enhancement investment.
Existing enhanced sampling as part of a risk based approach for nitrate and PFAS.	Additional requirements from the DWI Information Letter 02/2023 covering specific areas of activity to inform and manage (where viable) the PFAS risk in our sources.

Long term context (historic)

The enhancement investment at PR24 concerns new treatment capacity and upgrades to existing treatment facilities for both nitrates.

The 12 sites proposed for nitrate investment all have increasing trends in nitrate levels in the high nitrate sources. A number of the lower nitrate sources which are currently used for blending at some of these sites are also showing increasing nitrate trends. Where existing nitrate reduction treatment processes are in place i.e. ion exchange treatment or blending we have undertaken a comprehensive review of the raw water nitrate levels (including predicted values), the existing treatment design capabilities and the proposed reduction in abstraction licenses of the lower nitrate sources to inform this investment to maintain nitrate compliance.

Raw water deterioration due to nitrate is a significant risk in a number of our ground waters, linked historically to the intensive agricultural activity within areas of the Anglian region after the second world war and subsequent intensive farming activity since. Below is an overview of the number of enhancement schemes for nitrate schemes delivered in the current and previous AMP's.

Table 84 Nitrate schemes AMP4-AMP7

	AMP4	AMP5	AMP6	AMP7
Number of nitrate schemes	12	3	4	4

It is evident that nitrate levels within a number of our groundwater sources are still rising. Catchment management activities will take anywhere from 20 to 40 years to realise any impact and show a reduction in nitrate levels and then we anticipate that those reductions will be marginal. For those sources with nitrate levels significantly over 50 mg/l, it is most likely that significant future investment in nitrate reduction will be required in order to reduce the nitrate compliance risk. All the investments for nitrate are sources which are in Nitrate Vulnerable Zones (NVZ), we undertake catchment management activities for nitrate in all of these NVZ's and will continue to do so during AMP8.

At PR19, enhancement investment was allowed for additional ion exchange capacity at Wighton WTW and installation of ion exchange at Irby reservoir and Gayton WTW. Wighton and Irby reservoir have been delivered and Gayton is on track for delivery. No costs for these schemes are included in our proposed enhancement investments for PR24. In addition, we have also delivered against the requirement for further blend management and control philosophy at Little Saxham WTW for nitrate compliance. Since that investment we have observed atypical rises in the high nitrate source with an increase of 17.7 mg/l over an 11 week period following two consecutive wet winters, coupled with an increase in nitrate levels from the low blend source, this is representative of an increased risk in nitrate levels in a number of our source waters.

Long term context (future)

We are committed to our SDS ambition of making the East of England resilient to the risks of drought and flooding. As identified in our LTDS, we are anticipating additional pressures on drinking water quality up to 2050 due to abstraction reductions to achieve environmental destination which will lead to an increased use of surface water as opposed to groundwater sites. Additionally, climate change will likely increase the impacts of nitrates due to hotter summers and increased intensity of winter and summer storms.

In our LTDS, we have developed a twin-track approach to mitigate raw water quality risk.

1. Manage legacy contamination through treatment
2. Reduce future risk through catchment management approaches, where we work in partnership with landowners and land users to minimise the contamination of raw water sources.

Based on the information we currently have available, our AMP8 investments for nitrates are low regret as they place us on the right path to deliver on our ambition set out Drinking Water Quality sub-strategy through the twin-track approach. Our AMP8 investments will also deliver our long-term drinking water quality ambitions in the adverse scenarios through alternative pathways, which would require additional enhancement expenditure complementing that rolled out in AMP8. [38].

Our 'Long Term Planning for the quality of drinking water supplies' document [39] sets out that we expect climate change will increase the frequency of high rainfall events, and thus significant aquifer recharge and subsequently requiring additional intervention to reduce nitrate levels in groundwater. The investments we propose in AMP8 are low regret in the context of our Long-Term Delivery Strategy against both the high and low climate change scenarios which have different assumptions on rainfall and therefore aquifer recharge attached. The reductions in sustainable abstraction licenses also forms part of our thinking.

Customer support

The need for our raw water quality enhancement investments and selected options are driven by the need to comply with the Water Supply (Water Quality) Regulations 2016 (as amended). Our PR24 customer engagement reemphasises that customers consider providing safe, reliable water supply remains a top priority. In our investment priorities customer engagement, 53% of respondents stated that safe, reliable drinking water was their top priority (of eight areas) for us to invest in our business plan, with 80% ranking this in the top three.

We have used the views of customers on the overall scale of our business plan alongside our own technical expertise in this area to balance the investment required to comply with nitrate standards with other investment priorities by phasing investment over multiple AMPs where possible.

Cost control

The ultimate drivers for the investment are outside of company control. Firstly, as the investments are required to comply with the Water Supply (Water Quality) Regulations 2016 (as amended) for nitrate compliance.Secondly, historical contamination of our source waters from nitrate is outside of management control. Intensive agriculture in areas such as the Fens, means that the Anglian Water region experiences high nitrate levels in aquifers.

We have also taken steps to control costs and identify cost savings. The modular nitrate ion exchange plants which we have previously installed have been developed over a period of AMPs working with our suppliers to enable a more efficient construction and installation cost and to further optimise operational efficiency of the treatment process.

Both areas of investment have undergone internal and external audit scrutiny focusing on the need and the costs of the proposed investments. We have also undertaken bench marking on the nitrate investments, as outlined in section C.

11.1.2 Unlocking greater value for customers, communities and the environment

Option consideration

A wide range of options have been considered to address the need to reduce the concentration of nitrates in drinking water. We started by taking a broad view of how this need can be addressed before undertaking a cost-benefit appraisal to identify which options are feasible, meet the identified need and are cost-beneficial.

In addition to considering a range of options to make raw water quality improvements, we also ensure to maintain an awareness of emerging technologies and innovations which could deliver solutions more effectively in future. We continue to observe and take part in developments with technologies related to the removal of nitrates.

38 Please see Section 2.2.3 'Drinking Water Quality' in our LTDS for more detail
39 Please see Annex ANH48

Table 85 Options appraisal assessment

No.	Option	Description	Unconstrained	Feasible
1	Catchment management	Working in partnership with landowners and land users to change activities in a way which reduces the use of nitrates onto the land. This work will continue during AMP8.	Yes	
2	Blending	Blending is the first option we consider before identifying the need for a treatment solution. All of the sites proposed for investment already have some form of blending for nitrate compliance. Due to increasing levels of nitrates in all of the high nitrate sources, increased nitrate levels in some of the lower blend nitrate sources and the sustainable abstraction reductions proposed on all of the 12 sites any further blending availability is not considered viable from existing sources. This is also further impacted by one of the sites having PFAS levels in the source water at tier 2 trigger levels in the lower nitrate sources (although these lower nitrate sources are still above the PCV of 50 mg/l). Blending with the new strategic main has been considered but is not considered feasible. The likely levels of nitrate within the strategic grid system will be compliant with the required values for supply to customers, but will not provide low enough values to give a reliable blend source. Using the strategic grid as a formal blend would reduce the operational flexibility of the network. The strategic main has been designed and installed to provide resilience flows to specific sites and is not sized to provide the large volumes of blend water needed across the region.	Yes	
3	Ion exchange	Ion exchange technology is an effective process for nitrate removal through the use of nitrate selective ion exchange resin. The selective resin requires periodic backwash to regenerate the resin and therefore produces a waste stream which requires disposal of.	Yes	Yes
4	Reverse osmosis	Reverse Osmosis (RO) technology which is effective at nitrate removal through semi permeable membranes. The membranes typically require pre filters to prevent damage and blockage from large particulates. They also require a cleaning system which produces a waste stream for disposal. Waste streams from this treatment can be significant. RO treatment also removes most other impurities from the water such as calcium and magnesium , which will then require remineralisation of the water to make it acceptable to consumers and also reduce the risk of corrosivity of the water supply to the conveying pipes. Softened water can be detrimental from a health perspective.	Yes	Yes
5	Biological nitrate	Biological nitrate technology is not used currently within the UK for drinking water purposes. Any biological treatment can fail if the biological community are stressed or killed for some reason, therefore we would consider this technology to be at significant risk of treatment failure and therefore a compliance risk.	Yes	

Cost-benefit analysis

For each of the options identified in the section above we have considered where these are feasible and effective in delivering on reducing nitrate levels to below the required level.

Table 86 Feasibility assessment

No.	Option	Feasible (Y/N)	Justification
1	Catchment management	N	Already being applied to the feasible maximum extent, benefits expected over a significant lag time period (years) ,and then we anticipate small scale reductions in nitrate levels which for those sites in excess of 60 mg/l this may not be enough.
2	Blending	Y	Proven solution, however for the required sites no further blend options are available. Simplest solution however constrained by blending water available.
3	Ion exchange - nitrate reduction	Y	Proven solution
4	Reverse Osmosis (RO)	Y	Feasible, however not cost effective as require additional process steps required as RO softens water which then requires remineralisation, significant water wastage.
5	Biological nitrate reduction	N	Not currently used in the UK and higher risk associated, e.g. biological processes have the potential to fail resulting in no treatment and thus significant potential for compliance risk.

Catchment management is not feasible as modelling indicates the length of time to realise any nitrate reduction would not prevent an exceedance of the PCV in the final water regulatory compliance point, the preferred end-of-pipe options for AMP8 are blending sources to reduce nitrate concentrations or treatment using ion exchange with nitrate selective resin.

Catchment modelling which we have undertaken for all of the sources proposed in this investment identified the benefits of catchment management are likely to take >20 years to be realised and even then we could see only marginal reduction in nitrate levels. Therefore, catchment management cannot currently provide the solution in isolation and is unlikely to in the foreseeable future for those sites with very high nitrate levels.

Blending is always our preferred treatment method where there is availability of low nitrate blend water and where this does not interact with license restrictions. Where further blending is not viable, ion exchange treatment has been proposed as our preferred option as a proven efficient technology which we have significant experience of delivering in previous AMPs.

Ion exchange plants using nitrate selective resin are the most suitable options for nitrate removal, of the alternative technologies considered through the optioneering process:

Reverse Osmosis plants require water to be remineralised presenting an additional cost to treatment, therefore ion exchange is more suitable for nitrate-specific removal as this is selective to nitrate. There is significant waste of water from any RO process.

Biological nitrate plants were also considered, however were not selected as there are currently no plants in the UK, importantly it also comes with an inherent risk of treatment failure if the biology is stressed or killed and therefore presents an unacceptable compliance risk.

Our nitrate proposals have been included in our third party assurance process.

Environmental and social value

We have considered the environmental and social value of our nitrates investments as part of our options consideration process. Our Value Framework, structured by the Six Capitals has informed our investment decisions.[40]

The impact values within our Value Framework are made up of both private costs (e.g. costs to resolve an incident) and societal costs. Societal costs are derived through a robust Societal Valuation Programme considering a broad range of sources where customers views, preferences and priorities are canvassed, analysed and incorporated into the values through a triangulation process.[41]

Investments benefit

We do not anticipate that this investment will create any improvement in performance for the Compliance Risk Index (CRI) performance commitment. However, investment into raw water will prevent CRI performance from deteriorating in AMP8. Where nitrate trends are rising, we implement nitrate treatment before any impact on CRI could happen in line with drinking water regularity requirements. We note that we are intending to improve our performance against CRI in AMP8.

Each option is assessed from a benefits perspective using Anglian Water's Value Framework.

40 For more information on our value framework see chapter 7 Driving cost efficiency in our plan 2025-2030
41 For more information on customer insight see chapter 3 Customer engagement in our plan 2025-2030

A baseline position is established that captures any current or expected impacts to service, customers, the environment, safety etc (and their respected likelihoods).

Each alternative (i.e. option) is appraised to establish a residual position, with updated impacts and likelihoods. This residual position also considers any additional benefits and dis-benefits that may apply as a result of the intervention. These could be permanent (e.g. visual impact) or temporary (traffic disruption during construction) and consider a range of environmental and social measures including both capital and operational carbon.

This investment area primarily provides benefits by supplying safe water to our customers.

Nitrate is a health based parameter, high levels of nitrate in drinking water can be unsafe, especially to the health of babies and young children. These investments are to safeguard safe water for our customers.

Although this enhancement investment will prevent our performance from deteriorating against CRI, we do not anticipate this investment will generate any performance improvements against the CRI performance commitment. Performance against the CRI performance commitment will be delivered from base allowances through activities such as storage point inspections and inspection and maintenance programmes of our water treatment works.

Managing uncertainty

We consider that the increasing nitrate levels in the high nitrate raw waters and at some sources increasing levels in the lower blend raw water sources presents a significant risk of a nitrate compliance breach on the final water at the 12 sites listed in this investment. We predict this will occur within AMP8 if we do not install treatment, (whether new or additional) to reduce the nitrate levels in the final water below the PCV of 50 mg/l. This follows the principles of identifying risks using a water safety planning approach with our nitrate prediction modelling applying a robust scientific methodology to predict that risk. We do not believe that there is uncertainty around the need for this investment With our experience of operating ion exchange nitrate reduction treatment processes we also now this to be a proven technology for nitrate removal.

External funding

In principle, we support the potential for a ‘polluter pays’ approach to raw water deterioration, whereby some or all of the costs for nitrate treatment/ removal is taken up by the source polluters. However as there is no single source polluter (nitrate levels are predominantly driven by agricultural practices since WW2) this is not currently possible. Therefore, we do not currently consider third-party funding for this investment to be a possibility.

Direct procurement

We have considered the size and discreteness of raw water deterioration investment to understand their potential to be delivered through DPC. On an individual level, these investments do not reach the default £200m threshold for DPC.

The works required involve improvements to existing assets, which are not discrete. There are significant operational and commercial complexities involved if two parties were to construct and/or operate simultaneously on live operational assets. Accordingly, these projects have not been considered further for DPC.

