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3.3.7 LAYER BUSINESS CASE

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

LINE 13: INVESTMENT TO ADDRESS RAW WATER DETERIORATION (THM, NITRATES, CRYPTO, PESTICIDES, OTHERS)

Name of claim	DAF treatment at Layer WTW
Business plan table lines where the totex value of this claim is reported	WS2 – Wholesale capital and operating expenditure by purpose Line 13 Investment to address raw water deterioration.
Total value of claim for AMP7	£26,870,000
Total opex of claim for AMP7	£0
Total capex of claim for AMP7	£26,870,000
Remaining capex required after AMP7 to complete construction	Expected to complete scheme 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	2.2%
Does the claim feature as a Direct Procurement for Customers (DPC) scheme? (please tick)	No
Need for investment/expenditure	Raw water deterioration
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

Since the expansion of Abberton Reservoir we have seen a steady deterioration in raw water quality. This documents puts forward the case for introducing new treatment capability at Layer WTW so that it can continue to treat Abberton water and maintain its deployable output while algal blooms are occurring.

Need

Abberton raw water reservoir has experienced a progressive deterioration in raw water quality since 2011. The turbidity and algal load onto the receiving water treatment works, Layer, impacts on deployable output. Between 2012/13 and 2016/17, Layer WTW experienced a restriction on output on 456 days from algae, which is about 25% of the time. There is a need to restore Layer's ability to meet its deployable output during algal blooms and turbidity episodes arresting the reduction imposed by the raw water deterioration.

Abberton raw water reservoir was almost doubled in size over the period 2010-2015 as a key part of the water resource management plan for the Essex water resource zone. The enlargement is to ensure there is sufficient water to supply the forecast population up to 2065. Therefore being unable to treat the raw water is a significant supply issue.

The DWI and Defra are supportive of the need for this investment. The DWI has supported the need for this scheme in Final Decision Letter dated 10 July 2019. The DWI has informed us they are preparing a Notice under Regulation 28(4) of the Water Supply (Water Quality) Regulations.

Customers are also supportive of the need for this investment. This was one of three schemes which were collectively tested with customers and 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 six 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. We have examined an extensive modification of the existing plant; construction of a new plant; the addition of a DAF plant to the existing works with its current capacity; the addition of an increased capacity DAF plant to the existing works; and finally the addition of a DAF plant to part of the existing process. We have identified that the most cost-beneficial solution to the need is to add a DAF plant to cater for the existing plant capacity.

Connection with the Abberton to Hanningfield Pipeline scheme

In another enhancement business case we are proposing a resilience scheme to construct a new raw water pipeline which will allow movement of raw water from Abberton reservoir to support Hanningfield reservoir. The pipeline is required to maintain raw water availability to Hanningfield WTW to make full use of its treatment capacity and ensure supply resilience for the Essex area in the face of climate change. The Layer DAF scheme is different in that we are looking to ensure Layer is capable of meeting its deployable output during algal blooms – this expenditure seeks to restore a level of lost resilience but not increase resilience.

Need for enhancement

Since the enlargement of Abberton reservoir there has been a deterioration in raw water quality; specifically in turbidity and algae levels over the period 2011 to 2018. This may be a consequence of different reservoir dynamics (water depth, water temperature, mixing, leaching of nutrients from soil) due to the enlargement of the reservoir, or because of external climatic changes. The latter cannot be ruled out as other water companies have noted similar challenges relating to algae.

Failure mode

The expansion of Abberton reservoir and/or climate change impacts have led to unpredicted increases of algae (measured by chlorophyll A) and turbidity since 2011. Abberton reservoir is the sole raw water supply for Layer WTW and the deterioration in water quality means that Layer WTW, a slow sand filter works, is unable to maintain its deployable output without compromising water quality performance. Between 2012/13 and 2016/17, Layer WTW experienced a restriction on output on 456 days because of algae, which is about 25% of the time. Over the same period restrictions were imposed to preserve quality on a further 240 days due to turbidity.

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**

Restrictions on treatment capacity at Layer WTW has led to increasing demand being placed on Hanningfield reservoir. This is because Hanningfield WTW can make up the supply shortfall from Layer WTW.

