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3.3.2 ESSEX RESILIENCE - ABBERTON TO HANNINGFIELD TRANSFER MAIN

TABLE WS2: WHOLESALE WATER CAPITAL AND OPERATING ENHANCEMENT EXPENDITURE BY PURPOSE

LINE 14: RESILIENCE

July 2019

3.3.2 ESSEX RESILIENCE - ABBERTON TO HANNINGFIELD TRANSFER MAIN

Name of claim	Abberton to Hanningfield raw water transfer
Business plan table lines where the totex value of this claim is reported	WS2 – Wholesale capital and operating expenditure by purpose Line 14 Resilience
Total value of enhancement for AMP7	£20.35m
Total opex of enhancement for AMP7	£0m
Total capex of enhancement for AMP7	£20.35m
Remaining capex required after AMP7 to complete construction	Expected to complete schemes by 2025
Whole life totex of claim	n/a
Do you consider that part of the claim should be covered by our cost baselines? If yes, please provide an estimate	No
Materiality of claim for AMP7 as percentage of business plan (5 year) totex for the relevant controls	1.69%
Does the claim feature as a Direct Procurement for Customers (DPC) scheme? (please tick)	No
Need for investment/expenditure	Raw water transfer capacity resilience
Need for the adjustment (if relevant)	Customer protection from loss or reduction of service risk
Best option for customers (if relevant)	Refer to main text of business case
Robustness and efficiency of claim's costs	Refer to main text of business case
Customer protection (if relevant)	Refer to main text of business case
Affordability (if relevant)	Refer to main text of business case
Board Assurance (if relevant)	Refer to main text of business case

Contents

Executive summary

This business case presents the need for a single scheme to enhance supply resilience in Essex through improved raw water transfer capability. The proposed solution is an interconnecting pipeline from Abberton reservoir to Langford bankside storage with 50Ml/d transfer capability. Existing assets will then be used to transfer water from Langford to Hanningfield WTW. The interconnector addresses a resilience gap in the Essex water resource zone. The design of the scheme prevents the transfer any invasive non-native species (INNS).

Need

There is an increasing risk that we will be unable to meet demand in parts of the Essex water resource zone (WRZ) as a result of drawing down Hanningfield reservoir. The WRZ as a whole has ample resources to meet demand for the next 40 years. However, limitations on our raw water transfer could create localised water shortages. Reservoir drawdown at Hanningfield could occur as a result of a number of factors including:

- Knock on impacts from an increase in algal blooms, especially in Abberton reservoir;
- Reduced rainfall across the region;
- Population growth;
- Increased peak water demand periods during the summer months;
- Uncertain availability of the Ely-Ouse transfer.

Defra and the EA are supportive of the need for this resilience enhancement. The scheme has been included in the Essex Water Resource Management Plan at Defra's request.

In addition, this was one of three schemes collectively tested with customers which achieved 89% acceptance. This included illustrative costs and the fact that all our customers will pay for enhancements even if they do not directly benefit due to where they live.

Options considered

We have considered three main options in response to this growing risk. We have looked at the viability of deferring an intervention but consider that the risks are too high. Our default option was to invest in increased treatment capacity at Layer WTW from 145Ml/d to 165Ml/d, based on a feasibility study which was completed at the time of the Abberton reservoir enlargement. However, we have identified that the most cost-beneficial solution to this risk is a new raw water pipeline which will transfer water from Abberton reservoir to support Hanningfield reservoir and rebalance abstraction across the WRZ.

Connection with Layer DAF scheme

We are proposing a raw water deterioration scheme to add Dissolved Air Flotation (DAF) to the existing treatment process at Layer WTW. This additional treatment process will restore the deployable output of Layer WTW to pre-2016 levels, but it will not address the other risks which could lead to water supply shortages at Hanningfield reservoir. This interconnector scheme is required to maintain raw water availability to Hanningfield WTW to make full use of its treatment capacity.

Need for enhancement

This resilience enhancement business case is about multiple issues which combine to make one strategic risk. In recent years Hanningfield reservoir raw water levels have been drawn down to below historic minimum levels. A number of factors combine to increase the risk of this happening in future and further incidents could lead to a prolonged and widespread supply failure.

We do not have raw water resource deficit or treatment constraints which will prevent us from meeting current and future customer demand in the Essex region. Rather, we lack raw water transfer capability to fully utilise the water stored at Abberton across the wider Essex region. The Environment Agency (EA) agrees that the issues experienced in 2016 and 2018 were due to limitations in raw water transfer capability rather than a resource deficit.

Figure 1: Essex water resource zone schematic

Failure mode

This proposed resilience investment is not about asset failure, but aims to address the growing risk of supply issues resulting from a combination of factors which will increasingly impact on our ability to meet water demand in future:

- Knock on impacts from an increase in algal blooms, especially in Abberton reservoir;
- Reduced rainfall across the region;
- High projections of population growth;
- Increased peak water demand periods during the summer months;
- Uncertain availability of the Ely-Ouse transfer.

Algal blooms

The Essex water resource zone (WRZ) has five Water Treatment Works (WTW) producing over 98% of the potable supplies. Small ground water well sources make up the remaining 2%. We have seen a significant deterioration in water quality over recent years which has particularly affected treatment capacity at Layer, Langham and Chigwell WTWs. These works have slow sand filtration (SSF) while Langford and Hanningfield WTWs use physico/chemical treatment which can process algal blooms in their source water far more effectively than the current SSF works. This can be seen by the recorded outage at each works in Table 1.

Table 1: Essex WRZ outage assessment from 2012/13 to 2016/17 taken from the 2018 draft WRMP

Water Resource Zone		Raw Water Source	Planned	Unplanned - Algae	Unplanned - Nitrates	Unplanned - Pollution of Source	Unplanned - Power Failure	Unplanned - System Failure	Unplanned - Turbidity	Grand Total
Total Ml										
Essex	Chigwell	Reservoir	552	4,775				1,516		6,843
	Langford	River	3,862	1,232	1,215	1,357	57	330	1,912	9,965
	Langham	River	5,145	4,303	92	1,855		2,030	502	13,927
	Layer	Reservoir	3,996	17,351				219	13,442	35,007
	Total		**13,555**	**27,661**	**1,308**	**3,212**	**57**	**4,096**	**15,856**	**65,743**
Total Days										
Essex	Chigwell	Reservoir	14	229				64		307
	Langford	River	112	68	95	167	2	35	71	550
	Langham	River	282	219	12	115		109	36	773
	Layer	Reservoir	104	456				9	240	809
	Total		**512**	**972**	**107**	**282**	**2**	**217**	**347**	**2,439**
(Average Ml/d)										
Essex	Chigwell	Reservoir	0.30	2.62	-	-	-	0.83	-	3.75
	Langford	River	2.12	0.68	0.67	0.74	0.03	0.18	1.05	5.46
	Langham	River	2.82	2.36	0.05	1.02	-	1.11	0.28	7.63
	Layer	Reservoir	2.19	9.51	-	-	-	0.12	7.37	19.18
	Total		**7**	**15**	**1**	**2**	**0**	**2**	**9**	**36**
(Average Days / Year)										
Essex	Chigwell	Reservoir	2.80	45.80	-	-	-	12.80	-	61.40
	Langford	River	22.40	13.60	19.00	33.40	0.40	7.00	14.20	110.00
	Langham	River	56.40	43.80	2.40	23.00	-	21.80	7.20	154.60
	Layer	Reservoir	20.80	91.20	-	-	-	1.80	48.00	161.80
	Total		**102**	**194**	**21**	**56**	**0**	**43**	**69**	**488**

N.B. The outage tabulated above is calculated as per the Water Resources Management Planning (WRMP) guidance methodology using actual WTW data from 2012 to 2016. The full contribution from the 2016 exceptional algal events therefore only contributes 20% to the WRMP Layer outage figure.

The greatest impact in the Essex supply area is being experienced at Layer WTW, driven by algal blooms and turbidity changes. Whilst Layer's maximum works output is 145Ml/d for 7 consecutive days the annual average reliable Distribution Input is around 120 to 130Ml/d, as demonstrated by NWL's water treatment works output records. In years such as 2016, during periods when there are severe algal blooms, the output was considerably less at around 70 Ml/d. The knock on effect of this has been to increase demand on Hanningfield WTW and more particularly Hanningfield reservoir.

Although a treatment solution at Layer WTW addresses the water quality issue, this would not address the other factors affecting the risk of Hanningfield reservoir drawdown and the security of supplies.

Reduced rainfall

Although the Essex WRZ is not resource constrained, the impacts of a severe drought at a depth or duration not previously encountered could create supply issues because of a lack of integration on the raw water network. The likelihood and severity of droughts is expected increase with climate change.

Following the raising of Abberton reservoir, completed in 2014, Essex now has a significant surplus of raw water supplies against current and future demand. This has allowed us to trade raw water with Thames Water and to be in discussion with both Anglian Water and Affinity Water about trading water with them for resilience of their jointly owned Ardleigh WTW. To maximise the system's capability, both of our reservoirs should be drawn down at equal rates, meaning the flows from Abberton should, on average, be 50% greater than those from Hanningfield. If the reservoirs are not drawn down together, then we risk running out of raw water at one of the sites during a period of drought.

