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3.3.7 MOSSWOOD 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)

July 2019

3.3.7 MOSSWOOD BUSINESS CASE

Name of claim	UV treatment at Mosswood WTW
Business plan table lines w here the totex value of this claim is reported	WS2 – Wholesale capital expenditure by purpose Line 13
Total value of enhancement for AMP7	£7,900,000
Total opex of enhancement for AMP7	£0
Total capex of enhancement for AMP7	£7,900,000
Remaining capex required after AMP7 to complete construction	Expected to complete scheme by 2022/23
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	0.65%
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

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Executive summary

The raw water in Derwent Reservoir has deteriorated significantly over recent years. This means that Mosswood Water Treatment Works (WTW) is no longer properly equipped to treat the water in line with the company disinfection policy. We are proposing to introduce a new treatment stage of UV disinfection to reduce the risk of cryptosporidium failures occurring.

Need

Since 2012 we have seen a significant deterioration in the raw water quality at Derwent Reservoir. The final water leaving Mosswood WTW has also measurably deteriorated and we have mitigations in place that now limit the works output in order to manage the water quality risk. This creates the potential for supply impacts in the system which Mosswood supports during peak demand periods.

The DWI is supportive of the need for this investment and has issued a Final Decision Letter (provided along with this business case) supporting this investment due to the potential impact to public health and water quality.

This scheme was one of three schemes tested collectively with customers and achieved 92% acceptance. The information we shared with the research participants included illustrative costs and made it clear that all our customers will pay for enhancements even if they do not directly benefit based on where they live.

Options Considered

We have considered a range of options to resolve the risks presented by the deterioration in raw water quality in Derwent Reservoir. Discussions with ozone technology suppliers indicated that it would be too costly to use this form of treatment to resolve the risk. Membrane ultra-filtration would also be an expensive solution as it would normally be employed as an alternative to the current filtration system. UV treatment was identified as the most cost effective and reliable way to address cryptosporidium risk through inactivation. Therefore UV was considered to be the only solution to progress to optioneering. We have looked at five potential UV solutions which deploy the technology in different ways which are discussed in detail within this business case. Our preferred option is to install duty standby UV reactors on each outlet main as the two outlet mains supply entirely separate areas of the distribution system. This is the most cost-beneficial solution out of the options we consider to be viable.

Need for enhancement

This needs case is about addressing the risk posed by a deterioration in raw water quality at Derwent reservoir. Changes in the catchment water quality are identified in our Water Safety Planning process as increasing cryptosporidium risk at Mosswood WTW.

Failure mode

The change in quality at Derwent Reservoir has increased the cryptosporidium risk from these source waters to a point that now requires us to achieve 3 $\log_{10}$ removal at Mosswood WTW through our filters in comparison to the previously required 2 $\log_{10}$ removal. Cryptosporidium is a waterborne pathogen that is resistant to chlorination and accepted best practice is removal during pre-treatment or inactivation by UV.

Mosswood WTW was not designed to treat water to 3 $\log_{10}$ removal and maintain its deployable output. We are currently restricting the works output to maintain water quality compliance. If we increased the works output to respond to a period of peak water demand then this would likely cause a cryptosporidium breakthrough on the filters.

A secondary failure mode which this business case looks to address is that Derwent reservoir is frequently drawn down to low levels, as shown in Figure 1. Since 2013, our abstraction from the reservoir has been greater than yield. Together with the crypto risk, this limits the treatment capacity at Mosswood in a way that could affect customer supplies.