It is important to note that increasing the capacity of Abberton reservoir was a strategic investment designed to ensure sufficient supply to meet demand from population growth. Being unable to treat the raw water is a significant issue. There is a risk that we may have to enforce supply restrictions on our customers due to a reduction in works output required to maintain water quality standards and performance. Using alternative sources of water to meet demand is not a sustainable solution as there are already raw water constraints in the Hanningfield catchment.

Likelihood of failure

There are clear deteriorating trends in catchment water quality for turbidity and algae at Abberton which are already impacting on the ability to maintain both water quality regulatory compliance and deployable output from Layer WTW. This is shown on graphs below.

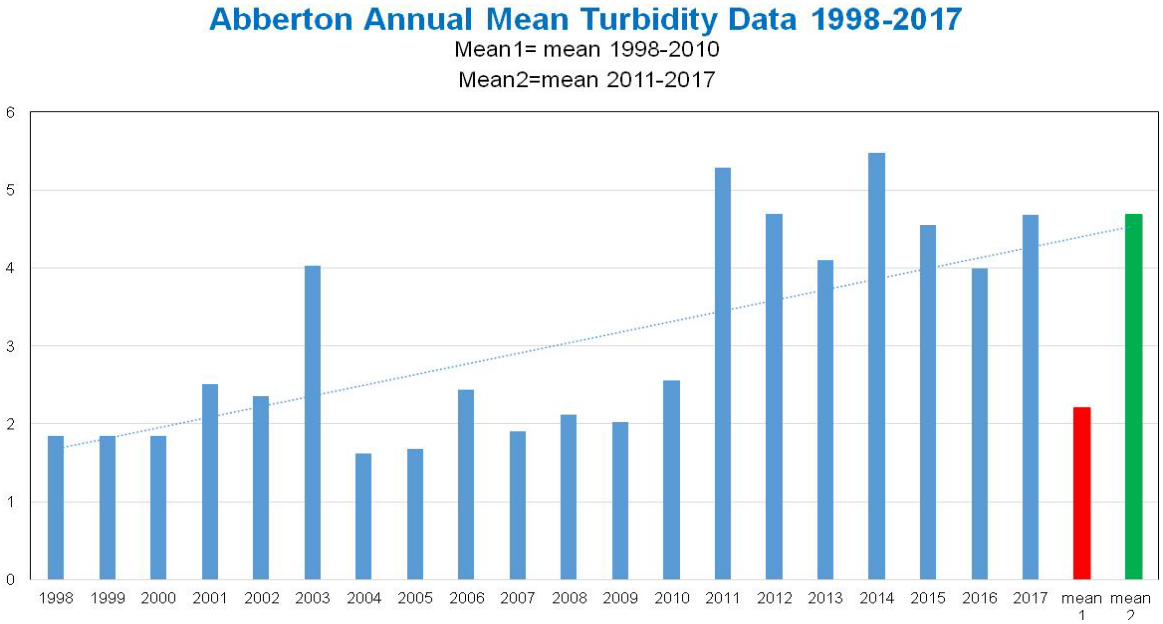

Figure 1: Abberton annual mean turbidity and trend

Figure 1 illustrates an increasing trend in annual average turbidity (blue bar) for each of the years between 1998 and 2017. The 1998 to 2010 mean turbidity (red bar) was 2.22 NTU but increases to 4.68 NTU post-2010 (green bar). Figure 2 compares turbidity and flow over time. It can be seen that when turbidity peaks flow reduces as a consequence. These are turbidity related outages.