The schematic below shows the linkages and interaction of assets in the Essex WRZ.

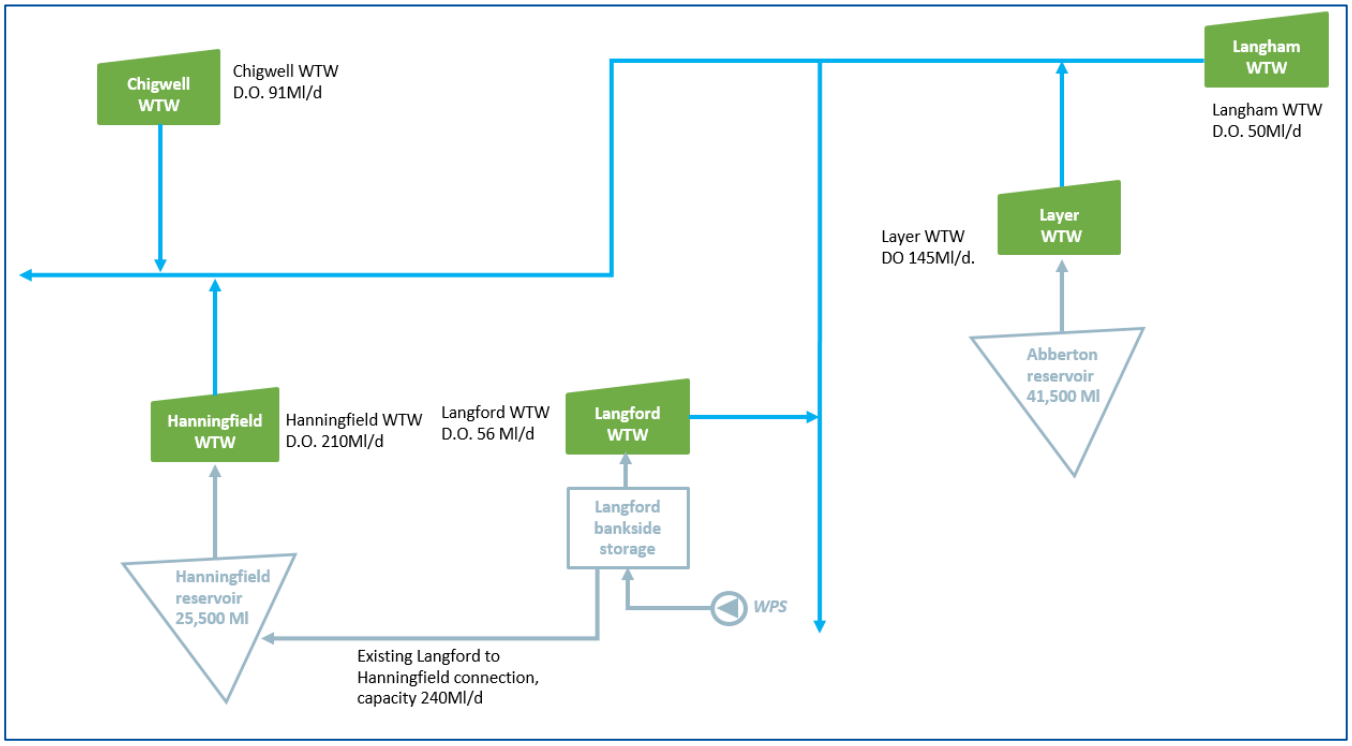


Figure 2: Schematic showing raw water and treated water assets in the Essex WRZ

Population growth
The Essex WRZ has sufficient supply capacity to meet the forecast population increase to 2060, as confirmed in the 2018 draft Water Resource Management Plan (WRMP). However, we expect to see a significant change in demand over the planning period, with growth of almost 20% by 2045. This will significantly increase the risks of localised supply issues associated with a lack of integration in the raw water network.

Peak demand periods
Drought is not the only effect of climate change on water supply. We have seen a marked increase in extreme weather events in recent years which have caused more frequent peaks in demand, particularly in the summer months in Essex. These peaks will grow larger as the population grows.

Dealing with peaks in demand requires flexibility in our treatment capacity but there are constraints in the Essex WRZ which can make it difficult to respond to peak demand periods. The preferred mode of operation of the Essex WRZ is for Langham, Langford, Layer and Chigwell water treatment works (WTW) to provide a reasonably constant base-load, with output from Hanningfield WTW varying to meet the remaining demand. Layer, Langham and Chigwell WTWs have slow sand filtration (SSF) where water is passed through primary roughing filters and then slowly passes through slow sand filters (large beds of fine grade sand where bacteriological processes treat the water). SSF works cannot quickly ramp up or down to meet demand due to the slow nature of the treatment process. This creates a dependency on Hanningfield WTW in particular – which in turn places increased demand on Hanningfield reservoir.

Ely-Ouse transfer
The availability of the Environment Agency's Ely-Ouse to Essex Transfer Scheme (EOETS) has also proved to be a critical factor in our ability to maintain supplies in the Essex WRZ. It leaves our ability to deploy the full output of Hanningfield WTW in the hands of a third party and outside our direct control.

Likelihood of failure
In the last four years we have experienced two periods where the raw water levels in Hanningfield reservoir have been at historic low levels due to restricted raw water transfer capability within our systems. Climate analysis indicates that warmer, drier summers are likely to become more frequent across an area already considered one of the driest areas of the country. This links to clear and sustained deterioration in raw water quality and increased algal blooms in the area. There is a degree of uncertainty around how soon factors influencing the drawdown of Hanningfield reservoir will combine in a way that impacts on supplies, but we have already been very close to seeing a widescale impact on customer supplies in 2016 and 2018. Without additional management control measures in place we are living with an immediate threat to supplies and we need to act now to prevent this impacting on customers.

How mitigating against the failure is currently beyond management control
In order to maintain water quality standards, deployable output from our slow sand filter treatment plants at Layer WTW and Chigwell WTW must be reduced accordingly whenever they are threatened by algal blooms or turbidity. This increases demand on Hanningfield WTW. Our current treated water network interconnectivity and the deployable output capability from Hanningfield WTW is sufficient to make up any shortfalls in treatment capacity at these works under normal operating conditions. However, raw water network connectivity does not support this.

In recent years we have expanded the storage volume of Abberton raw water reservoir to provide long term security of supply to our Essex region but this raw water cannot be transferred into the Hanningfield supply area.

We currently have a number of management controls in place to ensure our customers do not experience enforced supply restrictions across our Essex region. These include:

- The five yearly production of a Water Resource Management Plan to ensure we plan and invest to secure and store sufficient water to meet current and future demand from customers;
- Optimising the available water resources provided from the EA river transfer system between the Stour and Blackwater catchments;
- Planned and preventative maintenance (PPM) on our assets such as pumps, filters, clarifiers, dosing and control systems, isolation valves etc. Frequency of PPM is determined by the type of asset and the risk it presents to disruption of service if it fails or performance deteriorates; and
- Control Room software that automatically manages the reservoir storage at Hanningfield based on transfer capacity and availability of raw water from within the catchment.

None of these mitigating management controls can address the shortfall in our raw water transfer capability to support Hanningfield reservoir with our abundant water resource at Abberton reservoir.

The impact on customer service

There would be a number of supply consequences for customers in the event of Hanningfield reservoir being too low to continue providing water for treatment at Hanningfield WTW. These impacts would be felt by up to 365,323 properties. We would have to place mandatory supply restrictions on customers. This would be to avoid supplies being lost. Depending on customers' responsiveness to our efforts to reduce consumption, there would be a risk of localised depressurisation of the water distribution network, leading to subsequent water quality risks such as ingress. Customers could experience discolouration, aeration and taste and odour issues and even be subject to a 'do not use' notice if ingress was identified. Our customers tell us this is the worst possible service impact they could experience, after sewer flooding in the home. Customers could experience discoloration, aeration and taste and odour issues. Even when water is available it is likely customers would reject the water as not fit for human consumption until this exercise was complete, notices withdrawn and normal supplies restored. The seriousness of such an event cannot be underestimated as the effects could be prolonged over a number of months.

Such an event would likely attract widespread political and media interest, especially as it is likely that adequate supplies of water would be available in Abberton reservoir but we would be unable to use it. It would have a significant socio-economic impact on the day to day lives of customers in our region as well as presenting a substantial logistical and resource challenge for our business. We would need to prioritise those areas of our communities that would suffer the most from supply restrictions – hospitals, care homes, schools etc. It is highly probable that we would be required to seek support via mutual aid from other water companies and government agencies.

How the consequence is currently beyond management control

If Hanningfield reservoir was drawn down to even lower levels in future years we could be facing an event far beyond management control capability. Failure in this instance would not be sudden. We can monitor how the resource situation at Hanningfield reservoir is changing which enables an element of proactive response. However, there are limits on what we can do.