Customer view

Customers support safe clean water and highlight it as a priority for investment, however customers have not been involved in the proposed solutions as part of the customer engagement work. The investment has been driven by statutory drivers and the most effective way to treat water at the proposed sites as highlighted in our cost-benefit appraisal section (section 9 above).

11.1.3 Cost efficiency

Developing costs

The development of the nitrates costs in our plan follows our cost efficiency 'double lock' approach set out in chapter 7 of our business. plan. Through this approach we have ensured that are costs are efficient in their bottom-up build up, and this is cross-checked through external benchmark approaches. This section sets out how we have ensured efficiency of our nitrates costs through step one of our double lock approach. Step 2 is explored in the Benchmarking section below.

We have taken a robust approach to developing our nitrates costs, building on our experience from delivering similar schemes into the bottom-up development of costs (before external cost benchmarking challenges are applied in step 2 of our 'double-lock' approach). The detail of the cost development approach is set out below, along with a breakdown of costs we provide in table CW3.

<u>Cost Estimation Methodology</u>

We follow a common cost development methodology across our enhancement investments in a three phase process:

1. Establish cost and carbon models
2. Input the cost drivers into the model (including location specific factors)
3. Data validation, internal challenge and assurance.

Investment is proposed to install nitrate reduction ion exchange treatment to achieve nitrate compliance at 12 sites. This consists of the upgrading of three existing ion exchange plants and the replacement of three existing ion exchange plants which are no longer able to treat the increasing levels in the raw water, and the first time installation of ion exchange at five sites.

We derived our costs for each scheme by gathering site by site data which influence the cost estimates for each site, including:

- current operability
- boreholes abstraction licences flow (max, min, peak)
- historic nitrate concentration trend information
- site specific requirements and
- assessment of construction constraints such as SSSI.

We have installed ion exchange plants for nitrate reduction since AMP4 and this experience has helped us to establish the minimum design standards which are applicable to comply with process requirements and legislation.

We have continuously captured outturn costs data of all projects delivered in our capital investments including granular cost components such as pipework, pumps, ion exchange systems, on-costs, etc. These outturn costs have been the inputs to the parametric models to each specific assets. Building outturn costs into our cost assumptions in this way builds cost efficiency into the build up of costs. This is in addition to the external cost benchmarking that we carry out to inform the comparative efficiency of our costs with other companies (see section 17, Cost bench marking, below)

The key cost assumptions and estimations have been built using both the parametric models applicable to each asset and the on-site design information to inform our cost estimation for PR24. Cost estimations have been built using the design information available at each site alongside the parametric cost models applicable to each asset.

The table below provides a breakdown of the nitrates costs provided in data table lines CW3.97, 3.98 and 3.99 (Addressing raw water quality deterioration (grey solutions)) .

Table 87 AMP8 investment

Investment ID	Project name	Scope	Flow to be treated (Ml/d)	Capital cost (£k)	2025-30 Opex cost (£k)
I038901	Two Mile Bottom WS Nitrate Compliance	*Ion Exchange Plant and building to house it *Chlorination dosing / Contact Tank *Brine Waste system to STW *Run to waste *Interconnecting pipework * New pump station at Mundford Road new site to relift the flows to the reservoir *Water main To take water from the existing main to site and back- SSSI and crown land therefore the new site need to be 1.5kM away from the raw water main *Sites Ancillaries (hardstanding, fencing, Roads, landscaping, telemetry, BNG)	9.22	16,221.94	170.90
I038929	Houghton St Giles WTW Nitrate Compliance	*Ion Exchange Plant and building to house it *Chemical dosing relocation *Brine Waste system to STW *Run to waste *Interconnecting pipework *Sites Ancillaries (hardstanding, fencing, Roads, landscaping, telemetry, BNG)	8	6,972.80	503.68

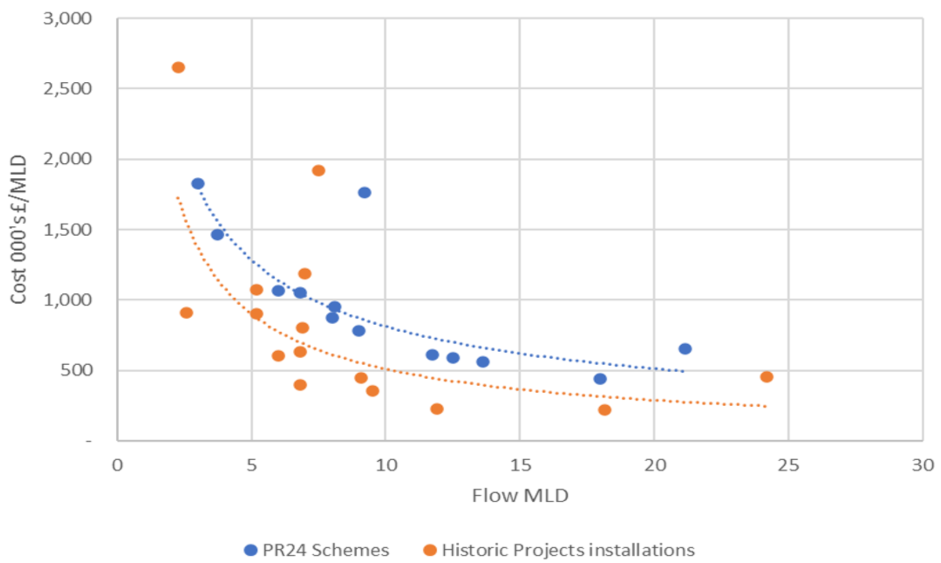
Investment ID	Project name	Scope	Flow to be treated (Ml/d)	Capital cost (£k)	2025-30 Opex cost (£k)
I039014	Barnham Cross/ Nunnery Lodge WS Nitrate Compliance.	*Ion Exchange Plant and building to house it *Rising main to discharge to near sewer *Run to waste *Interconnecting pipework *Sites Ancillaries (hardstanding, fencing, Roads, landscaping, telemetry, BNG)	9	7,021.06	110.10
I039192	Congham WW Nitrate Compliance	*Site specific Ion Exchange Plant and building to house it *Brine Waste system to STW *Run to waste *Interconnecting pipework *Sites Ancillaries (hardstanding, fencing, Roads, landscaping, telemetry, BNG)	8.1	7,712.79	69.14
I039260	Risby WTW Nitrate Compliance.		12.5	7,348.19	537.16
I039310	Twelve Acre Wood Nitrate Compliance		11.75	7,175.10	493.48
I039528	Ryston WTW Nitrate Compliance		13.64	7,664.80	151.22
I039551	Lyng Forge WTW Nitrate Compliance		3.73	5,456.71	45.17
I039563	North Pickenham WTW Nitrate Compliance		6.82	7,166.89	661.38
I039566	Denton Lodge WTW Nitrate Compliance[a]		3.02	5,525.76	28.39
I039572	Marham WTW Nitrate Compliance		21.16	13,821.45	780.39
I039578	Ringstead WR Nitrate Compliance		6	6,406.32	140.93
I039781	Clay Hill WTW Nitrate Compliance		17.99	7,926.30	216.67
		Total	**130.93**	**106,420**	**3,909**

a This investment was included in our plan prior to receiving DWI decision letters. Following receipt of these letters, this investment was not supported and so we will take this investment out of the plan. We have kept the investment in this table to show the breakdown of costs provided in table CW3. The Denton Lodge investment should not form part of Ofwat's cost assessment.

We have built in assumptions of efficiencies associated with economies of scale into the build up of these costs. This is illustrated in the graph below showing the relationship between the size of scheme and the unit capital cost associated with the scheme. The graph also shows a comparison of our historic total cost of schemes from 2004. There is an increase in the unit costs compared to those seen historically due to the inclusion of additional cost drivers such as:

- standby generators,
- run to waste commissioning costs,
- Environmental Impact Assessments
- Biodiversity Net Gain
- Studies of existing sewers to understand the impacts of waste discharge from the brine water and requirements of tankering of waste to STW sites and construction of receiving brine tanks.

Figure 58 Nitrate scheme cost comparison



The site at Two Mile Bottom is an outlier due to the complexity of the project associated to a new disinfection system required and the constraints associated with this being within an SSSI area.

Benchmarking

In stage 2 of our cost efficiency 'double-lock' on nitrates, we used the following methods to ensure the cost efficiency of our plan:

- Scheme outturn costs
- Industry cost models from TR61

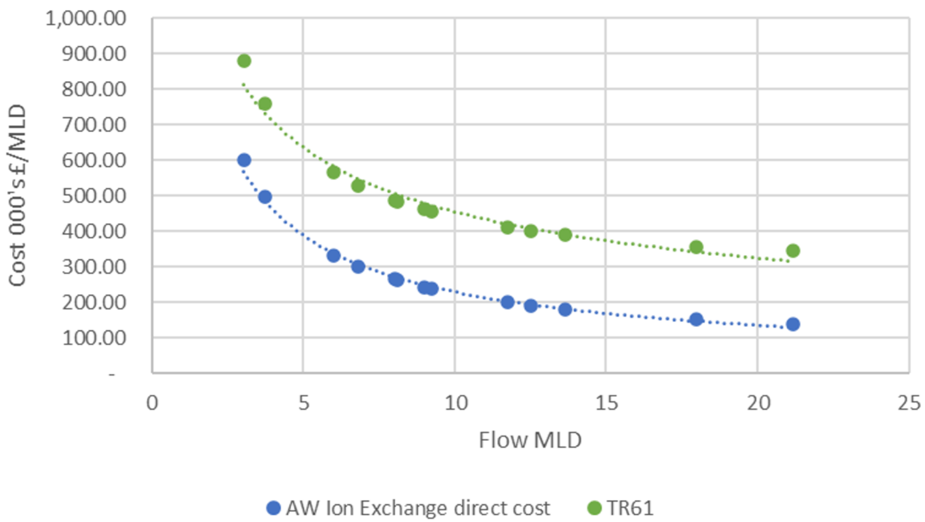
Scheme outturn costs

We have continuously captured outturn costs data of all projects delivered in our capital investments including granular cost components such as pipework, pumps, and ion exchange systems. These outturn costs have been the inputs to the cost models to each specific assets. Building outturn costs into our cost assumptions in this way builds cost efficiency into the build up of costs.

Industry cost models from TR61

For nitrates, we have sought assurance on the efficiency on the costs of the ion exchange plants through by bench marking to the parametric model build by WRCs TR61. From TR61, we are able to reliably compare 50% of the total direct asset costs (covering ion exchange plant costs) of the programme with the industry benchmark. In the process of cost benchmarking we identified efficiencies on nitrate removal which resulted in a £21m reduction in our costs. The graph below shows the comparison of our costs against the TR61 benchmark which demonstrates that our costs are on average 47% lower than the benchmark cost/ Ml/d flow rate basis.

Figure 59 Nitrate cost comparison - AW direct cost comparison: AW direct costs versus TR61



Assurance

The cost estimates have been developed using our costs estimation tool for which we have had third party assurance from Jacobs . Aecom has also carried out a process calculation assurance of a nitrate sample of sites which has supported our external cost bench marking, and the data for the external benchmarking was collated by WRC.

11.2 PFAS

11.2.1 Delivering for the long term

Investment context

Our raw water deterioration enhancement programme focusses on reducing the level of nitrates and PFAS in drinking water. The scale and pace of investment is driven by a requirement to meet regulatory standards in the Water Supply (Water Quality) Regulations 2016 (as amended), and the Drinking Water Inspectorate (DWI) PFAS guidance and Information Letters (IL). We are committed to mitigating risks to delivering safe, clean drinking water from source to tap by addressing emerging challenges through our long-term planning approach. As demonstrated by our collated customer insight captured within our Customer Synthesis Report[42]customers view that delivering safe, clean water is the most vital service we offer, and is one of our ten Strategic Direction Statement (SDS) long-term outcomes.

We have received DWI Letters Of Support (LOS) for all the capital PFAS investments. We are still awaiting confirmation by way of Letters Of Support from DWI on our PFAS strategy, however they have said that it should feature in our business plan proposals. [43]

The quality of the raw water is also affected by the emergence of PFAS, an umbrella term for a list of Poly and Perfluorinated Alkyl Substances. PFAS compounds are a group of man-made chemicals that include Perfluoro-octanoic acid (PFOA), Perfluoro-octane sulfonate (PFOS) and other related substances. They have been used widely for a range of purposes from industrial to household products, that have had or continue to have widespread use in England and across the world. Colloquially known as 'forever chemicals', certain PFAS compounds are known to have the potential to persist in the environment, including in water, and some have shown the capability to bio-accumulate. This has raised a keen interest in better understanding their potential impact on the environment and toxicity. The full public health impacts of PFAS are yet to be established. However, in advance of further international research on PFAS toxicity the DWI has introduced a precautionary margin of safety to reduce the potential for long term accumulation in the human body.

Water companies are required by the DWI to take specific actions to comply with PFAS standards such as additional treatment or blending with other sources to reduce PFAS levels prior to supply. Investment is required for enhanced monitoring, catchment management investigations (where appropriate), development of treatment approaches, and other measures to reduce PFAS in potable supplies until the industry gains a better understanding of the associated health risks. The DWI's guidance is based on a tier 3 trigger of greater than or equal to 0.1 µg/l and a tier 2 trigger of less than 0.1 µg/l which companies are required to comply with. This affects twenty three of our very high risk sites with specific investment proposals of virgin Granular Activated Carbon (GAC) installation at 20 sites, the installation of a GAC media adsorption treatment process at two tier 2 sites and the installation of a backwash water handling system(with GAC treatment) at one tier 3 site. One of the sites proposed for nitrate investment on the groundwater source also has high levels of PFAS in the groundwater, which is in the lower nitrate boreholes (although they are still over 50 mg/l) which results in this being a complex blend scenario site. We are currently engaging with external stakeholders on this matter. The DWI also requires companies to have a AMP8 PFAS strategy to develop an understanding of PFAS risk within our catchments and subsequent PFAS levels in our raw water sources and final treated waters.