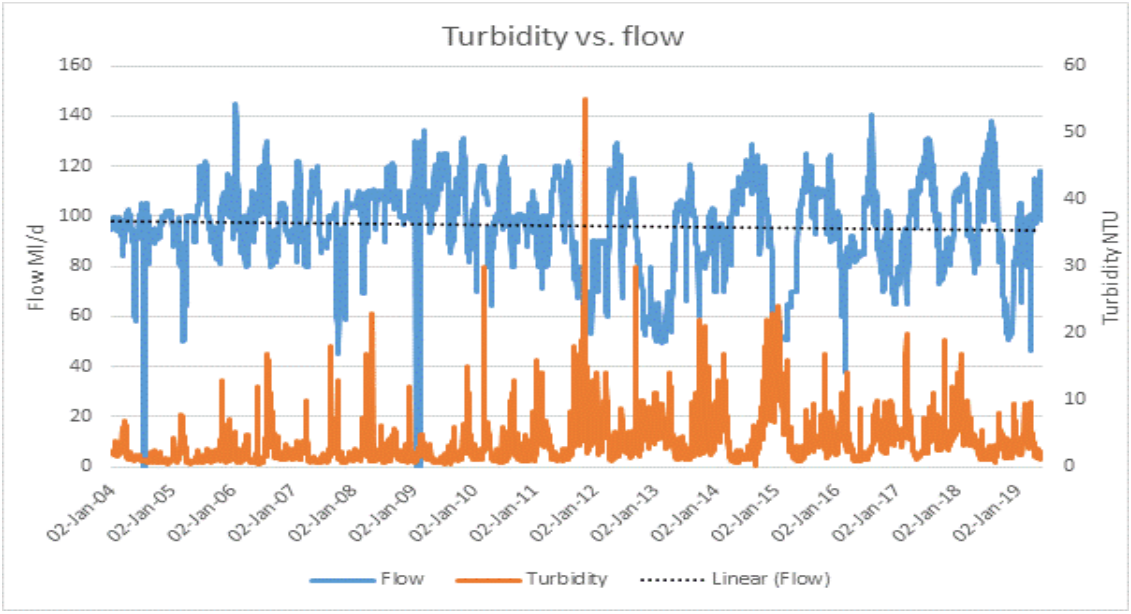

Figure 2: Abberton turbidity and Layer WTW flow, demonstrating outages

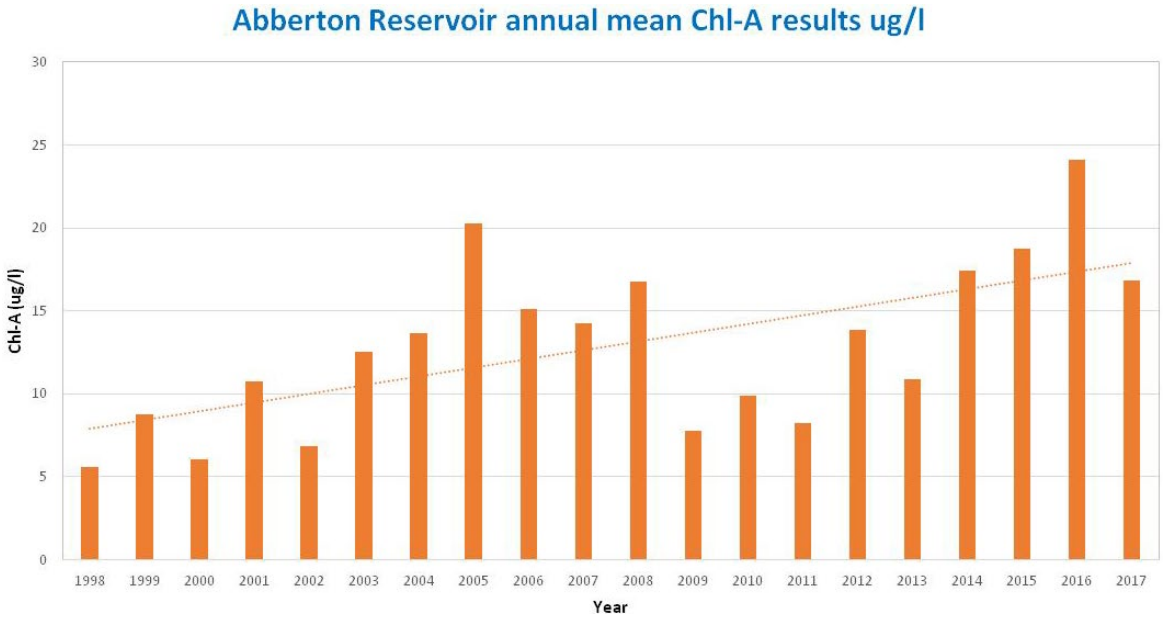

Figure 3: Abberton reservoir algal (chlorophyll A) annual mean results and trend

Figure 3 shows annual average Chlorophyll A concentrations for Abberton reservoir. This is an indicator of how much algae is present in the water column. This shows that a peak concentration of just under 25 µg/l was observed in 2016, the highest value since 1998. It also shows that 2014-2017 had concentrations that were higher than the previous 12 years with the exception of 2005 and 2008. The algal 'season' is extending with the algal challenge starting earlier and finishing later within a calendar year. This may be a consequence of global warming and is a phenomenon observed by other water companies.