Service reservoir storage within the networks provides additional security of supply during peak demand events. However, storage is designed to enable recovery from short term disruption. Part of what makes this risk so significant is the potential for more prolonged impact.

We have Strategic Outage Plans for all our water treatment works. Again, these are designed to enable recovery from short term disruption.

We can provide alternative water supplies such as bottled water and static tankers in the streets as per our regulatory obligations under the Security and Emergency Management Directive (SEMD). If we were in a situation where supplies were interrupted across this region our management control would rely on our ability to provide customers with an alternative water supply as per our requirements under the SEMD regulations. The number of properties supplied by Hanningfield WTW is well in excess of our current and future alternative water supplies capability. In addition, the alternative supplies we can provide would be temporary. The risk we are looking to address is about a potential supply failure that could last for much longer than a few days.

Details of the Events of 2016

In the summer of 2016, from August almost through to Christmas, all of our reservoir sources suffered severe algal blooms as evidenced by NWL water quality records. Whilst in eutrophic lowland waters algal blooms are common and expected, having all three sources so affected for so long is uncommon. Other companies with similar waters also reported similar problems (as evidenced in DWI annual reports). Abberton was worst affected both in type of algae, total biomass and duration of severe blooms. Abberton's algal blooms, predominated by diatoms that require silica salts to exist, were undoubtedly exacerbated by the reservoir raising. The new soils interacting with the raw water have been an abundant source of silica. For Chigwell to experience blooms at this time of year is unusual as normally this water source suffers more in early spring from diatom blooms. Hanningfield had severe blooms but the ability to disrupt the water in the reservoir using the installed air curtains reduced the duration and better treatment allowed higher outputs to be produced.

The autumn remained dry through to mid December reducing the volumes able to be pumped to Hanningfield reservoir. This combined with Hanningfield WTW having to run at a constant high load to compensate for the other WTWs and led to the reservoir declining by 4% per week, as evidenced by NWL reservoir level records. The Environment Agency's EOETS which, should water be available in the Ely Ouse, transfers water into the Essex rivers to aid in refilling Abberton and Hanningfield reservoirs was unavailable during 2016. This was due to problems with the power supplies and pumps following a major refurbishment.

The combined consequence of these events was the drawdown of Hanningfield reservoir below its historic minimum for six weeks (Figure 3 and 4). Note week 40 = 1st October for each year; this was the historic low level for Hanningfield reservoir. A wet December, improvement in algal content at Abberton improving Layer WTW output, and some transfer from the EOETS allowed recovery of Hanningfield reservoir.

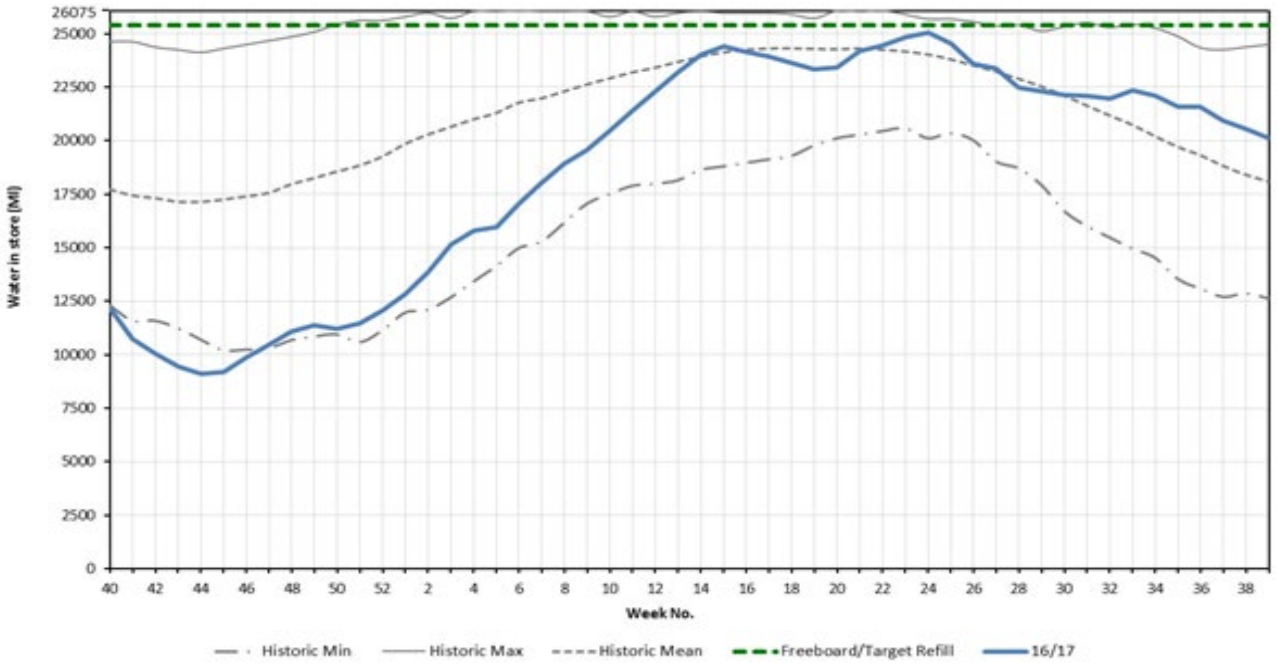


Figure 3: Hanningfield reservoir levels 2016/17, blue trend shows week 40-46 is a new low

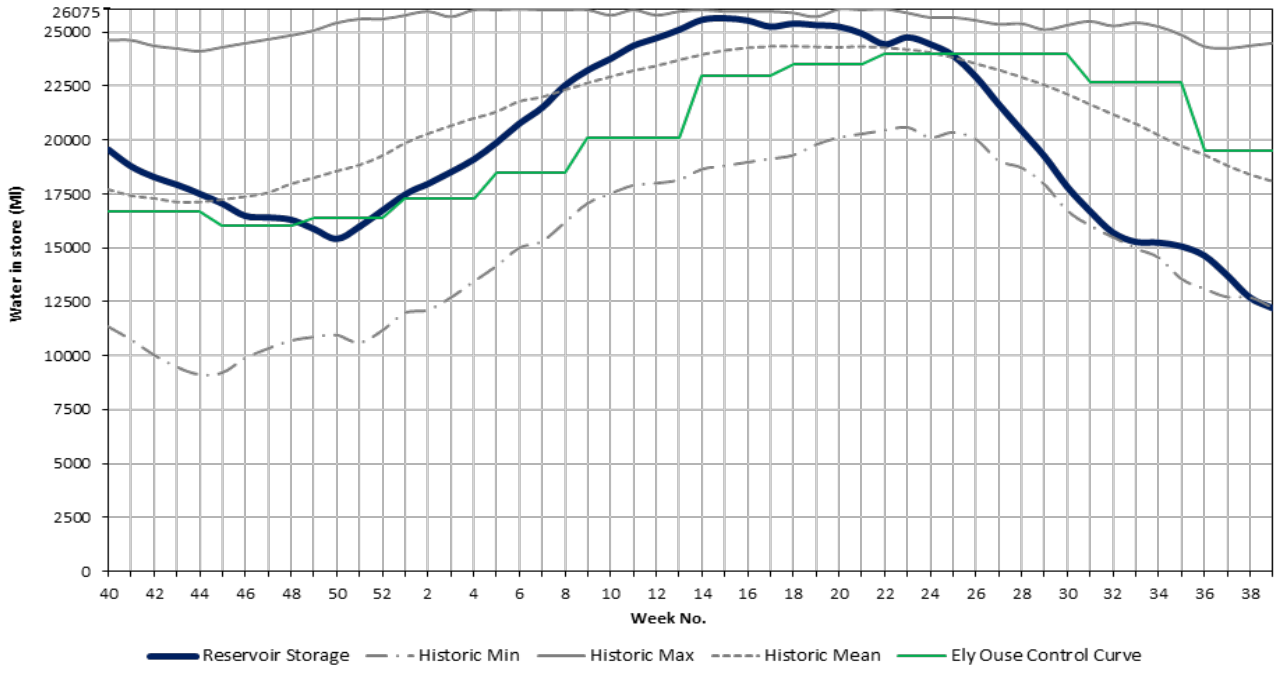


Figure 4: Hanningfield reservoir levels 2017/18, blue trend shows summer 2018 impact wk 26-38