42 Annex ANH 55 Synthesis Report
43 ANX ANH48

Scale and timing

The DWI introduced initial guidance on PFAS in October 2021, under Information Letter 05/20/21 - "Requirements for Poly and Perfluorinated Alkyl Substances (PFAS) monitoring by Water Companies in England and Wales". Additional guidance was issued in July 2022 under Information Letter 03/2022 Risk assessments, under regulation 27 and associated reports, under regulation 28 of the Water Supply (Water Quality) Regulations 2016 (as amended) which required us to develop an understanding of our PFAS catchment risks and to commence sampling for 47 compounds (listed in Annex A _list of 47 PFAS substances required for monitoring), with sampling to be based on a risk-based frequency. The DWI has taken a precautionary approach and produced tiered guideline values for water companies. For tier 2 final waters, the DWI requires review of any control measures and existing treatment and the preparation of measures to prevent the supply of water to consumer with levels less than 0.1 µg/l. Tier 3 final waters requires the preparation of emergency contingency measures to prevent the supply of water to consumers with greater than or equal to 0.1 µg/l PFAS.

The DWI information letter 02/2023 - Inspectorate expectations for PFAS activity in AMP8, outlined the requirements for companies to submit a PFAS strategy for AMP8, by the end of June 2023. We submitted this on 30 June outlining our investment proposals in catchment investigations, enhanced and operational sampling and further stakeholder engagement and collaborative work. This investment will further inform our understanding of PFAS risk, catchment management options (where viable), and future investment requirements.

We commissioned a project in 2021 to further develop our PFAS risk assessment methodology to establish the risk to each of our groundwater sources, which has since been aligned with further guidance from the DWI Information Letter 03/2022. Following the commencement of our sampling strategy for the full 47 PFAS compounds in September 2022, we have a number of our sites which are triggering tier 2 with two of our groundwater sources triggering tier 3 (one of which is a known PFOS contaminated site linked to fire testing activity from the local US military air base).

To meet regulatory expectations of a dual track approach (as outlined in DWI information letter 02/2023), investment is proposed to address the PFAS risk at these sites where we have identified a very high PFAS catchment risk and where we have already seen or there is a risk of PFAS levels which are triggering tier 2 or are close to doing so, or in some cases triggering tier 3. On that basis we have proposed investment at our very high risk sites where we have existing GAC treatment which is known to be effective at reducing PFAS. Investment has also been included for GAC treatment at two sites which have triggered tier 2 and currently have no PFAS treatment and for a wash water handling system at a tier 3 site. As part of the dual track approach the DWI required the development of a detailed PFAS strategy, with additional investment proposed which includes catchment investigations and enhanced monitoring.

At the Chief Inspector's Launch on 11 July 2023, the Chief Inspector made a very clear statement and expectation from the industry '*what are companies strategies to deal with tier 2 sites* '.

We have received DWI letters of support for virgin GAC media installation at the 20 very high risk sites, support for the installation of new GAC treatment stages at the two sites which have triggered tier 2, and we have been commended for support for the wash water handling system at our tier 3 site. DWI have advised via correspondence by email on 5 September 2023, *"PFAS strategies should feature in company Business Plans and should include the appropriate costings"*.We are still awaiting a decision on letters of support.

Interaction with base expenditure

The proposed investments are enhancement (rather than base) expenditure as they relate to the enhancement of the quality of drinking water supplies beyond that covered by base activities. The upgraded treatment schemes or installation of treatment capacity outlined in this investment will help ensure we do not exceed the exceed the tier 2 of less than 0.1 µg/l for PFAS as specified by the DWI.

The table below sets out the activities which we have not included in this enhancement plan (base) and those which are included in the plan as enhancement investments (enhancement).

44 Please refer to Section 2.2.3 'Drinking Water Quality' in our LTDS for more detail.

Table 88 Base and enhancement activities

Base	Enhancement
Existing treatment for nitrate compliance (to include ion exchange or blending for nitrate reduction).	Additional treatment to meet existing nitrate standards or new DWI PFAS requirements, based upon raw water deterioration risk.
Existing maintenance and operational activities to manage the operational risk of nitrate and PFAS.	Additional operational activities to manage the operational risk of nitrate and PFAS as a direct result of the enhancement investment.
Existing enhanced sampling as part of a risk based approach for nitrate and PFAS.	Additional requirements from the DWI Information Letter 02/2023 covering specific areas of activity to inform and manage (where viable) the PFAS risk in our sources.

Long term context (historic)

PFAS presents a new obligation for which funding allowances have not been made within the current AMP. The DWI IL 05/2021 required companies to monitor for all PAFS compounds in Annex A - list of 47 PFAS substances required for monitoring, using a risk-based approach following the development of a PFAS risk assessment. We have developed our PFAS catchment risk assessment with WSP and further developed it following further guidance in IL 03/2022.

Long term context (future)

We are committed to our SDS ambition of making the East of England resilient to the risks of drought and flooding. As identified in our LTDS, we are anticipating additional pressures on drinking water quality up to 2050 due to abstraction reductions to achieve environmental destination which will lead to an increased use of surface water as opposed to groundwater sites. Additionally, climate change will likely increase the impacts of PFAS and nitrates due to hotter summers and increased intensity of winter and summer storms.

Based on the information we currently have available, our AMP8 investments for PFAS are low regret as they place us on the right path to deliver on our ambition set out in our Drinking Water Quality sub strategy. Our AMP8 investments will also deliver our long-term drinking water quality ambitions in the adverse scenarios through alternative pathways, which would require additional enhancement expenditure complementing that rolled out in AMP8. The following graphic sets out our assumptions for PFAS up to 2050. [44]

We have mapped out our proposed long term PFAS strategy in our January 2023 'Long Term Drinking Water Supply' submission to the DWI. [45] This strategy recognises the significant uncertainties on the PFAS programme over the long term, including the timing of interventions, the optimal treatment processes to treat PFAS, and the likely increase in the number of recognised PFAS compounds due to ongoing research. We expect a similar number of schemes to be required in AMP9 as in AMP8 to ensure a proactive approach is taken to the treatment of emerging contaminants. The investments outlined for AMP8 are low regret through balancing the need to treat PFAS and waiting for developments in our understanding of the scale of the challenge, opting to use innovative solutions when these become available. It also recognises future investigations will inform where we can potentially control PFAS input into our source waters.

The submission of our AMP8 PFAS strategy 30 June 2023 further develops our thinking on PFAS in the short, medium and long term. We highlight areas of activity where we currently understand we can minimise PFAS use within catchment- for example, working on trade effluent discharges. However, it is likely PFAS treatment will be required for legacy PFAS which has already contaminated the raw water.

In 2022 we commissioned research with the University of Cranfield working closely with their Water Science and Technology team. The Cranfield research on Rapid Small Scale Column Tests on Beck Row raw water was undertaken with the aim of informing when do we observe breakthrough of the smaller chain PFAS compounds from the F400 GAC media installed at our tier 3 site. One of the outputs from the Cranfield research support that newer GAC with higher iodine numbers, and with a higher Empty Bed Contact Time (EBCT) as the best-case scenario to minimise the risk of PFAS breakthrough.

We are aware of the Defra (DWI) research project being undertaken by Cranfield University Bench-Scale Water Treatment Efficacy Study of Poly and Perfluorinated Alkyl Substances (PFAS). We are supporting this research with us providing raw water from three of our sources, one of which will be used to test the fluorosorb media, which is showing potential for PFAS removal

The research includes the following technologies: GAC, Reverse Osmosis, membranes, fluorosorb media (which is being used in the United States of America with NSF approval; however it does not have Regulation 31 approval for use), Advanced Oxidation Reduction processes and other novel absorbents. The research is due to conclude in February 2024. We await the outputs of this research to inform our future approach to PFAS and our understanding of mitigation risk at our treatment sites.

45 Please refer to Annex ANH48

Customer support

The need for our raw water quality enhancement investments and selected options are driven by the need to comply with the Water Supply (Water Quality) Regulations 2016 (as amended). Our PR24 customer engagement re-emphasises that customers consider providing safe, reliable water supply remains a top priority. In our customer engagement on investment priorities, 53% of respondents stated that safe, reliable drinking water was their top priority (of eight areas) for us to invest in our business plan, with 80% ranking this in the top three.

We have used the views of customers on the overall scale of our business plan alongside our own technical expertise in this area to balance the investment required to comply with nitrate and PFAS standards with other investment priorities by phasing investment over multiple AMPs where possible. We identified an additional eleven sources which are categorised as very high risk for PFAS. For these we have moved investment in PFAS treatment into AMP9, based upon the fact that our AMP8 PFAS strategy and research will inform that investment.

Cost control

The ultimate drivers for the investment are outside of company control. Firstly, the investments are required to comply with the Water Supply (Water Quality) Regulations 2016 (as amended) and DWI guidance specifically related to PFAS.Secondly, historical contamination of our source waters from PFAS is outside of management control. Reducing PFAS levels within raw water would require government intervention (for example, regulatory restrictions for PFAS), behavioural change and - for nitrate reductions - developments in optimal farming practice. Therefore end-of-pipe solutions are required to ensure high quality drinking water without further action to reduce these compounds which have already entered groundwater and surface water.

The sources of PFAS are ubiquitous within the environment. The industry Chemical Investigation Programme (CIP3) identified that domestic input was the main source of PFAS in Water Recycling Centre (WRC) final effluent. PFAS compounds are in a range of products which are used in households and manufacturing processes across the country. Historic use of PFAS already presents a risk; it is therefore outside of our control to remove historic, legacy PFAS contamination at our sources and avoid the need for treatment.

We have also taken steps to control costs and identify cost savings. The modular nitrate ion exchange plants which we have previously installed have been developed over a period of AMPs. We have worked with our suppliers to enable a more efficient construction and installation cost and to further optimise operational efficiency of the treatment process.

11.2.2 Unlocking greater value for customers, communities and the environment

Option consideration

A wide range of options have been considered to address the need to reduce the concentration of PFAS in drinking water. We started by taking a broad view of how this need can be addressed before undertaking a cost-benefit appraisal to identify which options are feasible, meet the identified need and are cost-beneficial.

In addition to considering a range of options to make raw water quality improvements, we also ensure to maintain an awareness of emerging technologies and innovations which could deliver solutions more effectively in future. We continue to observe and take part in developments with technologies related to the removal of PFAS. We will continue in AMP8 to develop understanding of the effectiveness of GAC media in PFAS removal, for example, and will continue to explore alternatives where possible.

Table 89 PFAS option consideration

No.	Option	Description	Unconstrained	Feasible
1	Catchment management	Catchment management activities has been included as part of our catchment investigations within our proposals for our AMP8 PFAS strategy. This will help inform whether the PFAS catchment risk is down to historical use or current PFAS use within the catchment. Catchment management will have no or very limited impact on historical legacy contamination in the environment. However, it does pose a potential route for control of current or future PFAS use in the catchment - for example, from businesses with a Trade Effluent Permit , which would prohibit the use of PFAS and thus could provide risk reduction from the route.	Yes	
2	Blending	Blending has been considered within our investment proposals where blend water is available. For the sites included in this investment proposal, this is applicable to those sites which currently blend for other parameters - for example, nitrate and pesticide compliance - or sites where surface and groundwater sources are blended together currently. As highlighted in the nitrate section above at one site, blending for PFAS reduction is also further impacted by the high PFAS levels in the ground water sources at tier 2 trigger levels which also are the lower nitrate sources which we use for nitrate blending, (although it must be noted they are still in excess of 50 mg/l).	Yes	Yes
3	Replacement of existing GAC media with virgin carbon	With the aim of the proposed investment being to achieve an optimised process for PFAS removal, we know that GAC media is very effective at PFAS removal and have experience of this technology. The Cranfield research undertaken informed us on breakthrough of PFAS compounds and confirmed this treatment process as effective at PFAS reduction.	Yes	Yes
4	Ion exchange	Ion exchange technology is effective at PFAS reduction, however there is currently no PFAS resin with Regulation 31 approval.	Yes	
5	Advanced oxidation	We understand advanced oxidation technology will have some effect on PFAS reduction. However, this is one of the technologies included in the Cranfield research on water treatment technologies. Further detail is provided below.	Yes	Yes
6	Enhanced GAC regeneration	Enhanced GAC regeneration at our very high risk catchment sites. Our AMP8 PFAS strategy will inform our regeneration frequency requirements. Our existing frequency is based upon pesticide removal.	Yes	Yes

A number of treatment technologies have been identified as being efficient at PFAS reduction.However, GAC media remains the main option currently with Regulation 31 approval.

We are aware of the Defra (DWI) research project being undertaken by Cranfield University Bench-Scale Water Treatment Efficacy Study of Poly and Perfluorinated Alkyl Substances (PFAS).

The research includes the following technologies: GAC, Reverse Osmosis, membranes, fluorosorb media (which is being used in the United States of America with NSF approval; however, it does not have Regulation 31 approval for use), Advanced Oxidation Reduction processes and other novel absorbents. The research is due to conclude in February 2024. We await the outputs of this research to inform our future approach to PFAS and our understanding of mitigation risk at our treatment sites.

Cost-benefit analysis

For each of the options identified in the section above we have considered where these are feasible and effective in delivering on reducing nitrate levels to below the required level.