Figure 4 shows the chlorophyll A and flow relationship to demonstrate the outage at Layer WTW in response to high algal loads.

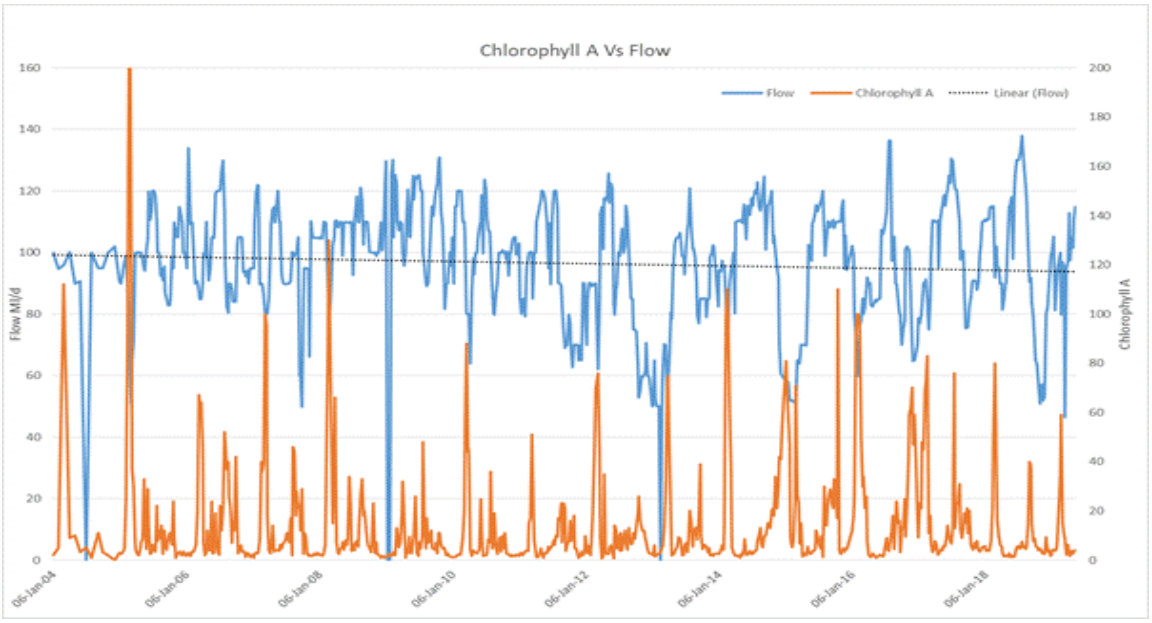

Figure 4: Abberton chlorophyll A and Layer WTW flow, demonstrating outages

The raw water quality deterioration as a result of exceptional outage events due to the dry periods since 2016 (including the long hot summer of 2018) have elevated the risk of severe restrictions on water use in the Essex Water Resource Zone.

How mitigating against failure is currently beyond management control

Layer WTW was not designed to be able to treat raw water of the quality now being experienced and still maintain its deployable output. In order to maintain water quality standards the volumes treated by our slow sand filter plant at Layer must be reduced accordingly. We currently undertake a number of mitigating actions to prevent customers' supplies being impacted. These include:

- The production, every five years, 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. This plan identified the need for the expansion of Abberton reservoir which we completed in recent years;
- Annual planned and preventative maintenance (PPM) activity on our assets at Layer WTW 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;
- Interconnectivity in the network enables other treatment sources to support Layer WTW in the event of any restriction in output. However this is not sustainable given that Hanningfield reservoir is not able to compensate for Layer WTW for lengthy periods without putting supplies at risk;
- The EA river transfer scheme between the Stour and Blackwater rivers is optimised around water availability but this is less reliable than our proposed solution;
- We plan to undertake a full zonal study of the Essex system, expected to be concluded in 2021 to explore opportunities that deliver a more sustainable and resilient network into the future.

Our mitigating actions are insufficient to address the evolving risk posed by the deterioration in water quality in Abberton reservoir. We are unable to manage water quality and still maintain our deployable output from this major treatment works. Continuing to rely on Hanningfield reservoir as an alternative source of supply is unsustainable.