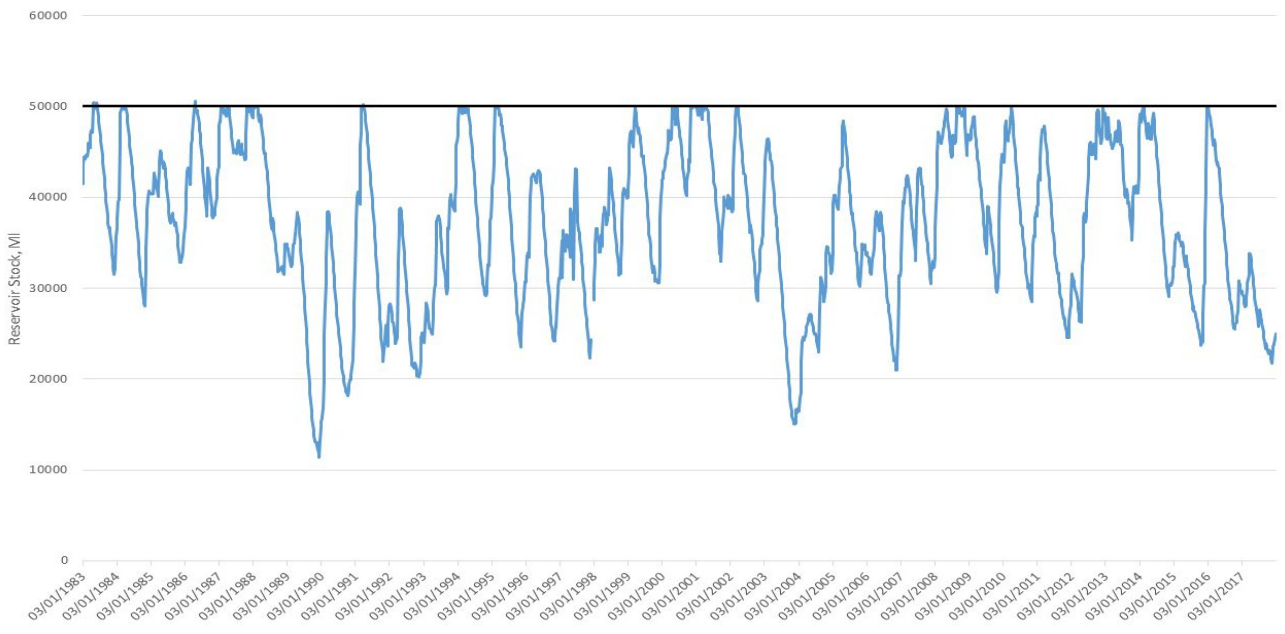


Figure 1: Derwent reservoir levels 2006 to 2017

Likelihood of failure

The deterioration in raw water quality is being evidenced now including through the increased cryptosporidium breakthrough risk. Figure 2 shows a clear deterioration in raw water quality since 2012, both in terms of coliforms and cryptosporidium levels.

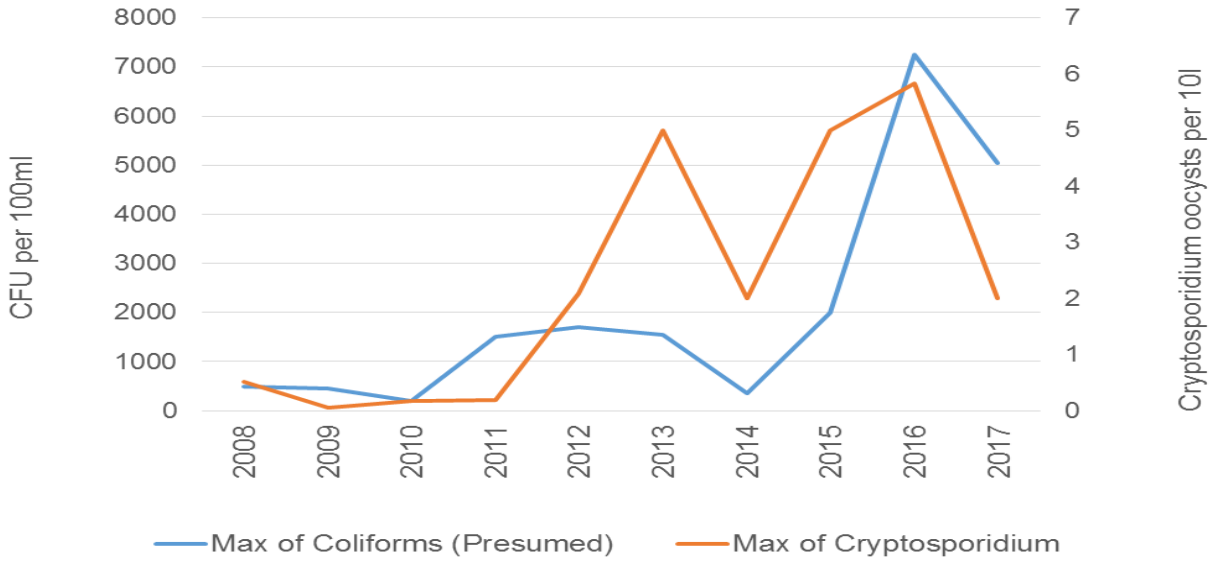


Figure 2: Derwent raw water coliform and cryptosporidium performance over time

For a thorough assessment of the likelihood of a cryptosporidium failure occurring after treatment at Mosswood WTW we refer to the NWG Disinfection Policy (independently assured by WRc) which sets out the treatment needs for effective disinfection. A treatment works' processing capability varies depending on the design of the WTW and the number and type of treatment processes. All treatments works must be able to process the maximum disinfection challenge so as not to pass any risk through to customers. The need to produce wholesome fully treated and disinfected water is also required by water quality regulation (see section on stakeholder expectations).