Table 90 Feasibility assessment

No.	Option	Feasible (Y/N)	Justification
1	Catchment management	Partly	Catchment investigations will inform our risk position. As part of our AMP8 Strategy we will seek to understand any new inputs of PFAS into the catchment, we can only seek to control new inputs. Legacy PFAS is outside of our control as the source is already contaminated.
2	Blending	Y	Feasible if there is a low PFAS source available at sufficient blending capacity, and there are no other water quality parameters requiring blending. Cost effective solution.
3	Replacement of existing GAC media with virgin carbon at our very high risk catchment sites,	Y	GAC has been proven to remove PFAS substances. Cost effective solution.
4	Ion exchange	N	This is a known treatment method but does not have Regulation 31 approval, therefore it is not currently a viable option.
5	Advanced oxidation (AO)	Y	Research to date suggests that GAC and ion exchange treatment are more effective treatment processes at PFAS reduction. Not costed, although AO is energy intensive.
6	Enhanced GAC regeneration	Y	We currently do not fully understand what the increased regeneration frequencies will be. Our AMP8 strategy will inform this. Cost unknown as we do not know the regeneration frequency required over the AMP and in the future. Additionally, the 47 PFAS compounds are likely to increase, which presents a further risk in this area.

For all options, there is a risk that the number of compounds the DWI require us to sample for will increase. We currently expect a 48th compound to be added to the Annex 1 suite.

For all our high risk PFAS catchment sources, the preferred option for all our surface water sites and the five listed groundwater sites is the replacement of GAC media with virgin carbon. Enhanced GAC regeneration, through increasing the frequency of GAC regeneration at sites, was considered as an alternative option. However, at our very high-risk catchment sites we consider that virgin carbon provides a more robust reduction in risk based on draft findings by Cranfield University. This indicates that virgin replacement will optimise treatment to reduce the risk of PFAS short chain compound breakthrough and the potential for elevated PFAS levels in the final water.

We are supportive of developments in innovative solutions to addressing PFAS compounds. Through our strong links with academic partners at Cranfield University, as well as our Innovation team, we are supporting research developing innovative treatment processes. We note ion exchange is not presently a viable option for PFAS removal as this currently has not Regulation 31 approval.

For one of our sites where historic pollution from a local US military base is causing the site to trigger tier 3, we have proposed installation of a backwash water handling system to prevent any deterioration in the raw water PFAS levels from the current wash water soakaway system. Through our sampling and investigations we have identified that there is a risk that the current soakaway system which we know links directly to the aquifer from which we abstract.

At present, virgin GAC remains the most cost-beneficial option to address PFAS while minimising the possibility for compound breakthrough. GAC treatment is recognised as an effective treatment process for PFAS removal.

Our nitrate and PFAS investment proposals have been included in our third party assurance process.

Environmental and social value

We have considered the environmental and social value of our PFAS investments as part of our options consideration process. We have developed a Value Framework, structured by the Six Capitals, which allows us to express benefits and dis-benefits in a common language (£) for use in cost-benefit analysis and to inform our investment decisions. [46]

The impact values within our Value Framework are made up of both private costs (e.g. costs to resolve an incident) and societal costs. Societal costs are derived through a robust Societal Valuation Programme considering a broad range of sources where customers views, preferences and priorities are canvassed, analysed and incorporated into the values through a triangulation process. For more information on customer insight see chapter 3 Customer engagement in our plan 2025-2030

Investments benefit

We do not anticipate that this investment will create any improvement in performance for the Compliance Risk Index (CRI) performance commitment.

Each option is assessed from a benefits perspective using Anglian Water's Value Framework.

A baseline position is established that captures any current or expected impacts to service, customers, the environment, safety etc (and their respected likelihoods).

Each alternative (i.e. option) is appraised to establish a residual position, with updated impacts and likelihoods. This residual position also considers any additional benefits and dis-benefits that may apply as a result of the intervention. These could be permanent (e.g. visual impact) or temporary (traffic disruption during construction) and consider a range of environmental and social measures including both capital and operational carbon.

This investment area primarily provides benefits by supplying safe water to our customers.

46 For more information on our value framework see chapter 7 Driving cost efficiency in our plan 2025-2030

Although this enhancement investment will prevent our performance from deteriorating against CRI, we do not anticipate this investment will generate any performance improvements against the CRI performance commitment. Performance against the CRI PC will be delivered from base allowances through activities such as storage point inspections and inspection and maintenance programmes of our water treatment works. As PFAS does not have a PCV it will therefore have no impact on CRI.

The investments into our PFAS strategy will allow us to understand PFAS risks and mitigation options for the future with this emerging substance to inform future investment requirements. The wider catchment sampling, which forms part of our strategy, will not only benefit drinking water quality but also the raw water quality of surface and groundwater sources. Our company strategy will allow us to work with traders where new sources of PFAS are are identified and we then can prevent them entering the environment. This will improve Water Recycling Centres (WRC) compliance which are part of the Chemical Investigation Programme (CIP) and they will have an PFAS limit imposed in AMP8.

We are part of national groups and will continue to support research into PFAS.

Managing uncertainty

As identified in our DWI submission 'Long Term Planning for the quality of drinking water supplies', as PFAS is an emerging contaminant there is uncertainty around the risk and possible risk mitigation measures that may be required. Any new parameters and subsequent standards recommended by the Drinking Water Quality Advisory Standards Board could also result in the potential for additional treatment, in particular for those new parameters which are currently not a requirement for us to monitor for. It is possible that investment in alternative treatment technologies will be required in AMP9 in readiness to meet any future standards requirements. It is also likely that the current 47 PFAS compounds will be added to. The DWI requested information on companies risk assessments into a 48th PFAS compound on 11 September 2023; it is likely inclusion of the 48th compound into the annex list is imminent.

There is currently a degree of uncertainty on what future regeneration frequencies of GAC will need to be to maintain the optimal efficacy of PFAS removal. The length and functionality of any PFAS compounds adds to the complexity. We currently stagger our regeneration frequency therefore we have a varying number of filters at different ages at all of our sites. We have yet to fully understand an acceptable PFAS removal rate to inform what this means in terms of carbon depletion. We are looking at the percentage removal of PFAS compounds from the raw water from those sites with GAC. This will be a data-driven PFAS strategy. It will take time to gather a more comprehensive data set, to include PFAS sample results and GAC efficiency for PFAS removal at an individual site level.

The PFAS enhancement programme requires a tenfold increase in the volumes of GAC purchased from supply chains. This is a new enhancement requirement which we expect to be faced by other companies. This therefore presents a potential cost uncertainty as costs could be expected to increase from the current level we have assumed as demand outstrips supply. As a cost challenge and to support customer affordability we have constrained our costs by not applying an RPE uplift to reflect this, though this does present an uncertainty that we would need to absorb were it to materialise.

The backwash water from the GAC filters at Beck Row WTW require GAC treatment on the waste stream. We do not have GAC treatment on the waste streams of other sites which have PFAS in the raw waters. Our WRMP requires supernatant return in the future. Any returns which contain PFAS are likely to need treatment in the future

The impact and therefore quantification of success of any catchment management interventions for PFAS are currently unknown.

External funding

In principle, we support the potential for a ‘polluter pays’ approach to raw water deterioration, whereby some or all of the costs for PFAS treatment/ removal is taken up by the source polluters. However as there is no single source polluter (historic PFAS come from a range of widely used products) this is not currently possible. Therefore, we do not currently consider third-party funding for this investment to be a possibility. With our PFAS strategy polluter pays will be considered as part of our PFAS investigations and for any new sources of PFAS identified.

Direct procurement

We have considered the size and discreteness of raw water deterioration investment to understand their potential to be delivered through DPC. On an individual level, these investments do not reach the default £200m threshold for DPC.

The works required involve improvements to existing assets, which are not discrete. There are significant operational and commercial complexities involved if two parties were to construct and/or operate simultaneously on live operational assets. Accordingly, these projects have not been considered further for DPC.

Customer view

Customers support safe clean water and highlight it as a priority for investment, however customers have not been involved in the proposed solutions as part of the customer engagement work. The investment has been driven by statutory drivers and the most effective way to treat water at the proposed sites as highlighted in our cost-benefit appraisal section (section 9 above).

11.2.3 Cost efficiency

Developing costs

The development of the PFAS costs in our plan follows our cost efficiency 'double lock' approach set out in chapter 7 of our business plan. Through this approach we have ensured that are costs are efficient in their bottom-up build up, and this is cross-checked through external benchmark approaches. This section sets out how we have ensured cost efficiency of our PFAS investments through step one of our double lock approach. Step 2 is explored in the Benchmarking section below.

We have taken a robust approach to developing our PFAS costs, building on our experience from delivering similar schemes into the bottom-up development of costs (before external cost benchmarking challenges are applied in step 2 of our 'double-lock' approach). The detail of the cost development approach is set out below, along with a breakdown of costs we provide in table CW3.

Cost Estimation Methodology

We follow a common cost development methodology across our enhancement investments in a three phase process:

1. Establish cost and carbon models
2. Input the cost drivers into the model (including location specific factors)
3. Data validation, internal challenge and assurance.

In phase 2, we derived our total cost estimation for each scheme by gathering location based data which influences the cost estimates for each scheme.

PFAS enhancement investments consists of virgin GAC installation at our very high risk PFAS catchment sources. This includes all of our surface water treatment sites and 5 groundwater sources. It also includes the installation of a GAC treatment stage at our Ulceby source and Parsonage Street (Parkfield Reservoir final WTW) which currently have no PFAS treatment and have triggered tier 3 on the raw water and tier 2 on the treated water respectively.

Additionally, a backwash water handling system is to be installed at Beck Row WTW, due to known perfluoro-octane sulfonate (PFOS) contamination in the raw water supplying the site linked to activity from the local military air base.

The investment also includes catchment investigations at our highest risk groundwater sites from PFAS and enhanced and operational sampling - aligned to the DWI Information Letter 02/2023 (PFAS - Inspectorate expectations for PFAS activity in AMP8).

We derived our cost for each schemes through gathering information on a site by site basis as this data influence the assets and dimension to be included in each estimate.

For the new GAC treatment stage installation and dirty washwater handling system we considered:

- Current operability and layout
- Flow licences (max, min, peak)
- Water quality and process calculations (for example mass balance calculations)to meet DWI standards
- Site specific requirements and
- Assessment of construction constraints such as SSSI areas.

Virgin GAC media installation

- GAC number of tanks (filters) installed at each site and their current GAC media capacity
- Supplier information in regard to the type of media suitable for PFAS removal
- Logistic and cost associated to disposal of contaminated GAC media as this cannot currently be repurposed.

Investigation and sampling

- Owing that these are new activities, we have worked with a specialised third party suppliers to gather the estimates for the investigations
- Sampling costs are from our laboratory for all 47 compounds.

The table below provides a breakdown of the PFAS costs provided in data table lines CW3.132, and 3.133 and 3.99 (Freeform - PFAS capex and PFAS opex).

Table 91 PFAS AMP8 investment summary

Investment ID	Investment name	Scope	Capital Cost £000	OPEX Cost (25-30) £000
I039133	Parsonage St WTW WQ Compliance	200 m3 GAC system Dirty/Clean Washwater handling plants UV disinfection Chlorine dosing for residual in network Feed pumps system Sites Ancillaries (hardstanding,fencing, Roads, landscaping, telemetry)	11,901.7	240.7
I039195	Ulceby WTW WQ Compliance	640 m3 GAC system Dirty/Clean Washwater handling plants Feed pumps system Sites Ancillaries (hardstanding,fencing, Roads, landscaping, telemetry)	13,803.8	369.5
I039836	Beck Row WTW WQ Compliance	Dirty Washwater Tanks and Clean Washwater Tanks (DWWT + CWWT) also required. 30 m3 GAC post DWWT Various pumping sets New RTW pipework main to the River Lark	5,051.4	149.2

Investment ID	Investment name	Scope	Capital Cost £000	OPEX Cost (25-30) £000
I039910 I040027 I040029 to I040039 I040041 to I040048	GAC Media Upgrade at 20 WTW	Branston Booths(I039910), Alton (I040027), Ardleigh (I040029), Beck Row (I040030), Grafham (I040031), Clapham (I040032), Covenham (I040033), Elsham (I040034), Etton (I040035), Hall PGAC (I040048)/RGAC (I040036), Heigham (I040037), Marham (I040038), Morcott (I040039),Thorpe-Mousehold (I040041), Pitsford (I040042), Ravensthorpe (I040043),Saltersford (I040044), Stoke Ferry (I040045), Watton (I040046) andWing (I040047), Total GAC media required 16,275 m3	41,678.6	-
I040432	PFAS Investigations	5 Level 3 investigations: all groundwater sources currently triggering at Tier 1 (<10ng/l) for more than three individual PFAS, Tier 2 (>=10ng/l & <100ng/l), or Tier 3 (>=100ng/l) for any PFAS in DWI's current list. 24 level 2 investigations: Level 2: all groundwater sources currently triggering at Tier 1 (<10ng/l) for any PFAS in DWI's current list.	2,096.0	-
	PFAS Sampling programme	Cost associated to catchment sampling and Risk assessment	-	1,672.0
		Total Costs	**74,532**	**2,431**

Benchmarking

In stage 2 of our cost efficiency 'double-lock' on PFAS, we have sought a variety of methods to assess, benchmark and challenge the costs in our plan.As PFAS is a new investment area for us, as well as most of the industry at PR24, we were advised by KPMG there is unlikely to be comparable data available for benchmarking this area. We have sought alternative methods to understand the efficiency of our costs by assessing the available cost models from WRC's TR61. However, there is no data available on GAC for PFAS removal because this is a new process that required larger retention times and therefore larger tanks and associated mechanical and electrical equipment. We have therefore relied upon scheme outturn costs for our plan (for individual bottom up components of our investment) in recognition of theabsence ofreliable external top-down benchmarks we have placed significant internal scrutiny on these outturn cost data.

Scheme outturn costs

We have continuously captured outturn costs data of all projects delivered in our capital investments including granular cost components such as pipework, pumps, ion exchange system, on costs, etc. These outturn costs have been the inputs to the cost models to each specific assets. Building outturn costs into our cost assumptions in this way builds cost efficiency into the build up of costs.