Impact on customer service

The two main consequences of raw water deterioration at Abberton reservoir are the potential for water quality impacts in the immediate supply area and the potential for supply impacts across the wider water resource zone. It is more likely that reduced supply from Layer WTW will impact on supplies across the zone which supplies 421,860 properties, as we would not breach our regulatory obligations (described under the section of regulatory expectations).

The impact would grow gradually, enabling a degree of proactive response involving the need for enforced supply restraints for customers. However, there are limits on the steps we can take. Our first course of action would be to enforce restrictions on our customers. The effectiveness of this action is in itself uncertain. If supplies got dangerously low there is a high likelihood that we would experience some localised depressurisation of the water distribution network. Customers could experience discolouration, aeration and taste and odour issues. Our customers could even be subject to a boil notice until the system has been purged of air and flushed through. The impacts could be prolonged and last a number of months.

How the consequence is currently beyond management control

Service reservoir storage within the networks provide additional security of supply during peak demand events. However, this storage is time limited. Strategic Outage Plans for our water treatment works are also designed to enable a response to a 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 SEMD. None of these management controls fully remove the risk of prolonged service impact.

Summary
Abberton reservoir raw water quality has deteriorated in terms of turbidity and algae over the 2011 to 2018 period. The quality data trends do not show a plateau or reduction, they show an increasing trend. It is not known whether the quality deterioration is a consequence of the expansion of the reservoir and new dynamics in the enlarged water body or climate change or some interaction between these. It is not known when or if the rate of deterioration will continue. What is known is that Layer WTW is presented with an algal and turbidity load beyond the treatment capacity of the current treatment process.

The expansion of Abberton reservoir was undertaken to ensure sufficient resource was available to meet demand from the growing Essex WRZ population. To protect customers from supply restrictions due to treatment works outage it is imperative that an asset intervention is made. A treatment solution designed to process the turbidity and algal load to restore deployable output is required.

Customer and stakeholder expectation

Customer engagement
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 the document 'Our approach to identifying discretionary enhancements'.

This scheme to address raw water deterioration risk has been prioritised through our conversation with customers about resilience 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. Raw water deterioration at Abberton reservoir has already started to impact on the security of supplies by constraining the treatment capacity at Layer WTW. This has led to increased demand on Hanningfield reservoir which cannot be sustained.

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.

We know from engagement with customers on multiple research projects that there are many technical areas of decision making which our customers simply expect to be able to trust us on - or want us to work with expert stakeholders and regulators to manage appropriately. We consider raw water deterioration risk as falling into this category. We have identified that there is a growing risk which needs to be addressed now and the DWI agrees with us. We take seriously the trust our customers place in us to address the risk and prevent an extended and widespread supply interruption from occurring in Essex, as a consequence of raw water deterioration at Abberton.

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 Layer Water Treatment Works. Participants were told that:

> *Layer Water Treatment Works provides water to 300,000 properties. The water treated at Layer comes from Abberton Reservoir. The quality of the water which comes from the surrounding landscape and fills Abberton has changed - it is cloudier and has more algae in it than before. This means the water that goes in Layer needs extra treatment to get it to the right level of quality and impacts the amount of water it can produce.*

We told participants that we would like to install new treatment capability at Layer to manage the quality of the raw water which comes from Abberton and to make sure the works can operate at its full capacity for the long term.

Participants were asked whether or not they accepted this scheme along with two others (a new water main between Abberton Reservoir and Hanningfield; 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

Drinking water quality legislation requires that raw water is subjected to sufficient preliminary treatment to ensure that the disinfection process if effective. The guidance provided by the Drinking Water Inspectorate is as follows:

> *26.6 Regulation 26(6)(b)(i) defines the preliminary treatment that companies must have in place to prepare water for disinfection. This means that suppliers must treat the water to modify its quality in respect of any properties (e.g. pH) and substances (e.g. ammonia) known to adversely affect the performance of the disinfection process (or processes). Where no preliminary treatment takes place the Inspectorate expects the company to be able to demonstrate using robust data why no preliminary treatment is required.*

> *26.7 Regulation 26(6)(b)(ii) requires that the turbidity of water presented for chemical or ultra violet disinfection must be less than 1 NTU at all times.*1

At times of poor raw water quality Layer WTW cannot compromise the disinfection process and so to protect disinfection a supply reduction is made and a turbidity or algal outage declared.