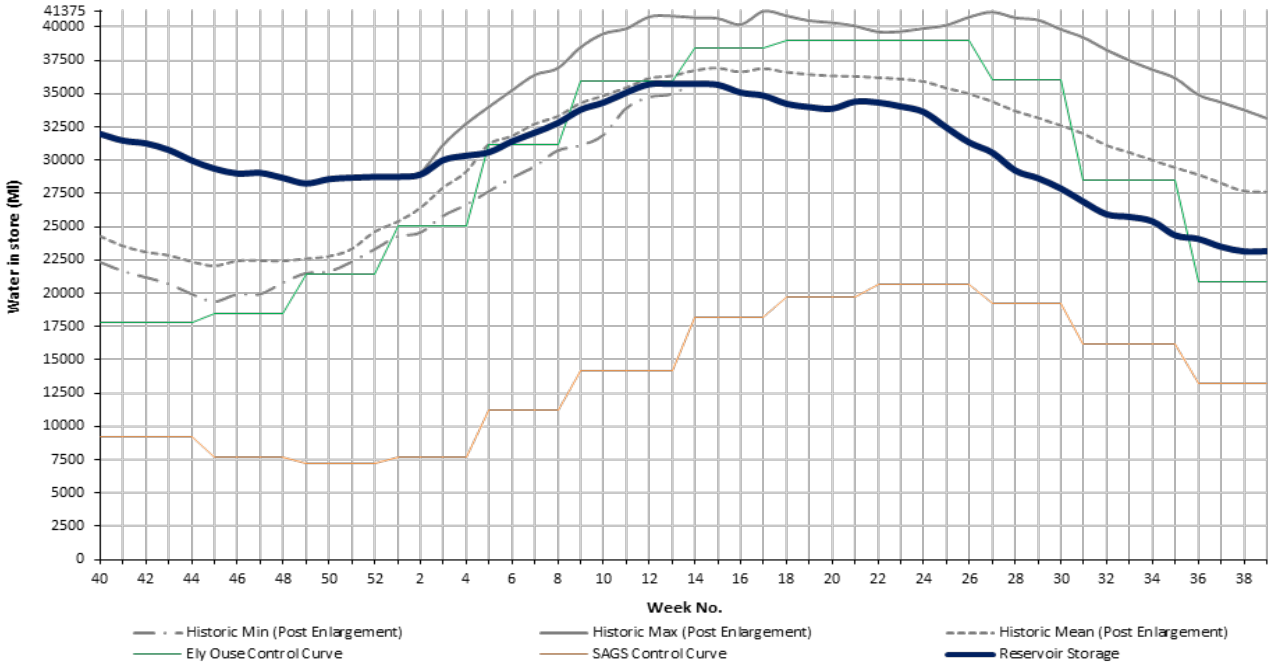


Figure 5: Abberton reservoir levels 2016/17, including historic trends

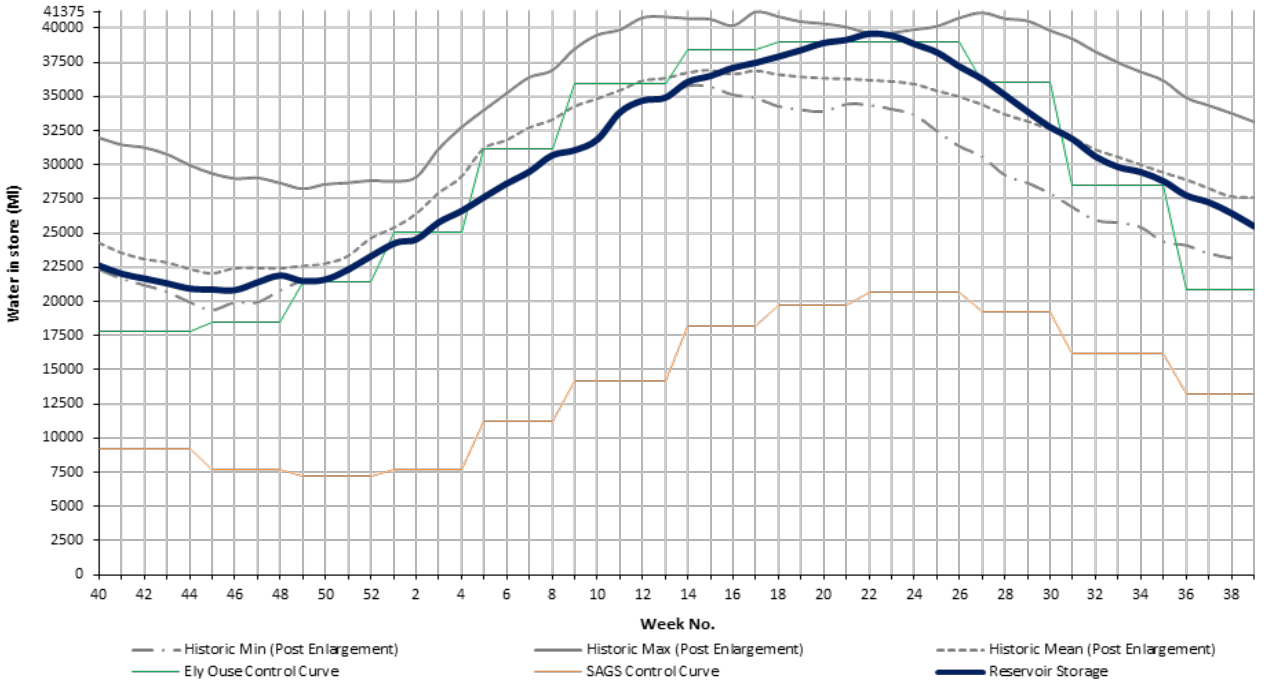


Figure 6: Abberton reservoir levels 2017/18, including historic trends

Details of the Events of 2018

The autumn of 2017 and the first 2 months of 2018 had been significantly dry. The cold spell during the *Beast from the East*, deposited useful amounts of snow and this was followed by above average wet conditions through to the end of May. This allowed full refill of both reservoirs by the end of May. From June onwards our Essex area along with most of England then entered one of the driest and hottest summers on record. Figure 7 below demonstrates the increase to demand over this period, peaking at 30% above normal and averaging 20% above normal between January and October.

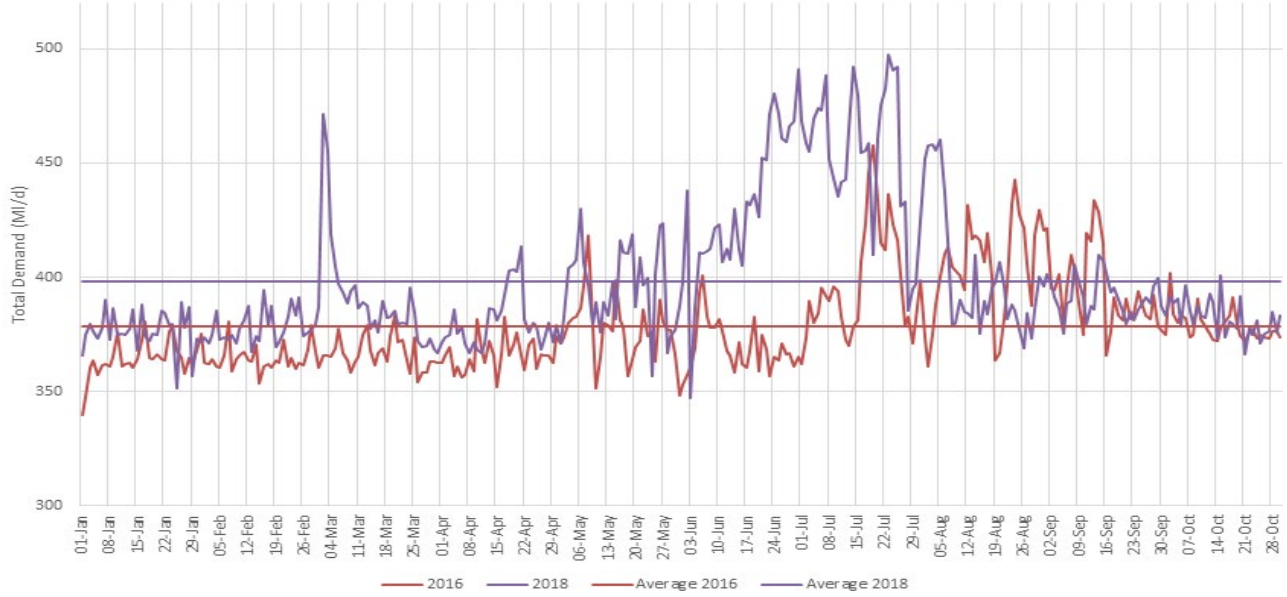


Figure 7: Essex system water demand 2016 to 2018

Layer WTW performed well over this period producing its expected 130Ml/d on average. Hanningfield was required to produce more water than in a normal year to meet the increased demand, as Hanningfield WTW is where the headroom in our deployable output resides. This resulted in Hanningfield reservoir beginning to draw down rapidly from July (Figure 5). Although the high temperatures reduced from August 2018, the period from then to end of January 2019 saw low rainfall levels and hence river flows. The rainfall was significantly below the long term average for the period.

Layer WTW performed as required up until September 2018, then entered a period of low output continuing through to end February 2019. The low outputs were due to a combination of one-off emergency repairs, and essential slow sand filter (SSF) maintenance.