Assurance

The costs estimates have been developed using our C55 costs estimation tool for which we have had third party assurance from Jacobs. AECOM has also carried out a process calculation assurance of a nitrate sample of sites which has supported our external cost benchmarking.

11.2.4 Customer protection

Customers are protected against the cancellation, delay or reduction in scope of our nitrates and PFAS investments in two main ways:

Firstly, the statutory obligations from the DWI on both our nitrates and PFAS schemes mean that in the event that any of the investment included in the raw water deterioration investment is not delivered, we will face enforcement action by the DWI.

Secondly, we have included two price control deliverables (PCDs) in our PR24 plan covering the raw water quality deterioration investment areas. These are:

- Water quality (nitrates) - this is based on the number of DWI Regulation 28 notices relating to nitrates.
- Water quality (PFAS) - this is based on the number of DWI Regulation 28notices relating to PFAS.

The investment fully aligns to statutory obligations with no discretionary areas of spend. Therefore, having protection mechanisms which relate to the statutory obligations from the DWI ensures that they cover all the benefit that the investments are designed to deliver.

12 Lead reduction

Overview

Delivering safe, clean water is the most vital service we offer, therefore we need to protect customers from the potential health risks associated with lead pipework within our network.We have developed a long-term integrated lead strategy, which addresses the highest risk locations first and places us on the right track to removal of all lead pipe by 2050.We will invest £19m to reduce the exposure of customers to lead in areas at high risk.Alongside continuing with our long-term lead pipe replacement programme, we will work with local authorities and schools to benefit the most at-risk vulnerable customers and children.

We partnered with KPMG to benchmark our costs to ensure our investment is cost efficient. We have aligned the lead communications pipe costs to be more efficient than the benchmark (£1.14k per pipe).

Table 92 Investment Summary

PR24 costs (£m)	
Capex	5.7
Opex	13.3
Totex	19.1
Benchmarking	
Method	Scheme outturn costs Ofwat cost data and models
Findings	Our historic costs have been higher than the industry benchmark so we have reduced our costs by £3m to align with the benchmark.
Customer Protection	
Performance commitment	CRI
Ofwat data table	
CW3.103-CW3.105 CW3.106-CW3.108 CW3.109-CW3.111 CW3.112-CW3.114 CW3.115-CW3.117	(Conditioning to reduce plumbosolvency for water quality) (Lead communication pipes replaced or relined) (External lead supply pipes replaced or relined) (Internal lead supply pipes replaced or relined) (Other lead reduction related activity)

12.1 Delivering for the long term

12.1.1 Investment context

This investment is driven by the need to meet the lead standard required by the Drinking Water Inspectorate (DWI) through our integrated lead strategy, creating a step change in service quality. We have an ongoing multi-AMP phased lead programme to address the highest risk locations and informing long-term planning for future investment with the ambition to remove all lead pipes by 2050.

We are committed to mitigating risks to delivering safe, clean drinking water from source to tap by addressing emerging challenges through our long-term planning approach. Customers have told us that delivering safe, clean water is the most vital service we offer, and this is therefore one of our four Strategic Direction Statement (SDS) long-term ambitions.

Lead pipework, commonly used before 1970 to connect properties to mains water networks, is a residual source of lead which can dissolve into water within the pipe. There are other sources of lead, such as lead in brass fittings, galvanised iron pipes and lead solder, which was banned for use on water systems in 1987. Although we recognise replacing lead pipes is an important priority, we must balance this replacement programme with cost and deliverability constraints through the phasing of investment into later AMPs.

The Water Supply (Water Quality) Regulations 2016 (as amended) requires us to keep lead levels in drinking water below 10 µg/l and replace the lead communication pipe where non-compliance with the standard is found. It also requires companies to inform customers of the health risks of lead and ways to reduce lead levels at the customer's tap following any infringement of the lead standard. As per the

2022-2023 APR return we reported we have an estimate of 515,073 lead communication pipes in our region. Therefore there is need for activities to reduce the potential impact of lead in water in the short term alongside lead pipe replacement programmes in the long term.

Through our Hazard and Control approach, we have developed a risk-based approach to lead and have grouped our 164 Public Water Supply Zones (PWSZs) into four categories based on the likelihood of exceeding 5 µg/l, which is half of the 10 µg/l lead standard. These risk categories are:

- High risk
- Medium risk
- Low risk
- Very low risk

Using data described in the following sections, the table below details the methodology of how each zone has been categorised using the previous 5 years worth of sample data. 'High-risk' zones are areas of the water supply network in which there is a higher probability that any consumer could ingest lead from drinking water at a concentration in excess of the water quality standard:

Table 93 Lead Risk Classification

Risk Category	Criteria	No of PWSZs
High	Any PWSZ with >5% of samples >5µg/l in zone	15
Medium	Any PWSZ with >2% and <5% of samples >5µg/l in zone	33
Low	Any PWSZ with >0 and <2% of samples >5µg/l in zone	73
Very Low	Any PWSZ with 0 samples >5% of samples >5µg/l in zone	43
	Total no. PWSZ	164

Addressing this issue requires a step-change in our strategy for our customers where they are at risk of ingesting lead from lead pipes.

One of the step changes in our AMP8 strategy is the replacement of lead supply pipes. If a lead communication pipe has been replaced, and a lead supply pipe remains there is still a risk of the property having elevated levels of lead in the drinking water. By replacing the external and internal lead supply pipe we can make the property lead pipe free to the point of compliance for the customer. In AMP7 we have carried out trials replacing lead to the point of compliance for a small number of properties. This investment allows us to take that learning and apply it to more properties in AMP8, targeting those which have had a lead failure.

12.1.2 Scale and timing

For AMP5 we developed a risk-based lead strategy aiming to deliver an integrated package of measures over the long term to ensure lead compliance for the entire Anglian region. This has been used to phase improvements over multiple AMPs to keep the levels of risk and cost acceptable to customers and regulators. We utilise a risk-based approach to assess each PWSZ against the likelihood of failing the standard for lead to determine the priority areas for each AMP. As specified by the DWI, the package of control measures (including both direct actions to control lead exposure in the supply network and approaches to protect and safeguard consumers most at risk) is applied to PWSZs based on their risk categorisation. Our lead strategy has been reviewed continuously and remains focused on delivering measures to high risk PWSZs.

For AMP8 we propose to continue delivery of our lead strategy, having reviewed it to ensure alignment with the requirements of the DWI including the report DWI 70/2/320 Long Term Strategies to Reduce Lead Exposure from Drinking Water published in 2021. The DWI's Guidance Note DWI 70/2/320 requires companies to continue to implement their risk-based approach to managing compliance with the lead standard as in previous AMPs. The timing of our interventions align with the expectations of the DWI in the document 'Long Term Strategies to Reduce Lead Exposure from Drinking Water' published in 2021 that models remediation to achieve compliance with 5 µg/l in high-risk zones by 2035 or 2040 and models no detection of lead between 2055 and 2070. We support the WaterUK Lead board ambition of becoming lead free by 2050.

We have considered the options for phasing of lead pipe replacements over the next five AMPs to achieve the lead free ambition by 2050 ambition. A completely linear profile of a lead-free objective would require the replacement of c. 125,000 lead pipes in every AMP for the next five AMPs adding c £547m, which would have significant implications on the affordability and deliverability of the PR24 plan. We also anticipate that new more effective and/or more efficient solutions could be realised over the next 25 years, rendering early action with existing technologies current options higher regret in terms of cost. We have therefore sought to phase investment in lead out beyond AMP8, with investment within AMP8 prioritising on the most high-risk areas and based upon lead trials as agreed with DWI.

12.1.3 Interaction with base expenditure

This expenditure enhances the quality of drinking water we supply to our customers by reducing the likelihood of compliance breaches at the customer's tap. We received email correspondence from DWI 5 September 2023 advising companies that '*both the lead and PFAS strategies should feature in company Business Plans and should include the appropriate costings*'. Therefore, and in line with the approach at PR19, we have considered the expenditure to reduce customers' exposure to lead to be enhancement expenditure.

12.1.4 Long term context (historic)

We have undertaken an integrated package of measures to reduce the risk from lead since AMP5. This has included enhancement investments in:

- Targeted planned replacement of lead communication pipework
- Reactive lead communication and supply pipe replacement where samples exceed the lead standard
- Replacing lead communication pipes where customers have proactively replaced their lead supply pipe
- Collaborative working with local authorities and other third parties to identify and engage with vulnerable customers (e.g. pregnant women and young children aged ten and under) as well as identify lead pipework in public buildings and social housing
- The introduction of our Lead Advice Line
- Extensive data mapping to inform where lead pipes are within our region.

The enhancement allowance requested for AMP8 builds on this previous investment, targeting areas /properties we haven't previously made enhancement investments at through prioritisation based on the likelihood of each PWSZ failing the proposed future lead standard of 5 µg/l. The enhancement also goes further than previously by offering replacement of lead supply pipes to the point of compliance to all customers who have had a sample result greater than 5 µg/l. There is no duplication of activities funded at previous price reviews.

12.1.5 Long term context (future)

Our Drinking Water Quality Sub Strategy comprises a core pathway of low regrets investment to deliver on our lead-free by 2050 ambition that enables. Our strategy recognises that the replacement of lead pipes is expensive and carbon intensive. As such, in AMP8 we have adopted a risk-based approach to the management of lead given short-term affordability and deliverability constraints, phasing investment into later AMPs. We will increase the replacement rate of lead pipes in AMP9 and beyond. [47]

47 Please refer to 2.2.3 'Drinking Water Quality' in our LTDS for more detail.

We are actively exploring longer term solutions to addressing the risk from lead. Orthophosphoric acid dosing is not a sustainable long-term measure for lead compliance. We aim to keep chemical dosing to a minimum and will continue to seek out alternatives to dosing in the long term. We aim to meet the standard for lead by replacing lead pipework, particularly where other work is being carried out for customers. We do however recognise that orthophosphoric acid dosing will need to continue and will need to be regularly reviewed and optimised to ensure that in the short to medium term we can meet the standard for lead. We recognise that to meet a proposed tighter lead standard, we will need to remove more lead, including lead supply pipes.

Some of our selected options within AMP8 are enablers for further progress and investment in AMP9 and beyond. Since 2022, we have been working with schools in the Norwich area to take samples as part of our 'Lead Free Schools' campaign, which aims to make all schools and nurseries for children under 10 lead free. Where lead is identified in samples or visibility identified, the communication pipe will be replaced. Investment is required in AMP8 to extend this scheme beyond Norwich to all high-risk lead zones to understand the scale of the challenge and begin to discuss with local authorities and those responsible for the maintenance of the schools the steps for replacing lead pipes in educational settings.

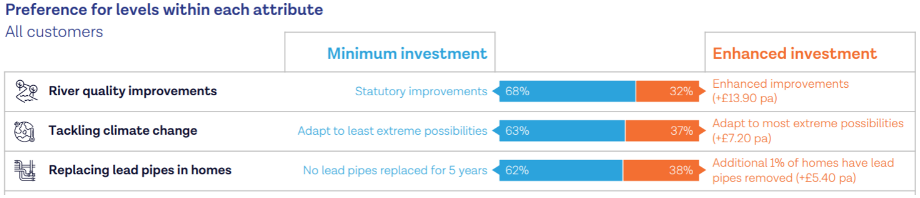
We continue to support wider industry research into innovative solutions to lead pipe replacements, with us having representation on the Wrc innovative solutions to lead identification research project which is being supported through the UKWIR lead steering group.

12.1.6 Customer support

As captured within our Customer Principles Report insight, safe, clean water is our customers fundamental expectation. Our customers are concerned about the health risk if no action is taken to replace lead pipes. However, customers recognise that replacement of lead pipes must be balanced with affordability constraints in the short to medium term.

Our customer engagement and insight showed what level of ambition customers were supportive of with respect to lead replacement in AMP8; when asked about replacing lead pipes in homes that they are supportive of no lead pipes replaced for 5 years versus an enhanced investment option of plus £5.40 per annum bill increase as shown below.62% of participants opted for the minimum investment scenario for the next five years, compared to 38% favouring further replacement of lead for a further 1% of homes with a £5.40 bill impact per annum. As such, in line with the preferences of our customers, we have phased investment in a way that limits the affordability impact of the investment on our PR24 plan whilst meeting the long-term expectations of our customers and regulators.

Figure 60 Trinity McQueen Customer Investment Priorities November 22



12.1.7 Cost control

This investment is driven by our statutory obligation under Water Supply (Water Quality) Regulations 2016 (as amended), to ensure that we are compliant with the standards. The DWI requires water companies to have a lead strategy and also to have a Water Fittings Regulation inspection programme and to enforce the Water Supply (Water Fittings) Regulations 1999.

Additionally, the DWI required companies to submit updated lead strategies as part of the water quality enhancement submissions by the end of 31 March 2023, detailing the AMP8 lead investment proposals.

Therefore, the requirement of this area is driven by statutory requirements and the scope is very clearly defined. Costs are managed through control of the supply chain and by clearly defining the scope and requirements of the investment. All opportunities for efficiency and collaborative delivery of the investments are exploited through the management of the projects.

All lead pipework was installed prior to privatisation, with the number and location of lead pipes driven by previous decision making by councils and housing developers. As such, the current investment is needed for reasons outside of our control. We have improved our understanding of which areas are more likely to have lead pipework from a desk-top exercise identifying areas with predominately cast-iron mains. Due to the timing of laying cast-iron mains, we can assume that there are more lead pipes in these areas than areas that have PVC or AC mains. This has helped us to control costs by ensuring investments are targeted based on risk.