The DWI has issued a Final Decision Letter supporting the need for an asset intervention to better manage the deteriorated raw water quality.

Our track record – Service delivery and expenditure prior to AMP7

Addressing raw water quality challenges is part of water resource management and planning. Our forward thinking approach to planning has been demonstrated over the series of Water Resource Management Plans which we have submitted. We have shown understanding and foresight of developing risks which has enabled us to manage the risks in advance and avoid placing unwelcome restrictions on our customers. We are proud of our record, especially as we operate in one of the driest parts of the UK in Essex. We believe the security of supplies we have provided over many years contributes to the high levels of trust and confidence our customers have in us.

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

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. These challenges are already being felt by us as a result of climate change and population growth. Our customers' expectations are simultaneously rising and they expect us to plan ahead so that they do not bear the consequences of our inaction to mitigate the effects of climate change.

Preparing better for the impacts of climate change is key strand to the UK government's policy for the water industry, which identifies resilience as a key priority. It 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.*

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1 http://www.dwi.gov.uk/stakeholders/guidance-and-codes-of-practice/wswq/08-water-treatment-part1.pdf

The effects of climate change have already created problems for us across the Essex WRZ in a way that we did not expect. The zone serves a population of nearly 1.66 million people in the East and South of Essex and three of the London Boroughs. This population is forecast to increase to 1.98 million by 2045, an increase of almost 20%. Given that the effects of climate change are expected to intensify simultaneously, we need to ensure our existing asset capabilities are maintained while also increasing our capabilities in preparation for the challenges ahead.

Option appraisal

As part of its PR19 Final Methodology, Ofwat has noted that it will assess the robustness and efficiency of all enhancement costs to ensure that any enhancement options put forward by the water companies represent the best options for customers. This includes an assessment of whether the company has considered an appropriate range of options for the enhancement with a robust cost–benefit analysis (CBA) before concluding that the proposed option is the best course of action.

We have used CBA in order to support a significant number of 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 concludes with our cost-benefit analysis.

Options considered

MWH was commissioned to investigate options on treatment works upgrade at Layer WTW, in order to address the concerns of increasing turbidity and algae concentrations in Abberton reservoir raw water. The report considered options relating to the use of Dissolved Air Flotation (DAF) processes, which are effective for the treatment of algae and turbidity–laden waters1. A summary of the options considered is given below:

Option 0 – Do nothing	
Due to this deteriorating water quality in Abberton reservoir, treatment output from Layer WTW has to be reduced. In turn this creates a supply-demand issue in ESW water supply zone. Therefore, doing nothing is not considered a viable option.	
Option 1 - Modify existing plant & build parallel treatment streams	**£13.35m**
This option considers the modification of the existing treatment plant by building parallel treatment streams of the required capacity, comprising of dissolved air flotation (DAF), followed by rapid gravity filtration (RGF), and followed by granular activated carbon (GAC) contactors. As the feasibility study progressed it became clear that the design of this option would mean that at times Layer would be unable to achieve output in excess of 110 Ml/d. This does not restore the deployable output.	
Option 2 - Construct a whole new treatment train (DAF+RGF+GAC)	**£83.58m**
This option proposed that in order to reach flows of 145Ml/d the existing works would be abandoned, and a whole new treatment train would be constructed comprising DAF, RGFs and GAC contactors. This option would result in increased costs from having to construct an entirely new treatment works.	
Option 3 - Upstream DAF plant with 145 Ml/d capacity	**£26.87m**
This option was also designed to achieve the required deployable output of 145Ml/d, with a DAF plant positioned upstream of the existing treatment processes, which will make the treatment process more efficient.	
Option 4 - Upstream DAF plant with 165 Ml/d capacity	**£43.24m**
This option was identical to Option 3 but would look to treat higher quantities of up to 165 Ml/d, potentially requiring interstage pumping and further treatment downstream. However, this level of output is not currently required, so these increased costs are unlikely to be justified.	
Option 5 - Upstream DAF process, but only on one rather than both of the current process streams	**£27.88m**
This option also included an upstream DAF process stream but only on one rather than both of the current process streams. However, there are concerns over whether this option would meet the required treatment works output.	