To apply the policy a Site Specific Disinfection Assessment (SSDA) is carried out for each treatment works. This considers the level of risk based on raw water data and treatment needs as per the table below. The assessment is routinely carried out using a three year data set to incorporate changes in risk and quality over time. Table 1 below shows how raw water quality defines treatment capability and disinfection needs.

Table 1: Raw water classifications (NWG Disinfection Policy)

Risk category	Raw water risk categorisation				Treatment and disinfection requirements
	Typical water type	Max coliform result (cfu/100ml)	Viral risk	*Cryptosporidium* Risk	
Very Low	Pristine ground water	0 coliforms*	Negligible	Insignificant	Marginal chlorination, final water with a chlorine residual within the normal operating range, no CT requirement.
Low	Ground water	1-10 coliforms	Very low	Insignificant	Effective CT 15mg.min/L
Medium	Ground/ Surface water	>10-2000 coliforms	Low	Low - Moderate	2 log_{10}** removal of *Cryptosporidium* Effective CT 15mg.min/L
High	Surface water	>2000-20000 coliforms	High	High	3 log_{10}** removal of *Cryptosporidium* Effective CT 15mg.min/L
Very High	Surface water	>20000 coliforms	Very High	Very High	4 log_{10}** removal of *Cryptosporidium* Effective CT 15mg.min/L

* One non-faecal coliform result of 1cfu/100ml within three years will not change pristine designation.
** Log10 removal is the accepted method of expressing the factors of 10 the cryptosporidium risk is reduced.

Historically Mosswood WTW receiving Derwent reservoir water was classified as a medium risk. The SSDA assessment, based on data from 2010-12, 2011-2013 and 2012-14 confirmed Mosswood WTW has the capacity to manage this risk. In Table 2 below it can be seen that there has been deterioration in the raw water quality within the impounding reservoir over the 2015-17 period.

Table 2: Derwent reservoir raw water quality data 2008 to 2017

Year	Max of Coliforms (Presumed)	Max of E.Coli (Presumed)	Max of Colonies 2 Day 37 C YEA	Max of Colonies 3 Days 22 C YEA	Max of Cryptosporidium	Max of Colour Filtered
2008	500	250	50	650	0.513	83
2009	450	150	27	300	0.056	150
2010	200	100			0.176	63
2011	1500	550	950	15000	0.187	60
2012	1700	1050	300	5300	2.091	84
2013	1550	400			5	75
2014	350	150	50	150	2	52
2015	2000	400	13000	3300	5	72
2016	7250	1050	8600	150000	5.83	79
2017	5050	450	2	81	2	59

The latest data (2015-17) changes our assessment of risk from medium to high. The raw water deterioration means that Mosswood WTW no longer meets the standard for disinfection capability. This means that there is now an unacceptable likelihood of failure.

We are currently managing this risk by restricting works output. Significant water demand events that are beyond our control, such as *The Beast from the East*, or a hot summer could significantly increase the risk of the service failure occurring. Our last significant winter peak was in 2010/11 and we had an extreme peak in demand in the summer of 2006. If such demand levels were seen now Mosswood WTW would not be able to increase supplies without breaching water quality standards. The likelihood of similar extreme weather events is increasing with climate change and we need to act now to ensure we can prevent any customer impact.

How mitigating against the failure is currently beyond management control

Mosswood WTW benefits from being supported by the Kielder Transfer System. Kielder Reservoir, located in Northumberland, is the largest artificial lake in the United Kingdom by capacity holding 200 billion litres (200,000Ml) of water. The transfer network enables water to be transferred throughout the Northumbrian operating area to the rivers Wear, Derwent and Tees, as shown in Figure 3. Mosswood WTW is located downstream of Derwent reservoir and Eddy's Bridge crossing.