12.2 Unlocking greater value for customers, communities and the environment

12.2.1 Option consideration

We have sought to consider a wide a range of options as possible in addressing the need to reduce exposure to lead from the water supply. We start by considering a broad range of potential (unconstrained) options including traditional engineering approaches such as lead pipe replacements and dosing and non-traditional approaches such as customer engagement and education. After identifying a range of options, we undertake cost-benefit analysis and site based considerations to identify which options could feasibly be included in the plan, this is highlighted in section 9. The following options were considered as options which could address lead, prior to further optioneering:

Table 94 Options appraisal assessment

No.	Option.	Unconstrained	Feasible
1	Replacement of lead pipes • Replacement of lead communication pipes following exceedances of the lead standard • Customer replacement requests • Planned programme of lead pipe replacement	Yes	Yes
2	Relining of lead pipes	Yes	
3	Customer control (ie education on lead, flushing pipework or using lead filters) • Collaborative working with local authorities, health professionals and UKHSA to identify 'Vulnerable' customers • Collaborative working with local authorities and housing associations to identify and develop tandem lead pipework replacement/ modification schemes • Customer education, lead identification studies and monitoring	Yes	Yes
4	Plumbosolvency control	Yes	
5	Further research into innovative approaches	Yes	
6	Customer grant for lead pipe replacement	Yes	

12.2.2 Cost-benefit appraisal

Following the consideration of each of the unconstrained options, we reviewed each of these to understand whether it was a feasible option to include in the plan. The findings of this process are summarised in the table below. In order to continue implementation of our lead strategy, we propose nine packages of control measures for AMP8, this aligns to the DWI requirement to implement a risk based approach to lead.

Table 95 Feasible option assessment

No.	Option	Description	Feasible?	Justification
Selected Options				
1	Replacement of lead communication pipes following exceedances of the lead standard	We will currently replace/or modify our lead communication pipe and advise customers regarding replacement of their supply pipe following any exceedances of the 10 µg/l standard. We will seek to understand the potential for contribution to lead levels and subsequent failure of 10 µg/l standard from water fittings in the presence or absence of lead pipework.	Yes	In AMP8 we are proposing to replace lead to the point of compliance for properties with a sample result of >5 µg/l . This will require the agreement of the owner of the property This builds upon our learning from previous trials for customer-owned lead supply pipe replacement during AMP7.
2	Customer replacement requests	Replacement/modification of lead communication pipes when customers have replaced their lead supply pipe.	Yes	We will continue to replace/modify lead communication pipes, when customers have informed us that they have replaced their lead supply pipe, in line with regulatory requirements.
3	Planned programme of lead pipe replacement	A planned replacement programme of lead pipe.	Yes	Required to meet our 2050 lead free target. The scale of the planned replacement programme phases interventions, therefore cost, over multiple AMPs while meeting regulatory requirements each AMP.
4	Collaborative working with local authorities, health professionals and UKHSA to identify 'Vulnerable' customers	Collaborative working with local authorities, Health Professionals, and the UK Health Security Agency (UKHSA) to identify 'vulnerable' customers and public buildings in high priority PWSZs. Our aim is to explore appropriate approaches to this section of the population in line with stakeholder advice, for example the promotion of lead testing and subsequent replacement/modification of lead communication pipework following exceedances of the 10 µg/l standard, educational campaigns to child care facilities targeted within our high priority PWSZs.	Yes	Collaborative working is a key element of our lead strategy, with health professionals playing an important role in the endorsement of any lead message whilst not causing unnecessary concern for our customers. For AMP8 an addition to this will be our Lead Free Schools programme in our high risk area zones, an extension of the trial we have started this AMP in Norwich.
5	Collaborative working with local authorities and housing associations to identify and develop tandem lead pipework replacement/modification schemes	Collaborative working with local authorities and housing associations to develop tandem lead pipework replacement/modification schemes whereby we will replace/or modify lead communication pipes when lead supply pipework is replaced during refurbishment of social housing association-owned properties.	Yes	Collaborative working in this area is an area identifies an efficient opportunity of removing lead pipework for example when local authority and housing association properties become void or if kitchen/bathroom modifications are being undertaken.
6	Customer education, lead identification studies and monitoring	Customer education to raise awareness of lead issues, studies into the prevalence of lead pipework, and enhanced monitoring across our region to verify the effectiveness of control measures.	Yes	DWI have a clear expectation that we provide clear advice to customers on the presence and health implications of lead pipework and actions they can take to minimise lead levels, therefore it is important that we understand what the lead risk is within our PWSZ in our region.

No.	Option	Description	Feasible?	Justification
Selected Options				
7	Seasonal dosing	Refer to 'plumbosolvency control' below.	Yes	Our seasonal dosing programme will help to lessen the impact of the warmer weather on the dissolution of lead into pipes, helping us respond to our approach to the proposed 5 µg/l limit, and any change in the lead standard during AMP8.
Options we didn't select				
9	Introduction of new plumbosolvency control	We have installed dosing units at all sites including those which supply PWSZ deemed very low-risk. We continue to optimise the orthophosphoric acid dose to maximise plumbosolvency control .	No	By the end of AMP7, we will have orthophosphoric dosing units at all WTWs.
10	Further research into innovative approaches		Partly	We continue to have representation on the WATER UK lead steering group and will actively support innovative solutions. We also will take learning from the current Green recovery schemes on working on the customers pipework.
11	Relining of lead pipes		No	We have considered relining as a control measure, however in order to meet Water UK's lead free by 2050 we would be required to replace any relined pipes before this date, increasing the overall scale of investment required. The DWI currently support replacement of lead pipes over relining, as detailed in the Guidance note: long term planning for the quality of drinking water supplies - July 2022 where they consider *'lining a medium term solution which will require further intervention'*.
12	Customer control measures only		No	We we do not consider asking customers to clear pipes of standing water through running taps a long-term solution to addressing lead in drinking water or meeting our long term lead reduction targets, although it can be an effective recommendation until lead pipe replacement is possible. This is supported by the DWI in 'Long Term Strategies to Reduce Lead Exposure in Drinking Water', along with recommendations to continue these activities in the interim.
13	Customer grant for lead pipe replacement	This could be considered as an option for properties where we technically may not be able to offer a pipe replacement, but could offer a contribution to the customer towards the cost of their supply pipe replacement.	Partly	We undertook an ncentivisation trial in AMP6. The take up rate and complexity of this approach highlighted that to do this at scale would require significant additional resource and costs, and there is the risk that this will be less effective than other options as it relies on customers taking it up.

12.2.3 Environmental and social value

Our Value Framework covers a wide range of categories and incorporates environmental and social measures (such as biodiversity net gain, carbon, traffic disruption and noise) alongside traditional measures such as flooding, interruptions to supply and pollution. This enables us to consider a broader range of benefits and dis-benefits of our investments and their alternatives, leading to investment decisions that more holistically consider value and the impacts our actions may have on the environment, customers, and communities.

This is an investment area, where the right plan can offer significant social and health benefits for communities in our region. In this investment area particular consideration was given to the following points.

WHO has changed it guidance in 2022 to state that there is no safe level of lead for all, everyone should minimise exposure. We are working to respond to a reduced lead standard of 5 µg/l to improve the overall health benefits for our customers who have a lead sample which is greater than 5 µg/l. We have included in our plan a targeted approach to offering customers a supply pipe replacement to the point of compliance, as replacement of just the communication pipe may not always secure compliance with the lead standard.

For schools in high risk PWSZ we will be proactively offering a lead sample and inspection, responding to low levels of lead detected. Targeting those most vulnerable to the health impact of lead, which are children aged 10 and under.

We are required to provide advice to customers to minimise lead levels within their drinking water, which includes flushing the tap before using for cooking or drinking purposes. The ambition to be lead free at a property will remove this requirement to flush to minimise lead level from water which has been stood in contact with a source of lead, reducing water consumption in our water stressed region.

Replacing lead pipe work proactively is a more efficient way of removing lead economically and seeks to minimise disruption to customers. Collaboratively working with organisations such as Housing Associations supports this approach.

12.2.4 Investment benefits

Each option is assessed from a benefits perspective using Anglian Water's Value Framework.

A baseline position is established that captures any current or expected impacts to service, customers, the environment, safety etc (and their respected likelihoods).

Each alternative (i.e. option) is appraised to establish a residual position, with updated impacts and likelihoods. This residual position also considers any additional benefits and dis-benefits that may apply as a result of the intervention. These could be permanent (e.g. visual impact) or temporary (traffic disruption during construction) and consider a range of environmental and social measures including both capital and operational carbon.

Across all of our replacement investment packages we will be replacing an estimated 14,794 m of lead communication pipes, 23,452 m of external supply pipe and 4,340 m of internal lead supply pipes.

Our investments to replace lead to the point of compliance will result in 1,580 properties becoming lead free (this number is dependent on customer uptake of replacement of their supply pipe). If we are able to make these 1,580 properties lead free we will be removing any requirement for the customers to flush their tap before using for cooking or drinking purpose.

2184 schools and nurseries in our high risk lead PWSZ will benefit from investigations, sampling, and lead communication and supply pipe replacements to help them to become lead free thanks to the enhancement investments we have planned in AMP8.

Failure of drinking water standards would impact on the Compliance Risk Index (CRI) as measured by the DWI. CRI will be a common performance commitment at PR24. We are aiming for full compliance with this measure.

12.2.5 Managing uncertainty

Over the long-term our lead strategy faces some deliverability risks to achieve our lead-free by 2050 ambition. We have aimed to mitigate these risks through phased investment over the course of multiple AMPs permitting flexibility to address emerging issues.

Within AMP8, there is currently uncertainty on the number of schools within our high-risk lead zones which will require communication pipe replacement. Our AMP8 lead free schools strategy will inform this knowledge gap and reduce the levels of uncertainty surrounding this investment. Until such time further detail is available, for determining cost we have assumed that schools where lead is detected from sampling will have on average of 3 communication pipes and an average 11m supply pipe length based on our existing experience.

For our reactive pipe replacement programme, we recognise that there is uncertainty around the volume of replacements that will be needed. To address this, we have established our expectations of the number we expect to be required to replace in AMP8 by projecting historical data on replacement from previous AMPs.

There is uncertainty about the number of supply pipe replacements both in the short and long term, as these are not our asset so is dependent on customer up take. Current industry research shows that customers are unlikely to replace their lead pipe due to the cost, followed by the disruption and then a lack of lead being a priority for them. There is further research to be undertaken here through the UKWIR lead steering group.

Other deliverability risks for delivering these improvements before 2050 include a national shortage of specialists in the teams who replace lead pipes, especially at the large volumes we expect to see in future AMPs, and the potential for another significant increase in the cost of phosphate in AMP8 as seen in AMP7. Our investment intends to minimise the risk of these two factors, by 1) developing capacity and capability in the supply chain to resource greater levels of activity in future AMP's to ensure the delivery of this strategy, and 2) developing a plan for strategic dosing on the most at-risk sites if a shortage in phosphate does transpire.

12.2.6 External funding

No third party funding is reflected in our PR24 lead reduction enhancement investments. For our planned communication pipe replacement programme we will seek to find opportunities to carry out tandem replacements work with Local Authorities to replace lead supply pipes for the properties which they are responsible for.

12.2.7 Direct procurement

The investments do not meet the size criteria for consideration as DPC schemes on an individual or collective basis. Accordingly they have been discounted from further consideration for DPC.

12.2.8 Customer view

As highlighted in the customer support section above, we have developed a scale of programme which is supported by customers. We have reflected customer views on the relatively high cost of lead reduction for the benefit delivered (despite the efficiency of our costs (see 'Cost efficiency' section below) in our approach to identifying innovative approaches to lead reduction in future.

12.3 Cost Efficiency

12.3.1 Developing costs

The development of the lead reduction costs in our plan follows our cost efficiency 'double lock' approach set out in chapter 7 of our business. plan. Through this approach we have ensured that are costs are efficient in their bottom-up build up, and this is cross-checked through external benchmark approaches. This section sets out how we have ensured cost efficiency of our lead reduction investments through step one of our double lock approach. Step 2 is explored in the Benchmarking section below.

We have taken a robust approach to developing our lead reduction, building on our experience from delivering similar schemes into the bottom-up development of costs (before external cost benchmarking challenges are applied in step 2 of our 'double-lock' approach). The detail of the cost development approach is set out below, along with a breakdown of costs we provide in table CW3.

Cost Estimation Methodology

We follow a common cost development methodology across our enhancement investments in a three phase process:

1. Establish cost and carbon models
2. Input the cost drivers into the model (including location specific factors)
3. Data validation, internal challenge and assurance.

In phase 2, we derived our total cost estimation for each lead strategy scheme by gathering location based data which influences the cost estimates for each scheme, including:

Lead Pipe replacement programme

- Historic average length of pipe replaced, captured on the schemes delivered in AMP7.

Domestic - 1,580 replacements

For domestic properties where we will replace both the communication pipe and supply pipe to the point of compliance for samples greater than 5 µg/l has been estimated using historic date of the number of sample results >5 µg/l from 2016 to 2022 and the number of pipe replacements completed in those years.

Schools - 552 replacements and 300 in Norwich

The number of pipes in schools has been estimated using data from the Department of Education Website, and nursery data as held on our internal systems for schools in our high risk lead PWSZ, with the exception of those in Norwich, as these communication pipe replacements (100) would have taken place in AMP7. We have estimated an average of three points on entry per school.

Communication Pipe Only - 2,420 replacements

2,000 planned replacements maximising collaborative working. 420 pipes replaced from our Development Services team has been estimated using historic replacements data from AMP7, up to October 2022. An average of 7 replacements take place per month, so this is the figure which has been used for planning.

Costs have been developed from out turn AMP7 costs to capture efficiencies already achieved from the delivery of our lead strategy in previous AMPs. The costs for communication pipe replacement is based on cost base models which are validated models based on current out turn costs, which captures this embedded efficiency.