Costing of options

NWG 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 20182.

In June 2019 NWG 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 NWG's iMOD system against the market. The result of this exercise showed that NWG's cost estimates were on average 15% lower than the cost estimates returned by

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

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].

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 421,680 properties that are reliant on Layer WTW. 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 are presented in Table 2.

Table 2: Risk reduction and benefit cost ratio (BCR) for the individual options

Option Number	Customers benefiting (Nr Properties)	Totex (£m)	£ per customer benefited	Risk Score- Before	Risk Score - After	Risk Reduction delivered	BCR
Option 1	421680.00	13.35	31.65	124.13	2.57	121.56	17.99
Option 2	421680.00	83.58	198.21	124.13	1.28	122.84	5.50
Option 3	421680.00	26.87	63.72	124.13	12.46	111.67	9.60
Option 4	421680.00	43.24	102.55	124.13	9.62	114.51	7.88
Option 5	210840.00	27.88	132.23	65.05	13.09	51.96	4.60

The cost benefit analysis shown in Table 2 suggests that Option 1 provides the higher BCR. However, as this scheme was designed it became clear that the design of this option would mean that at times Layer would be unable to achieve output in excess of 110 Ml/d. Therefore this option was deemed non-viable. The viable option with the highest BCR is Option 3. Whilst this does not deliver the highest risk reduction, it provides the best value to customers.

Based on our approach to CBA and risk reduction, we estimate total customer benefits of £474.3m from the scheme. This value captures only the benefit that the investment delivers in terms of reduction in risk of supply interruptions. This is likely to be a conservative estimate as it 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 £49.4m, and implies a benefit cost ratio (BCR) of 9.6. 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 £687. 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

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

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

interruptions of up to 24 hours is £553. This valuation implies a BCR of 0.80, indicating that customer benefits would be 20% less than costs when this more conservative value is used.

Our preferred plan/option

Our preferred option is to install a new DAF treatment process stream at Layer WTW to address the changes to raw water quality from Abberton reservoir. The DAF process is a proven treatment technology effective at tackling both turbidity and algae. This will ensure that the works can maintain the full deployable output throughout a year and will remove the risks of customer supply restrictions.

An indicative process flow diagram for the recommended option is shown in Figure 5 below. Blue process boxes indicate new structures; green modified structures; and orange an abandoned structure.