When a SSF has been in operation for approximately 20 weeks, it must be drained down, an approximate 10cm of sand skimmed off the bed and then 'ripened' by running the bed to waste until the bacteriological fauna has built up sufficiently to reduce coliform and E.coli within the filtered water to a predetermined level. In warm water conditions this can take three weeks or more. Only two beds can be ripened simultaneously. Additionally after five or so skims the whole bed then requires reinstatement. Having fulfilled its role through the summer we would expect lower output from Layer WTW during the late summer/autumn. However the number of beds requiring skimming at similar times, due to the high summer demand, in conjunction with emergency contact tank repairs meant the works output was much lower in this period than historically. Hanningfield WTW was required to make up this shortfall of Layer output and meet the higher than normal water demand. Figure 5 shows the rapid decline of the reservoir through to the end of September 2018. Figure 9 below demonstrates the slow rate of refill, compared to long term average, due to high output and low river flows. Transfers from the EOETS through to the end of May 2019 have supported refill to current healthy levels.

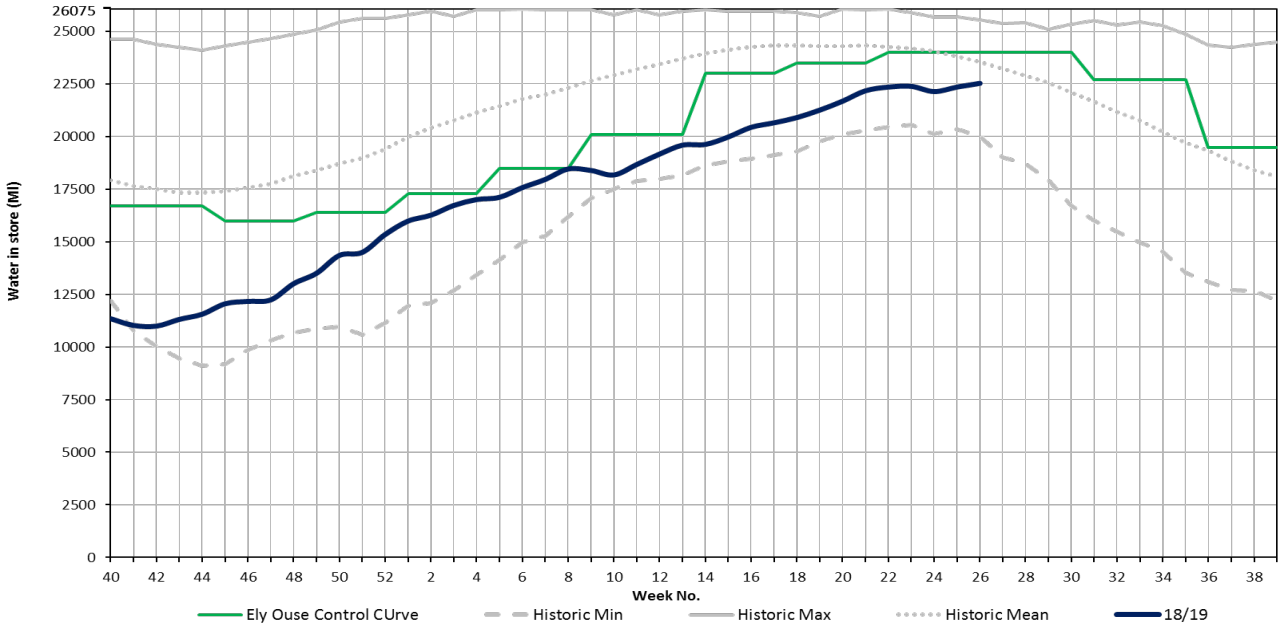


Figure 8: Hanningfield reservoir levels from Oct 2018 to June 2019

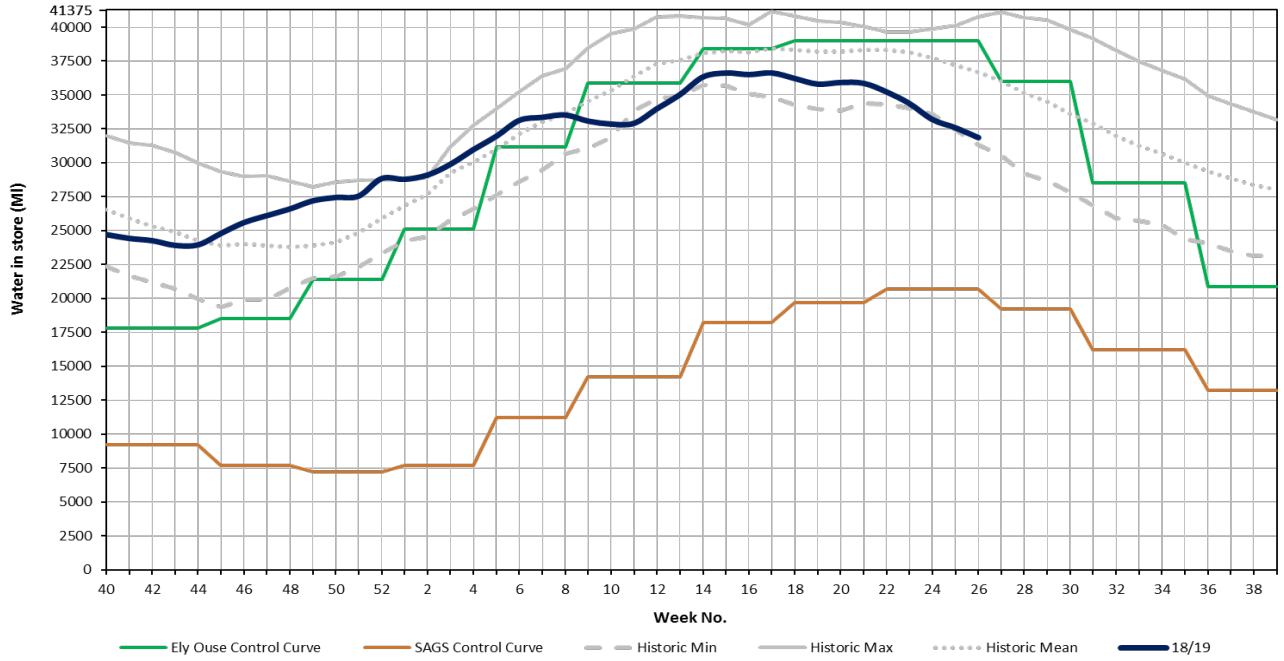


Figure 9: Abberton reservoir levels from Oct 2018 to June 2019

Customer and stakeholder expectation

Our discretionary enhancements package has been developed in participation with 3,297 household and non-household customers and stakeholders and reflects their priorities and tolerance of risk. We explain this process in some detail in our document 'Our approach to identifying discretionary enhancements'. This scheme to address the supply risk resulting from reservoir drawdown at Hanningfield reservoir has been prioritised through our conversation with customers over a period of several years of planning for PR19.

In our initial engagement with customers about resilience for PR19 planning ('Resilience' research project, 2016) our customers identified the worst water service failings they could experience from a pre-defined list of potential service impacts we provided. The worst service impact they identified was "sewer flooding inside your home following a period of heavy rainfall". After this, the next worst impacts identified by our customers were "a 'do not use' water notice as there is a risk to your health if water is touched for five days", and "an unexpected interruption to the water supply to your home for more than six days."

Although customers accept that supply interruptions may occur, it is clear that extended supply interruptions lasting several days would not be acceptable and could lead to a loss of trust. *Explain* summarised this in their report: "Prolonged interruptions and severe issues such as flooding in the home were felt to indicate a fundamental failure in [the] system which could cause customers and stakeholders to lose confidence." Some participants commented that following an unexpected interruption they would expect us to restore their water supply within 24 hours. We are introducing a measure of supply interruptions over 12 hours from 2020 as an indicator of resilience and we would count anything longer than this as being an 'extended interruption'. Our start point for resilience planning was that we should look to prevent such incidents from ever occurring.

We have looked at our asset systems from source to tap and identified weaknesses which could lead to extended supply interruptions or 'do not use' notices being required. Increasing demand on Hanningfield reservoir and a lack of raw water transfer capacity has already had the effect of reducing the reservoir storage level to lows which have not previously been seen.

Having identified strategic risks which posed the greatest threat of causing extended supply disruption we engaged with customers on the subject of 'Resilience, asset health and long-term affordability' in early 2018. We shared a number of resilience scenarios as part of this research to understand customer expectations around resilience planning. In one scenario we said that over 60,000 properties could be impacted by a long duration supply interruption. Our customers' response was that such incidents should never be 'allowed' to occur. This research also included the question of whether customers would be willing to pay for improvements to asset health and resilience, if it was a case of taking a smaller reduction to bills than the 10% we were planning to make as a minimum. Two thirds of customers were in favour of waiving the full 10% of our planned bill reduction for investment in resilience and asset health. We took this as a strong indication that customers would be willing to fund a discretionary package of prioritised enhancements to strengthen resilience.