Table 96 AMP8 lead investment summary

Investment ID	Project name	Scope	Avg Length (m)[a]	Quantity	Capital Cost £k	OPEX Cost (25-30) £k	Unit rate £k/pipe
I040270	Lead Strategy Pipe Replacement (Supply) at 5 µg/l	Customer supply External	11	1,580		3,522.28	2.23
		Customer supply Internal	1	1,580		880.57	0.56
I039557	Lead Strategy Pipe Replacement (comms) at 5µg/l	Customer comms only	3.25	1,580	1,416.85		0.90
I034859	Lead Strategy Lead In schools (comms)	Trial at 184 schools, average 3 comms pipes per school		552	929.39		1.68
I040269	Lead Strategy Lead In schools (supply)	Schools supply External 184 schools +100 Norwich school Average 3 section of external pipe	11	852		2,529.47	2.97
		Schools supply Internal 184 schools +100 Norwich school Average 3 section of internal pipe	5	852		632.37	0.74
I039558 I039571	Lead Strategy Planned Pipe Replacement (Comms)	Customer comms only	3.25	2,420	3,430.36		1.42
				Total	5,776.60	7,564.69	

a Length; AMP7 data has proven that replacement of lead supply pipes in properties developed in the earlies 60's in the East of England tend to have in average larger areas of private front garden to the point of compliance (kitchen tap) which range can vary from 9 to 22m

Table 97 Lead pipe investment summary

	Quantity	Capital Cost £000	OPEX Cost (25-30) £000	Unit rate £000 /pipe
Comms	4,552	5,776.60		1.27
Supply External	2,432		6,051.76	2.49
Supply Internal	2,432		1,512.94	0.62
Total cost per pipe (comms+supply)				4.38

Conditioning and Other Lead Reduction

- The estimated use of phosphate for summer dosing has been calculated at 1590 tonnes, using WTW site flow and setpoints from summer 2022.

  It is worth noting that the unit rate for Orthophosphoric acid has tripled in costs in the last 4 years due to China stopping all production and the Fertiliser Market demand increase; this has put pressure in the chemical supply market which is primarily sourced by Israeli Chemicals.

- With the additional work planned for AMP8, we have identified an additional 3 full time employee roles will be required to respond to the increase in customer responses and lead pipe replacements to sample results >5 µg /l and also the work to promote and manage the lead free schools initiative and samples result from this project.
- Customer education - this is based upon the historic number of advertising in educational magazines, TV adverts and customer engagement events. Due the nature of these activities, we have contacted our framework suppliers to provide the cost for these activities.

Table 98 Wider lead strategy costs

Investment ID	Project name	Scope	CapitalCost £000	OPEX Cost (25-30) £000
I034480	Lead Strategy - Seasonal Phosphate Dosing	Seasonal summer dosing at 42 sites to keep to the 5 µg/l standard (321 tonnes per year)		4,371
I034842	Lead Strategy Resourcing	3 Full Time Employees		844
I034860	Lead Strategy Customer Education	Comms and education		97
I034861	Lead Strategy Sampling	Sampling , introduction of NVVS and social housing sampling		407
Total				5,719

12.3.2 Benchmarking

In stage 2 of our cost efficiency 'double-lock' on lead reduction , we used a variety of methods to assess, benchmark and challenge the costs in our plan. We have principally used a combination of similar scheme outturn costs and Ofwat data and cost models.

Scheme outturn costs

All our unit rates are based on the outturn cost and assets characteristics that we collected from completed schemes. We have ensured efficient costs are built into the plan by using out turn cost data, and particularly using the more efficient rates where communications and supply pipes have been replaced at the same time, benefitting from economies of scale.

Ofwat data and cost models

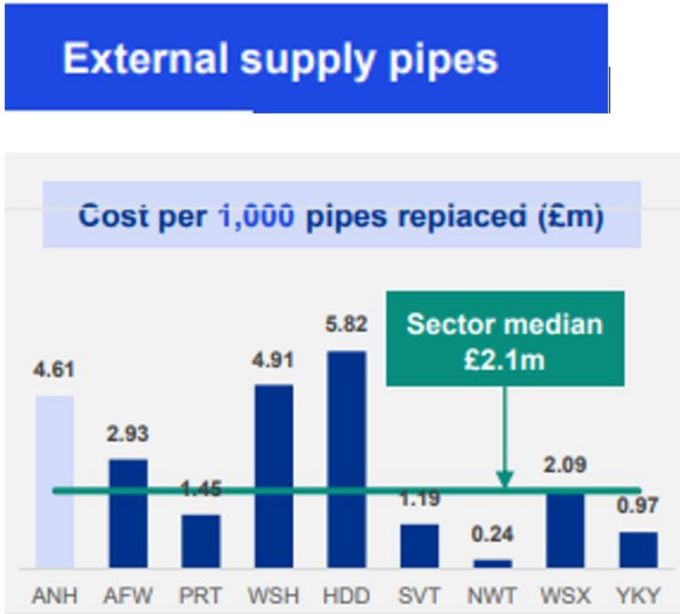
For lead pipe replacement programme, we have benchmarked our costs using data from PR19, APRs and a specific data request from Ofwat to understand unit costs and modelled costs for lead pipes on the basis of cost per pipe replaced and cost per length of pipe replaced. KPMG's findings were that for communications pipes "*The most credible unit cost for the replacement of lead communication pipes is c.£1.4m per 1,000 pipes (£1,400 per pipe), within a range of £1.3m to £2.0m.*" The range of cost benchmarks that KPMG reached using each of these methods is summarised in the table below.

Table 99 Unit cost benchmarks for lead pipe replacement

	Average unit cost (£m/1,000 pipes replaced)
Communication pipes, PR19 business plan data	1.4
Communication pipes, APR data (2012-2022)	1.3
Communication pipes, special data request	2.0
External supply pipes, special data request	2.1

The bench marking allows us to challenge further our efficiencies achieved in AMP7. We have aligned our costs to ensure that they are more efficient than the most credible unit cost benchmark of £1.4k per pipe at an average level (noting for example that reactive replacements typically cost more than planned replacements). As shown in the table above, we now have an average unit cost of £1.27k/ pipe.

Figure 61 Lead pipe benchmarking



On supply pipe replacement, KPMG assessed the data available for the external and internal supply pipe replacements. For external supply, it highlighted that "*The median cost of replacing an external lead supply pipe is comparable to that of a communication pipe, with a median unit cost of just over £2.1m per 1,000 pipes replaced (2017-2018 prices) The unit cost decreases with a larger volume of work in a comparable rate to the unit cost on communications pipes.*"

We have used the outturn cost data from those projects with a unit cost £2.49k/pipe for external pipes and and £0.62k/pipe for internal. KPMG has advised that, on average, our costs are in line with the overall benchmark for lead pipe replacements.

12.3.3 Assurance

Our cost estimation approach has been assured by an independent third party (Jacobs) and the cost bench marking for the lead pipe replacement we have used to validate our costs has been carried out independently by KPMG.

12.4 Customer Protection

Our investment in lead reduction has been built to align with statutory guidance. We will engage and provide updates to the DWI on the progression of our lead strategy to ensure we are meeting the customer expectations which have informed our PR24 investment. As this is a statutory area of investment and the total cost falls below the materiality threshold for a PCD, we have not included a specific customer protection mechanism for lead reduction within our plan.

Customers are also protected through the Compliance Risk Index (CRI) common performance commitment.

13 Improvements to taste, odour and colour

Overview

It is possible for traces of substances from raw water, and treatment processes, to give rise to taste or odours to drinking water that are detectable by customers and by laboratory tests. This water is safe to drink, but may have an undesirable taste, odour or colour. For the three sites (twoWater Treatment Works (WTW) and one source water) where we require investment the taste and/or odour has been detected in our laboratory sampling but we have not received related taste or odour complaints from customers in the downstream Public Water Supply Zones (PWSZs).

To deliver on this strategy, we will invest £4m at three sites to reduce the risk of the laboratory detected taste and odours impacting the taste and odour of water for the 90,000 customers in the associated PWSZs

Table 100 Investment Summary

PR24 costs (£m)	
Capex	3.7
Opex	0.1
Totex	3.8
Benchmarking	
Method	Scheme outturn costs Industry cost models from TR61
Findings	Our costs align with the industry benchmark.
Ofwat data table	
CW3.91-CW3.93	(Improvements to taste, odour and colour)

13.1 Delivering for the long term

13.1.1 Investment context

We are committed to mitigating risks to delivering safe, clean drinking water from source to tap by addressing emerging challenges through our long-term planning approach. Customers view that delivering safe, clean water is the most vital service we offer, and is one of our four Strategic Direction Statement (SDS) long-term ambitions; this outcome captures the aesthetics of the drinking water our customers receive.

It is possible for traces of substances from raw water, and the treatment processes, to give rise to taste or odours to drinking water that are detectable by customers and by Laboratory tests. This water is safe to drink, but may have an undesirable taste and odour. For the three sites where we require investment the taste and/or odour has been detected in our laboratory sampling but we have not received related taste or odour complaints from customers in the downstream PWSZs. The DWI standard is that samples for taste and odour must be 'acceptable to consumers and no abnormal change', as stated in the Water Supply (Water Quality) Regulations 2016 (as amended).

Our PR24 plan includes investment at three sites to address existing issues and improve service:

- Bocking (source) - odour
- Codham WTW - odour
- Earls Colne WTW - taste and odour

Codham raw water contains hydrogen sulphide, thus the requirement for the existing aeration stage. The majority of the final water odour detections from the final water regulatory compliance sampling point have had the descriptor 'bad egg'.

Bocking raw water sources have very similar water quality with notable quality challenges being from ammonia, iron, manganese and hydrogen sulphide. Thus the requirement for the existing packed tower aerator for hydrogen sulphide reduction. The majority of the partially treated water odour detections have had the descriptor 'bad egg'.

Earls Colne raw water source does not contain hydrogen sulphide, although the raw water sources have similar water quality with notable quality challenges being from ammonia, odour, iron, fluoride and sodium. The majority of the final water odour detections from the final water regulatory compliance sampling point have had the descriptor 'musty'.

Odour removal plans have been developed following extensive site investigations after repeating quantitative odour and or taste detections from the final water compliance sampling points of the sites named above. To ensure the robustness of the treatment process in minimising the risk of taste and or odour, the proposed investment introduces:

- Additional aeration and a redox tank
- Provision of unchlorinated wash water and UV installation
- Clean wash water tank and backwash pumps

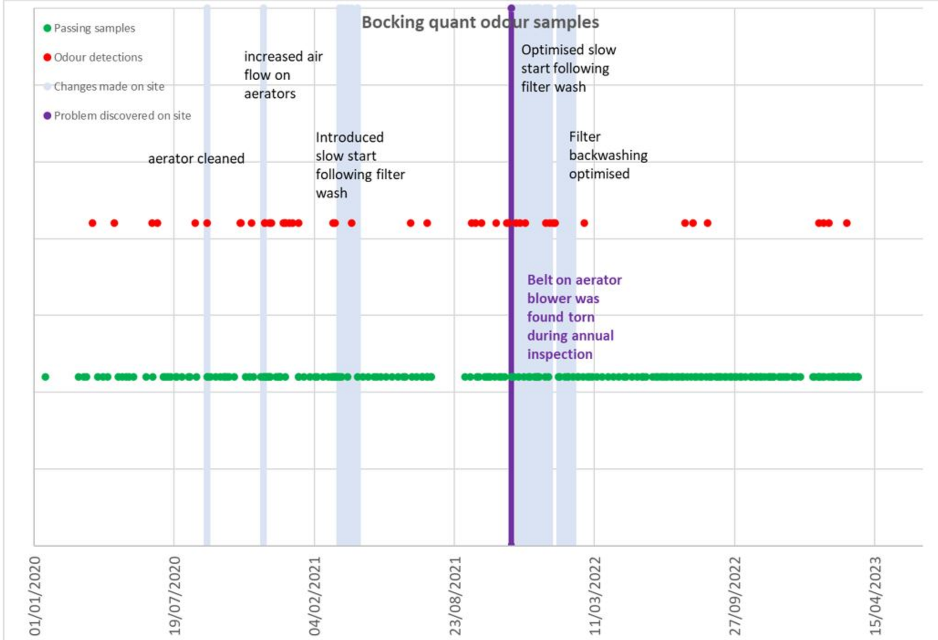
We submitted our strategy to reduce the risk of odour and taste to the DWI on 31 March 2023. All of our taste and odour investments have been supported or commended for support by the DWI.

13.1.2 Scale and timing

As we propose only a limited programme to address existing issues and improve service to meet regulatory requirements, we consider this feasible to deliver entirely within AMP8. We only propose schemes where the DWI will have issued decision letters either commending for support or providing letters of support and subsequently Regulation 28 notices (where applicable) with AMP8 completion dates. DWI letters of support / commend for support for these schemes were received on 31 August 2023.

The three sites where we are investing cover two PWSZs where we currently have Regulation 28 notices for; Braintree and Bocking PWSZ (which is supplied by the Bocking source and Codham WTW) and Halstead Rural PWSZ which is supplied by Earls Colne WTW for the risk of taste and/or odour with the associated risk of failure of the upstream asset. Following extensive investigations in response to repeat quantitative final water sample taste and/or odour detections, we identified that further work was required to optimise the treatment process with the introduction of odour removal plans. As an example, the following chart shows odour detections from Bocking WTW treated water from January 2020 to March 2023, and was included in our strategy submission to the DWI.

Figure 62 Odour detections: Bocking water treatment works



In response to this, we developed odour removal plans using desktop and onsite investigations, trend analysis and sampling for each site. The plans identify and document how the treatment works and sources should operate to minimise the chance of any odour detections (and associated taste detections), and details actions to be taken following an odour detection.

13.1.3 Interaction with base expenditure

This investment is considered enhancement expenditure (rather than base) as it enhances the quality of drinking water we supply to our customers by building upon the existing odour removal optimisation work undertaken at the named sites. It involves the installation of additional treatment stages and introduces a solution to reduce the disruption of the biological activity on the filtration stage.

13.1.4 Long term context (historic)

We have not previously submitted any investment for base or enhancement specific to taste and/or odour risk reduction following repeat taste or odour detections from these three sources.