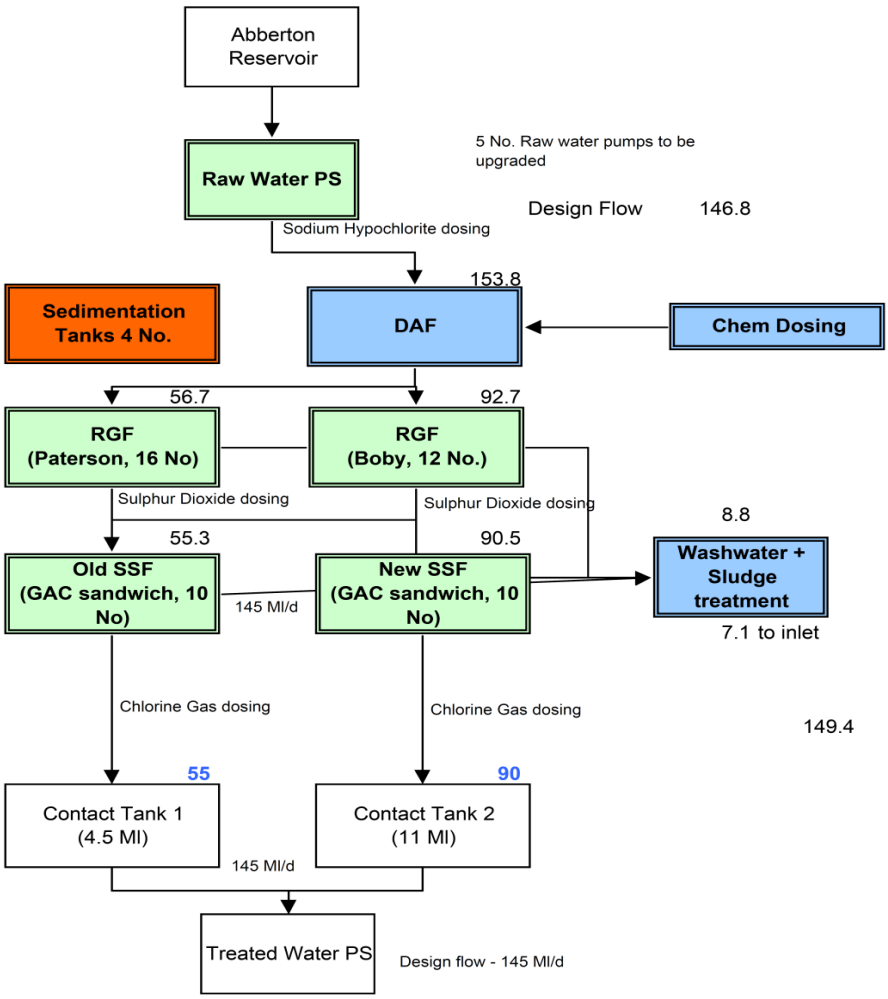


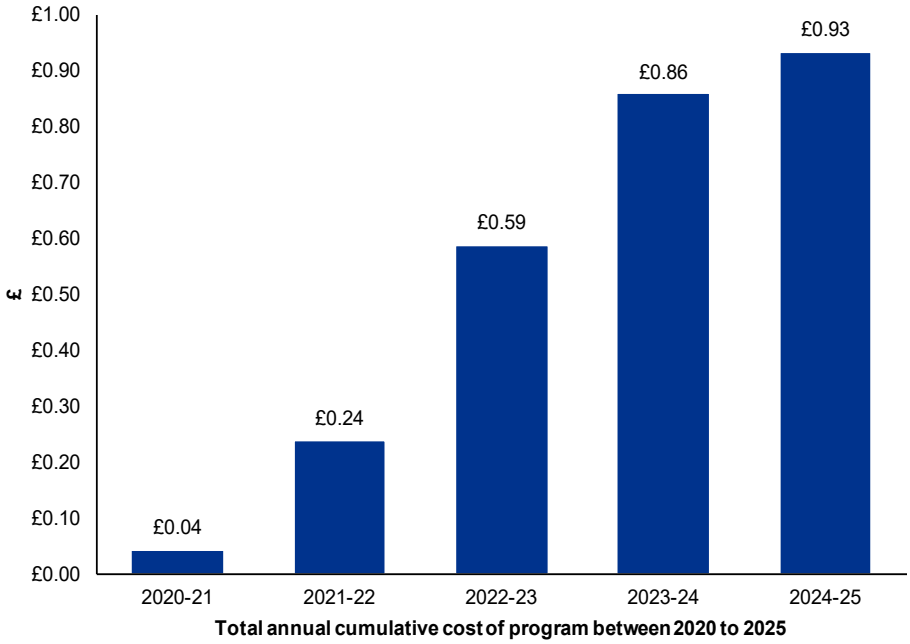
Figure 5: Process flow diagram with preferred option.

Summary of totex

We are restating our expenditure request for £26.9m to construct a DAF plant sized at 145 Ml/d. This is included along with the Mosswood UV scheme on Line 13 'Investment to address raw water deterioration' of data table WS2. Together the schemes total £34.8m.

Affordability

The impact of these enhancement investments on customer bills are shown below with this scheme costing customers a one off cost of £0.93 on their bill between 2020 and 2025[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.

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 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.

[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

[7] See section 3.2 of our business plan, https://www.nwl.co.uk/_assets/documents/NWG_PR19_Interactive_FINAL_RS.pdf

Alignment with stakeholder needs

Regulators and other stakeholders

At times of poor raw water quality Layer WTW cannot compromise disinfection. To protect the disinfection process a supply reduction is made and a turbidity or algal outage declared. This short term operational activity achieves stakeholder needs. However it is not sustainable and an asset intervention in the form of an appropriate treatment process for the increased algal and turbidity load is required to restore deployable output.

The DWI understand this need and support the solution we are planning to deliver. Their Final Decision Letter is provided alongside this business case.

Customer protection

Details of how we propose to incentivise delivery of our proposed enhancement schemes and to protect customers from non-delivery are included in section 4 of the April 2019 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 NWG 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].

[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