In March 2018 we conducted four deliberative workshops in our Essex and Suffolk operating regions to explore participants' acceptability of a shortlist of specific discretionary enhancement schemes. The schemes were presented in the context of a commitment from us that by 2020 customers' bills would be reduced by 10% and that the schemes could be funded by making the 10% reduction smaller.

One of the schemes tested was our plan for a new pipeline between Abberton and Hanningfield. Participants were told that:

> *During times of peak water demand Essex & Suffolk Water sometimes has to move water around the network to make sure their customers get the supply they need.*
>
> *The transfer system between Abberton reservoir and Essex & Suffolk Water's largest water treatment works, Hanningfield, is managed by the Environment Agency. In the past asking the Environment Agency to move water has proved unreliable.*

We told participants that we would like to lay a new main to transfer raw water between Abberton reservoir and Hanningfield, which would remove our reliance on the Environment Agency and allow us to move water around the network more effectively.

Participants were asked whether or not they accepted this scheme along with two others (new treatment capability at Layer WTWs; and a new water main to provide an alternative source for Romford, Dagenham and Brentwood) in return for taking 1.48% less of the 10% bill decrease we had committed to giving. They were told that this would be equivalent to £3.63 per year and that all our customers would pay for this, whether they live in the areas which would benefit or not. The three schemes collectively achieved 89% acceptance from customers.

We presented this result to the Enhancement Sub Group of the Water Forums on 19 April 2018. Members agreed that the overall customer engagement approach and rigour was good and noted that they were not surprised at the high levels of acceptance for all water schemes as they are very specific with specific benefits.

All our enhancements were presented back to participants at our PR19 Acceptability Research deliberative workshops. They were available on request to the quantitative research participants. In overall acceptability research, Our Plan was supported by 91% of customers.

Regulatory expectations

On 09 August 2018, Defra, the Environment Agency, the Drinking Water Inspectorate and Ofwat wrote to the water sector companies to set out expectations to build resilience in water resources management in England.

Ofwat stated in 2017 that “resilience should be at the core of how the sector plans to deliver its services to customers”[1], highlighting the importance of resilience to business planning and its potential to bring benefits to customers. Investments in resilience generally have multi-faceted benefits that range from reducing the risk of events with low probabilities and high consequences to being able to manage our networks in a more flexible way.

This scheme is designed to meet customers’ needs in a safe, resilient and efficient way, while protecting the environment and respecting good supply practice and the needs of other water users.

Our track record - Service delivery and expenditure prior to AMP7

We consider resilience as the ability of assets, networks and systems to anticipate, absorb, adapt to and/or rapidly recover from disruptive events. The UK government sets out that there are different ways in which resilience provision can be delivered. These are categorised as:

[1] Ofwat (2017), Resilience in the round https://www.ofwat.gov.uk/wp-content/uploads/2017/09/Resilience-in-the-Round-report.pdf

Redundancy	avoiding dependencies on single assets
Resistance	proofing the system so that it is resistant to known risks – for example, flood defences or access procedures
Reliability	a system that operates effectively irrespective of whether or not risks materialise – for example, design standards
Response/recovery	the ability to recover quickly so that service is not unduly impacted – that is, tested procedures and appropriate resources

We have shown strong resilience in our service provision, in particular around the response and recovery aspects of resilience. In 2018 the 'beast from the east' caused major impacts to services and widespread travel disruption. There was also an impact on water services across the UK and Ofwat completed a review after the event to identify strengths and shortcomings to identify how the industry should improve. Through that review process we were able to evidence our very strong performance through that particular resilience challenge and highlight some of the activities undertaken. The actions that underpin our strong response and recovery capability include:

- Optimisation of our assets and resources to provide maximum value and resilience for our customers. Examples include our water supply planning processes; our operational risk assessment (coordination planning) process; and the outage plans developed for each water treatment works.
- Training and companywide processes. Examples include calm networks operational training; and we were one of the first two companies awarded the new competent operator framework by EU Skills.

Our asset base is also resilient. For example, most of our water treatment works have some level of redundancy through duplicated chemical dosing systems and two or more treatment streams, allowing some water supply provision to continue to be made in the event of an outage, asset failure or maintenance. Our assets also feature strong resistance through appropriately graded security covers, doors and monitoring/control and alarm systems. These are all supported by operational procedures which are tested through simulated and real circumstances.

Our approach to resilience planning is highlighted in the document 'Our approach to identifying discretionary enhancements'. Through this robust process we have identified our highest resilience risks and then developed solutions which will greatly reduce these risks by lessening the severity and/or likelihood of the impact on customers.

We are confident that we can deliver major projects in the 2020-25 period. We have an excellent track record in delivering major expenditure commitments. Some examples include:

- The Abberton reservoir 58% increase in capacity from 25,500 to 41,500Ml.
- The Acceptability of Drinking Water programme, cleaning in excess of 380km of trunk mains, including 16km duplication of a key trunk main on Tyneside
- The development of new treatment works assets at Horsley WTW (2006), Wear Valley WTW (2003), Lound WTW DAF (2004).
- The Section 19 mains rehabilitation programme replacing circa 1020km of small diameter distribution mains.

Forward looking analysis

The needs for enhanced resilience is connected to the challenges which are already being felt as a result of climate change and population growth. Our customers' expectations are simultaneously rising. The UK

government has made resilience a key priority for the water industry and considers it to be an issue which is not only urgent in the present but also developing into an even greater challenge for the future:

> *Resilience is vital to current and future customers. The water sector faces serious resilience challenges including climate change and population growth, which present real threats to the resilience of assets, water resources and services to customers. The combination of these threats and changes in people's expectations – including about how we treat the environment itself – makes tackling these resilience challenges urgent.*

Our Water Resources Management Plan states that, whilst our water resource zones are all in surplus across the planning horizon, our Essex and Suffolk supply zones are located within some of the driest areas of the country and as such face particular challenges including growing demand, uncertainty from climate change and a general lack of new intrinsic water resources.

The Essex Water Resource Zone (WRZ) serves a population of nearly 1.66m people in the East and South of Essex and three of the London Boroughs. This population is forecast to increase to 1.98m by 2045, an increase of almost 20%. The majority of the population resides within the London Boroughs and the greater Southend-on-Sea area is the next most populous.

Option appraisal

In its PR19 Final Methodology, Ofwat stated that it would assess the robustness and efficiency of all enhancement costs to ensure that any enhancement options put forward by the water companies represented the best options for customers. This was to include an assessment of whether the company had considered an appropriate range of options for the enhancement with a robust cost–benefit analysis (CBA) before deciding the best course of action.

We have used CBA in order to support optioneering for our enhancement investment proposals. A common CBA model was applied across all schemes which ensured consistency in our assumptions and approach to analysis.

The following sections describe the options considered, our approach to costing and finishes with our cost-benefit analysis.

Overview of options considered

Option 0 – Do nothing

The risk of doing nothing is that a longer repeat event of the outages experienced in 2016 and 2018 could result in impact to the supply to at least 365,323 properties. Therefore this option has not been considered viable.

We did consider the possibility of formally adopting the Ely / Ouse Essex Transfer Scheme (EOETS), including the existing river transfer stations at Kennet and Wixoe. This scheme and associated assets are currently owned and operated by the Environment Agency. This option was discussed by our Board but discounted as the EOETS would not address the imbalance in Hanningfield and Abberton Reservoir storage in dry years whereas the proposed pipeline will transfer raw water from Abberton reservoir to Hanningfield WTW making the best use of existing assets.

Option 1 - Increase Layer WTW capacity to 165 Ml/d and triplicate mains (£58.8m in 2006 prices)

Feasibility and Conceptual Designs for increasing Layer's output were produced at the time of the Abberton enlargement scheme by our engineering consultancy MWH and this would address the risks outlined in the needs case.

Layer WTW is currently designed to treat a seven day peak output of 145Ml/d and an average annual output of 120-130Ml/d, while the enlarged Abberton reservoir, and the associated infrastructure and licenses, can

support a deployable output of 210Ml/d. The feasibility report defined the work needed to increase the Layer treated water output to first 165Ml/d and the further work to reach the maximum output of 210Ml/d. Each stage of capacity increase would be timed for when population growth would require a higher works output.

In addition to the new treatment stream it would be necessary to triplicate the strategic mains that take the flows from Layer and Langham into the north Essex zone to meet the forecast demand. The current strategic mains from Layer and Langham are limited to a total capacity of 180Ml/d meaning if Layer is on full flow of 145Ml/d then the maximum Langham WTW can produce is 35Ml/d compared to its DO of 55Ml/d.

Increasing Layer to 165Ml/d would require triplication of the following mains:

- Layer Marney to Tiptree (6 km)
- Tiptree to Oxley Green (1 km)
- Woodham Walter PS to Butts Green (7.1km)

Note: The raw water quality in Abberton Reservoir has been deteriorating with regular algal blooms. This means that we are often unable to meet the current target output from the works. Our raw water deterioration scheme proposing the installation of a Dissolved Air Floatation (DAF) front end treatment stream has been submitted as a separate PR19 enhancement proposal.