13.1.5 Long term context (future)

We are committed to our SDS ambition of making the East of England resilient to the risks of drought and flooding. Building on our SDS ambitions, our LTDS Drinking Water sub strategy comprises of activities to manage taste and odour issues at water treatment works.

In our LTDS, we have taken a pragmatic approach to addressing taste and odour in the long term and assumed similar levels of expenditure in AMP9-12 to those we require in AMP8 as we have not seen an increasing risk profile. Therefore, the strategic investments we considered comprise of schemes that can be deployed with a specific AMP as needs are identified. As a result, this approach avoids any investments that may not be required in the long term. Our AMP8 investment is therefore also low regret as it avoids investments that may not be required in the long term, only responding to Regulation 28 notices as required.[48]

13.1.6 Customer support

We have engaged extensively with our customers to inform our AMP8 water quality strategy, with insight compiled and synthesised in our Customer Synthesis Report. Across our insight, although our customer evidence shows that water quality remains a high priority for our customers for PR24, the limited scale of investment at AMP8 reflects that most Anglian Water customers are content with the aesthetics of water and instead prioritise water safety. According to a recent nationwide study (CCW's Water Matters 2020-21 customer satisfaction research) 93% of participants were satisfied with the appearance of water . In Customer Investment priorities Wave 4 April 2023 conducted by Trinity McQueen, 80% of customers put safe, reliable drinking water in their top 3 priorities, but safety was much more important than appearance. However, we have not specifically conducted any customer engagement directly on the three sources requiring investment.

13.1.7 Cost control

The odour and or taste risk outlined in the sections above are primarily caused by naturally occurring compounds (such as hydrogen sulphide) in the raw water sources which are outside management control. We have undertaken optimisation work and introduced odour removal plans on all three sites and have identified further investment is required.

48 For more detail, please refer to Section 2.2.3 'Drinking Water Quality' in our LTDS.

13.2 Unlocking greater value for customers, communities and the environment

13.2.1 Option consideration

The investments at all three sites relate to enhancement on the optimisation of the filter operation and washing processes as identified in site-specific odour removal plans. To address taste and/or odour notices at the three sites, we considered the following options:

Table 101 Options appraisal assessment

No.	Option	Unconstrained	Feasible
Bocking			
1	Provision of unchlorinated water wash water and UV installation	Yes	Yes
2	Filter run to waste following a filter wash	Yes	No
3	Wash water de-chlorination	Yes	No
Codham			
1	Installation of a more effective aeration system	Yes	Yes
2	Installation of an additional filter to provide further capacity at the site	Yes	No
Earls Colne			
1	Clean wash water tank and backwash pumps	Yes	Yes
2	Filter run to waste following filter washing	Yes	No

13.2.2 Cost-benefit appraisal

The derivation of the benefits that form part of our cost benefit analysis (CBA) consists of two parts, the private value (i.e. the direct cost to Anglian Water avoided by improving service) and a societal/environmental value (i.e. the customer valuation of the benefit of improving service. This is derived predominantly from our willingness to pay research). The table below outlines the selected option for addressing odour and/or taste risk at each site, and the justification why this option was selected during the optioneering process. More detail on optioneering for each site is available in our proposals submitted to the DWI on 31st March 2023. For drinking water quality improvements, we have a series of measures we use to assess the benefit of investment. These include physio-chemical (iron, manganese and turbidity), hydrocarbon and solvents, pesticides, lead, nickel, nitrate and 'other' chemical parameters.

There are other measures which we may consider appropriate to include in the CBA depending on the individual case (i.e. microbiological, aesthetics, Water Quality Notices (i.e. boil/do not drink/do not use)) along with a set of common (water/wastewater) measures such as prosecution. We assess the pre and post-investment position in terms of number and likelihood of failures per year, the number of properties or population affected, and the severity of the failure (where appropriate) over a 40 year period. The private and societal values are then applied to provide the overall calculation of benefit. This is then assessed against whole life cost to produce a 'value' score, which is the difference between the discounted sum of benefits over the discounted sum of costs over the 40 year period (this is based on Ofwat guidance at PR09 and is now used as an industry standard). Where this is positive, we can conclude the investment is cost beneficial. We have determined that the proposed investments are cost beneficial.

Table 102 Feasible option assessment

No.	Option	Feasible?	Justification
Bocking			
1	Provision of unchlorinated water wash water and ultra violet disinfection to replace the current chlorine disinfection and residual disinfectant dosing.	Yes	Our sampling investigations have shown that biological activity is lower immediately after a filter back wash has taken place.
2	Filter run to waste following a filter wash	No	The filter run to waste was rejected as an option as it was not seen as a sustainable solution for the environment following the license reduction discussions at Bocking source with the EA. This is also in conflict with our forward WRMP requirement for supernatent return.
3	Wash water de-chlorination	No	Wash water de-cholorination was not seen as the preferred option due to the requirements for additional chemical usage
Codham			
1	Installation of a more effective aeration system	Yes	Proven technology for reducing risk of odour from site Sampling investigations shown further optimisation of the existing aeration system is not possible, therefore requires additional treatment
2	Installation of an additional filter to provide further capacity at the site	No	An additional filter was rejected due to the inherent risk that it may not improve the overall risk position
Earls Colne			
1	Clean wash water tank and backwash pumps	Yes	Deemed the most viable option considering the site is subject to potential license reductions. Our sampling investigations have shown that biological activity is lower immediately after a filter back wash has taken place.
2	Filter run to waste following filter washing	No	The filter run to waste was rejected as an option as it was not seen as a sustainable solution for the environment following the license reduction discussions at Earls Colne source with the EA. It is also more expensive than our preferred solution, and requires the use of additional chemicals. This is also in conflict with our forward WRMP requirement for supernatent return.

13.2.3 Environmental and social value

For Bocking and Earls Colne WTW the preferred options selected have taken into account benefits of the environmental impact compared to the other options proposed. For example, the preferred option has a lower water usage compared to options of filter running to waste. In areas which are already subject to sustainable abstraction license restrictions, and supply demand challenge having an additional run to waste requirements would not be seen as a suitable use of water. This is also in conflict with our forward WRMP requirement for supernatent return. The wash water dichlorination option will require the use of additional further chemicals to dechlorinate the water which will increase our carbon footprint in terms of chemical usage production and, additional deliveries to site.

For Codham the options were limited in terms of addressing the water quality risk. The alternative option had uncertainty around it actually addressing the risk. The chosen solution is proven technology. However an additional filter would increase water usage across the WTW, specifically in terms of demand for filter wash water.

13.2.4 Investments benefit

We do not anticipate there will be any benefits to performance for the Water Quality Contacts PC from our AMP8 enhancement programme. We propose enhancement investment to address additional risk mitigation being required to three taste and odour Regulation 28 Notices following odour detections from the regulatory monitoring point final water samples. This is not related to customer complaints rather addressing real risks at the works, not for water in distribution. As such, this will not lead to any noticeable impact on our performance against this performance commitment, as captured in CW15.

13.2.5 Managing uncertainty

The DWI have supported the solution for Codham WTW as it involves additional aeration and the requirement for a redox tank to stabilise the raw water chemistry, therefore there is certainty around the solution.

From the DWI decision letters, for Braintree and Bocking the DWI commends for support the delivery of the scheme “in order to secure or maintain drinking water quality. There is a clear need for a long term solution for odour issues, given the repeated failures in the zone. At present, the interim mitigation is working in the short term. The company are yet to prove the long term solution will work”. For Earls Colne DWI commends for support the delivery of this scheme “in order to secure or maintain drinking water quality. This is due to the solution not yet being trialled and so its effectiveness is not yet proven.”

Both of these have more uncertainty around the solution, however DWI do state that “We confirm that the proposed scheme is consistent with the Inspectorate’s guidance on principles for the assessment of drinking water quality provisions within the PR24 process, as set out in the Guidance Note: Long term planning for the quality of drinking water, in September 2022.”

13.2.6 External funding

Given the materiality of this investment and that the benefits accrue directly to water customers, we do not expect to secure third-party funding for this activity.

13.2.7 Direct procurement

The investment at the three sites do not meet the size criteria for consideration as DPC schemes on an individual or collective basis. Accordingly, they have been discounted from further consideration for DPC.

13.2.8 Customer view

Our approach to taste and odour investments is consistent with customer views on the scale and timing of this investment. Given the small materiality of the investment and the site specificity of what we are proposing we have not tested the specific solutions with customers.

13.3 Cost efficiency

13.3.1 Developing costs

The development of the improvements to taste, odour and colour costs in our plan follows our cost efficiency 'double lock' approach set out in chapter 7of our business. plan. Through this approach we have ensured that are costs are efficient in their bottom-up build up, and this is cross-checked through external benchmark approaches. This section sets out how we have ensured cost efficiency of our improvement to taste, odour and colour investments through step one of our double lock approach. Step 2 is explored in the Benchmarking section, below.

We have taken a robust approach to developing our improvements to taste, odour and colour costs, building on our experience from delivering similar schemes into the bottom-up development of costs (before external cost benchmarking challenges are applied in step 2 of our 'double-lock' approach). The detail of the cost development approach is set out below, along with a breakdown of costs we provide in table CW3.

Cost Estimation Methodology

We follow a common cost development methodology across our enhancement investments in a three phase process:

1. Establish cost and carbon models
2. Input the cost drivers into the model (including location specific factors)
3. Data validation, internal challenge and assurance.

Phase 2; We derived our total cost estimate for each scheme through the following process:

This enhancement investment proposes to install retrofitting of equipment assets that allow management of odour and or taste in drinking water.

We derived our costs for each scheme by gathering site by site data which influence the cost estimates for each site, including:

- Current operability
- Current flow licences (max, min, peak)
- Process Mass balance
- Site specific requirements
- Assessment of construction constraints.

The key cost assumptions and estimations have been built using both the cost models applicable to each asset and the on-site design information to inform our cost estimation for PR24.

The table below provides a breakdown of the taste and odour costs provided in CW3.

Table 103 AMP8 odour investment summary

Investment ID	Project Name	Scope	Capital Cost £m	OPEX Cost (25-30) £m
I034354	Bocking WTW Water Quality Odour	*UV unit to treat 5 ML/D and kiosk to in house it *Chlorination dosing point post UV treatment to maintain residual level *Interconnecting pipeworks from existing plant *Sites Ancillaries (hardstanding, telemetry)	1.792	0.043
I034353	Codham WTW Water Quality Odour	*Redox system-Installation of aggressive aeration system to strip out H2S and Redox tank to stabilise chemistry. Flow 4.6 MLD *Interstage Pumps 6.5 kW	1.151	0.010
I034823	Earls Colne WTW Taste and odour	*A new clean wash water tank 75m³ that contains unchlorinated water. Unchlorinated wash water to be taken post filter pre chlorination. *New 20kW backwash pumps to provide higher backwash velocity	0.699	0.029
I038846	Regional Retiring Redundant Mains	*Valves fittings *Water main Cut and cap	0.117	
Total			3.760	0.082

13.3.2 Benchmarking

In stage 2 of our cost efficiency 'double-lock' on improvements to taste, odour and colour, we used a variety of methods to assess, benchmark and challenge the costs in our plan. We have principally used cost evidence from

- Scheme outturn costs
- Industry cost models from TR61

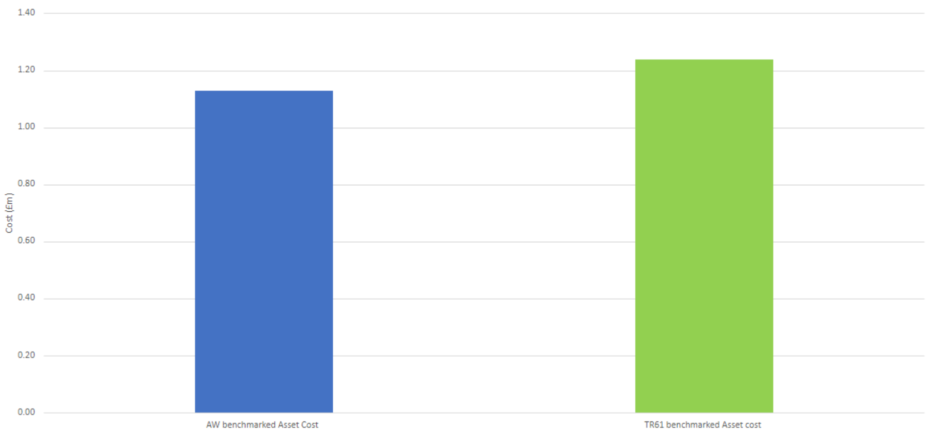
Scheme outturn costs

We have continuously captured outturn costs data of all projects delivered in our capital investments including granular cost components such as pipework, pumps, motors, PLC, tanks, on costs, etc. These outturn costs have been the inputs to the cost models to each specific asset. Building outturn costs into our cost assumptions has been done in a way which ensures that any economies of scale achieved through the delivery of these assets in other programmes are embedded in the estimations.

Industry cost models from TR61

For taste and odour, we have sought assurance on the efficiency on the costs through by benchmarking to the available cost models build by WRCs TR61. £1.1m of the costs in our plan had comparable benchmark with TR61 and the the graph below shows that our benchmarked costs are lower than the industry benchmark.

Figure 63 Taste and odour direct cost of asset only benchmarked to industry data TR61



Across the evidence from scheme outturn costs and TR61 cost comparison, we have confidence that the costs included in our plan represent efficient costs for taste and odour investments.

13.3.3 Assurance

The development of our costs within our cost estimation system (C55) have been assured by Jacobs. Our cost estimation process was assured by Arup.

13.4 Customer protection

As this investment aligns with statutory obligations from the DWI, customer are protected through enforcement action from DWI. We have not proposed an additional PCD for this investment as it falls well below the materiality threshold for PCDs.

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