Option 2 - Link Abberton and Hanningfield reservoirs (£20.4m in 2017/18 prices)
This option considers creating a link between the two Essex reservoirs, Abberton and Hanningfield, via a raw water pipeline capable of transferring up to 50 Ml/d.

The concept of the pipeline is not that water from Abberton is piped directly to Hanningfield reservoir but rather that a new pipeline will support the system by substitution. Abberton reservoir water will be transferred directly to Langford WTW, via its bank-side storage reservoir. This removes the risk of transferring Invasive Non Native Species (INNS). This risk would arise if Abberton raw water was discharged directly into the River Blackwater to then be abstracted at Langford RWPS and pumped into Hanningfield reservoir.

Langford is a stand-alone WTW with a DO of 56Ml/d and is a physico/chemical works very able to treat water of poorer quality, including during algal blooms. Historic limitations on treatment at this works have typically been due to nitrate and pesticide levels from the river water, especially in the autumn/early winter flows. Water is abstracted from the rivers to firstly supply Langford WTW with excess flows pumped 14km to Hanningfield reservoir. When river flows allow, up to 240Ml/d can be pumped to Hanningfield reservoir. By supplying between 30Ml/d - 50Ml/d of Abberton water to Langford WTW, the equivalent volume is then available in the two rivers for pumping onwards to Hanningfield reservoir. This allows Hanningfield WTW to increase its average output by the equivalent 30 to 50Ml/d without increasing its normal drawdown of the raw water reservoir storage on site.

A further benefit of Abberton water going directly on to Langford WTW is the improvement to water quality compared to that in the River Chelmer and Blackwater, especially so in the autumn and winter months. Both reservoirs are predominantly filled in the autumn and winter months where, following dry summers, rainfall usually washes out nitrates from agricultural land in to the rivers. These nitrates reduce significantly in the impounding reservoirs during summer leaving low nitrate water. By using Abberton water at Langford WTW, all of the treatment constraints due to nitrate and most pesticide outages are significantly reduced or removed.

This is our preferred option as it makes full use of existing assets and treatment capacity to address current risks in a way that defers the need for more costly expansion of Layer WTW until at least 2045.

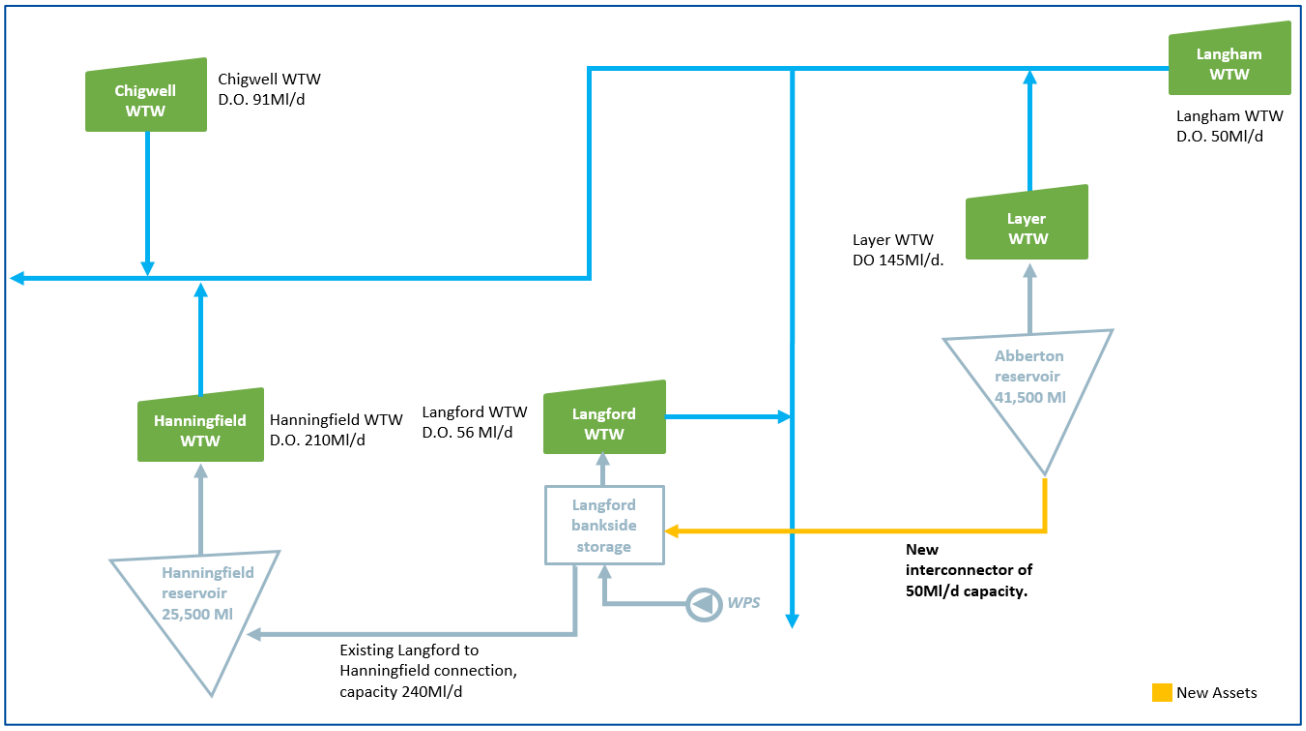


Figure 10: A schematic of our preferred option

Costing of options

NWL has assessed the costs for this and other enhancement claims through a structured and robust approach, involving benchmarking of cost estimates against alternatives. The cost assurance process and associated costs generated for the water enhancement schemes have been subject to third part assurance provided by Mott Macdonald in July 2018[2].

In June 2019 NWL commissioned a shadow pricing exercise by our contractor partners and commercial consultants for preferred option costs for each of the enhancement projects. The purpose of this exercise was to benchmark the costs produced by NWL's iMOD system against the market. The result of this exercise showed that NWL's cost estimates were on average 15% lower than the cost estimates returned by our contractor partners and 7% higher than the cost estimates returned by our commercial consultants Turner & Townsend. This gives confidence that the cost estimates produce by the iMOD system for the enhancement projects are efficient.

Cost-benefit analysis

We have undertaken our cost-benefit assessment on the basis of the avoided risk of long supply interruptions. This is one of the major benefits from the scheme that can be quantified and we have a customer valuation for interruptions greater than 12 hours from our customer valuation research conducted collaboratively with Explain, Frontier Economics and Supercharge[3].

[2] Mott Macdonald, Oct 2018, PR19 Enhancement Programme Business Case Assurance Summary Report (Report available upon request)

[3] NWL PR19 Research Tool, Striking the right balance between delivering business plan insights and cognitively valid results, January 2018.

The valuation result from the research was that customers value 12-hour supply interruptions at £6,599 per property. There is a reduced risk of supply interruptions to the 365,323 properties that would benefit from the new link between Abberton and Hanningfield reservoirs.

This approach has limitations as it does not value the full scale of the benefits. For example, benefits such as avoided discoloration or odour contacts are not included. Nevertheless, it provides a clear valuation for the key change in service level that results from our investment.

Based on our approach to CBA and risk reduction, we are able to calculate the benefit to customers for each option considered. These can be compared by their benefit cost ratio (BCR) and risk reduction for each intervention, analysed through NWL's risk reduction AMPS system. Both the BCR and the risk reductions for the interventions are presented in the table below. The cost benefit analysis shows that Option 2 provides the higher BCR of 19.27 and this is the most beneficial option for customers.

Option Number	Customers benefiting (Nr Properties)	Totex (£m)	£ per customer benefited	Risk Score- Before	Risk Score - After	Risk Reduction delivered	BCR
Option 1	365323	42.80	117.16	111.35	5.57	105.78	11.63
Option 2	365323	20.35	55.70	111.35	11.14	100.21	19.27

We estimate total customer benefits of £429m. This is likely to be a conservative estimate as it only includes the benefits from avoiding long supply interruption but does not capture any other benefits.

Lastly, we estimate the benefit-cost ratio based on the present value of the total costs set out above. Assuming a discount rate of 3.5%, these costs amount to £22.3m, and implies a benefit cost ratio (BCR) of 19.27. Therefore, the implied benefit to customers exceeds the costs that they would incur from supporting the enhancement.

We acknowledge that this BCR is relatively high, which is driven by the customer valuation in our research. We have estimated that the investment would be cost-beneficial as long as the valuation of individual supply interruptions is higher than £296.55. A comparative review of PR19 willingness-to-pay estimates prepared by Accent and PJM Economics shows that the average willingness to pay[4] to avoid unplanned supply interruptions of up to 24 hours is £553. This valuation implies a BCR of 1.87, indicating that customer benefits would exceed costs by 87% even when this more conservative value is used.

Our preferred plan/option

The proposed scheme is to build a new raw water transfer linking the Abberton reservoir to Langford. Through existing assets the raw water from Langford can then be used to supply Hanningfield WTW. This proposal addresses a gap in the resilience of the Essex WRZ.

This option will balance abstraction from Hanningfield and Abberton reservoirs, thereby reducing the likelihood of supply disruption to 365,323 properties. This option has numerous benefits, including:

- Resilience to changes to weather and rainfall as a result of changes to the climate as seen in 2016 and 2018/19;
- Hanningfield WTW will be able to meet increased water demand when other treatment works have extended outages without drawing down the reservoir to unacceptably low levels;
- If we increased the treatment and potable water transfer capacity at Layer to balance an equal percentage drawdown of the reservoirs we effectively mothball a significant percentage of

[4] This is based on three independent willingness to pay estimates for unplanned supply interruptions ranging up to 24 hours.

Hanningfield WTW's existing treatment capacity. This option removes this risk and allows the full treatment capacity at Hanningfield to be utilised;

- It is the most cost effective solution to address the current resilience risks;
- Further resilience and efficiency is derived from our ability to transfer water from Abberton to Hanningfield without restriction at the most effective and efficient times of the year;
- Having the ability to treat Abberton water at Langford WTW reduces the outage risk at Langford posed by nitrates and pesticides from the rivers;
- Building the link defers the upgrade to Layer WTW from 145Ml/d to 165Ml/d to 2045 based on current demand forecasts;
- No invasive non-native species transfer risk.

3.3.2 ESSEX RESILIENCE - ABBERTON TO HANNINGFIELD TRANSFER MAIN

Summary of totex

This proposed investment is part of a package of investments in resilience, collectively included in line 14 of data table WS2. We are resubmitting this table on 30/08/2019 with our response to the draft determination, as required.

Below we provide a breakdown of our resilience package including how it has changed between our business plan resubmission on 01/04/2019 and the package we are proposing as part of our draft determination response on 30/08/2019.

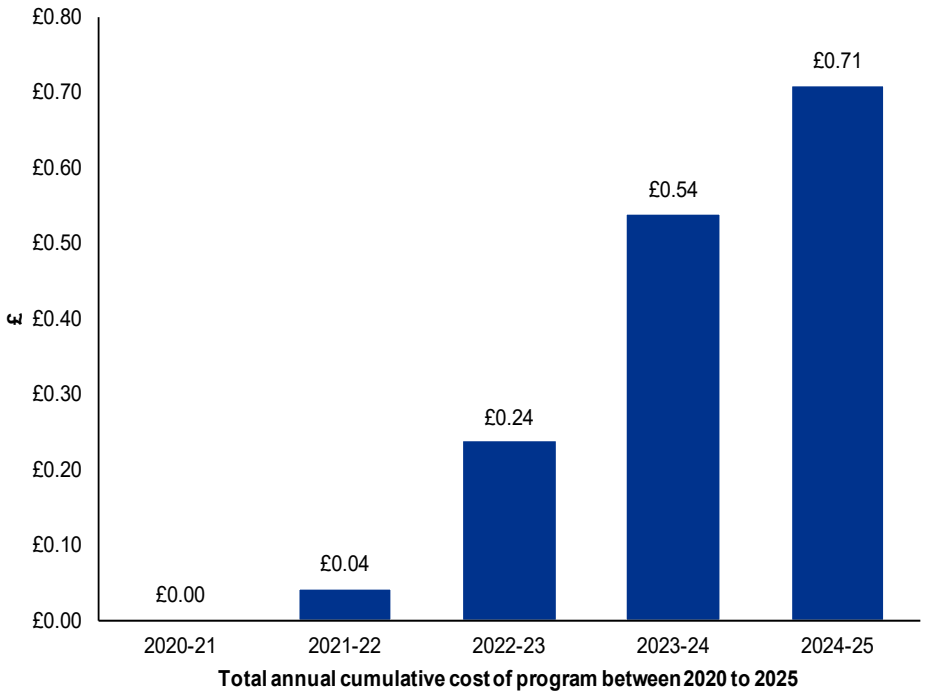
Region	Scheme	March 2019 Totex (£m)	August 2019 Totex (£m)
Essex	Abberton to Hanningfield raw water transfer via Langford (this business case)	20.350	20.350
Northumbrian	Cross connection C60/C60a	0.210	0.210
Northumbrian	Duplicate Chirton SR outlet main (315m of 700mm)	0.400	0.400
Essex	Herongate SR (30m of 900mm main)	0.230	0.230
Northumbrian	Replace 37.5km 600mm with 800mm main	14.08	0.000
Northumbrian	Whorley to Shildon main (16km of 800mm)	19.200	19.200
Northumbrian	Carr Hill link main to Springwell SR (1.5km of 600mm)	3.000	3.000
Northumbrian	Springwell SR to Pikes Hole main + EOV (7km of 1000mm)	14.860	14.860
Northumbrian	Heworth to Pikes Hole main + EOV (4km of 1000mm)	8.520	0.000
Northumbrian	Shildon SR WPS (55Ml)	3.160	3.160
Northumbrian	Maltby SR inlet/outlet arrangement	5.400	0.000
Northumbrian	Ormesby WPS modifications and SR abandonment	0.700	0.000
Suffolk	North Cove and South Lowestoft flow restriction removal	4.100	4.100
Suffolk	Barsham WTW treated water storage and WPS	10.140	10.140
Northumbrian	Springwell SR 62Ml size	16.200	16.200
All	Too critical to fail	8.340	4.690
Totals		128.89	96.54

Risks, uncertainties and further work

Appropriate environmental assessments will be undertaken including Water Framework Directive 'No Deterioration' assessments which will cover the risk of transferring Invasive Non-native Species (INNS) and a Habitats Regulation Assessment (HRA).

Affordability

The impact of this enhancement investment on customer bills is shown below[5].



We shared details of our plans with customers at two phases of discretionary enhancement research with 193 customers. Participants were asked if they would be willing to return a portion of the 10% bill decrease we had committed to giving to fund this and other enhancements. Overall customer support for our plans to improve the resilience in our Essex area was supported by 89% of our ESW customers.

Our final plan includes an overall reduction in bills of more than 12% in AMP7, including all enhancement investments, one of the largest across the sector. At an aggregate level recent changes in average earnings have been positive and third party projections from the OBR for 2020-23 suggest that, at a national level, real earnings is predicted grow at between 0.8-1.2% per annum[6] driving significant improvements to average customer affordability. For the Business Plan, Northumbrian Water commissioned Economic Insight to forecast the Relative Price Effects adjustment for capex enhancements. This was assessed at around 1% pa over 2020-25. We separately set ourselves an annual efficiency target for capex enhancements of 1% pa.

We recognise that affordability will remain a concern particularly for some low income customer groups. Our plan sets out detailed proposals and mechanisms to help our services remain affordable for our most

[5] Bill impacts were calculated using a simple ready reckoner based on profiles of opex and capex costs for the specific enhancement, asset lives and run-off rates consistent with overall price control specific rates consistent with App16 and using revenues and combined bill average values consistent with App7.

[6] See: https://obr.uk/efo/economic-fiscal-outlook-october-2018/ Table 1.1 difference between CPI and average earnings forecast

vulnerable customers including specific proposals to eradicate water poverty by 2030[7] and to meet Ofwat's new sector specific PC on the number of customers on our Priority Services Register.

Alignment with stakeholder needs

Regulators and other stakeholders
The scheme is consistent with Water Resources Management Planning guidance and also with the guiding principles regarding the need for resilience set out by Defra.

Defra has also requested that the proposal for this interconnector between Abberton and Langford is included in the draft Final Water Resource Management Plan prior to Defra issuing permission to publish the final document.

Customer protection
We are proposing appropriate mechanisms to incentivise delivery of our proposed enhancement schemes and protect customers between 2020 and 2025 in the event that schemes are not developed or delivery is delayed. We are proposing a cost adjustment mechanism for enhancement costs that will protect customers against late or non-delivery of those enhancement schemes. If delivery is late, or does not occur at all, a penalty will be calculated based on the NPV of the difference in cash flows compared to on time delivery. Full details of our enhancements delivery incentive mechanisms are included in Chapter 4: Measuring and Incentivising Success of our final business plan.

Board assurance

The details of all our enhancement cases have been shared with and discussed by our PR19 Board Sub-group on 20 February, 8 March and 14 May 2018 and 12 February, 4 March and 21 March 2019 and by the full NWL Board on 18 July 2019. During these discussions the details of the enhancement proposals were carefully reviewed and were challenged in a number of ways which have been taken into account in our final enhancement cases[8].

The full Board approved a revised Board Assurance Statement at the full Board meeting on 29 March 2019, confirming that the Board has reviewed and has confidence in the enhancement cases. The Board has, accordingly, signed the Assurance Statement, confirming that "large investment proposals are robust and deliverable, that a proper assessment of options has taken place, and that the option proposed is the best one for customers[9].

[7] See section 3.2 of our business plan, https://www.nwl.co.uk/_assets/documents/NWL_PR19_Interactive_FINAL_RS.pdf

[8] For further detail on how the Board has challenged our enhancement cases and the response from management please see our 'Board engagement on enhancement cases document'

[9] See Board Assurance Statement