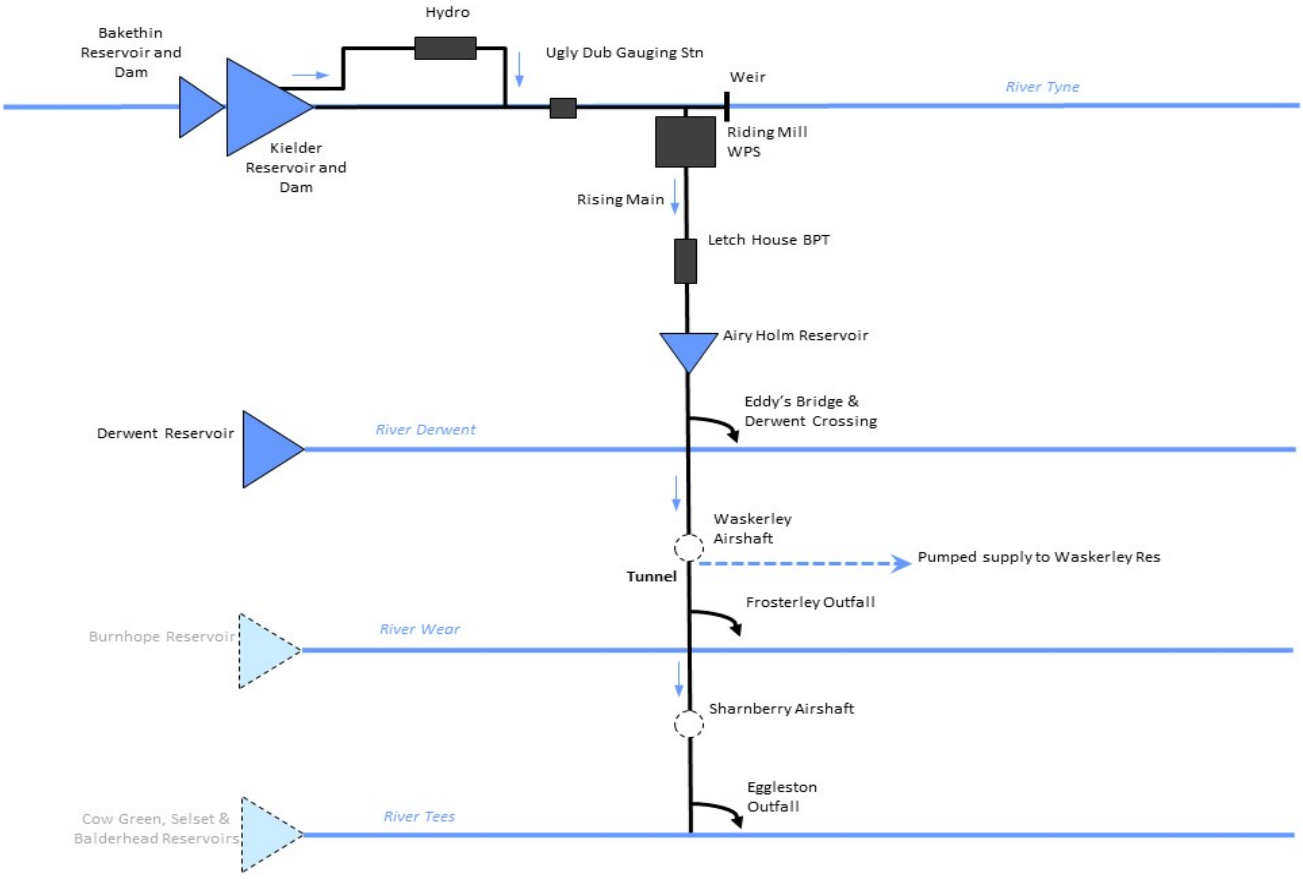


Figure 3: The Kielder and Tyne Tees Transfer Scheme

The existence of the Kielder Transfer System means we can use this source as an alternative means of supply. However, the quality of raw water from the Kielder Transfer System has always been categorised as high risk and the raw water quality remains poorer than the quality of water in Derwent Reservoir. At present, we are only able to use water from the transfer system when it is blended with Derwent water with no more than 20% of the total flow being taken via the transfer. This means there are limits on how far this secondary source can be used and we cannot take full advantage of the resilience it offers.

We undertake a number of actions to manage the risk of raw water deterioration on treatment capacity at Mosswood WTW. These include:

- Proactive catchment management alongside local land owners and users to reduce their impact on raw water quality and quantity as much as possible;
- Annual planned and preventative maintenance activity on our assets at the treatment works is determined by the type of asset and the risk it presents to disruption of service if it fails or performance deteriorates.
- The treatment works is optimised to treat as much water as possible to a high quality standard. For example, we have increased the back wash frequency on our filters;
- We are monitoring 24/7 for crypto breakthrough from the filters.

Our catchment management work across the Derwent catchment to influence and change land management practices is limited and unlikely to have any immediate short term benefits. Therefore our ability to mitigate the cryptosporidium risk at Derwent in the short term is very limited.

None of our current control measures can fully remove the risk of a cryptosporidium breakthrough occurring on this works, a point recognised by the DWI. The mitigation we have in place reduces the likelihood and consequence of failure but not to the extent that we would deem acceptable.

The impact on customer service

Cryptosporidium breakthrough is a serious consequence which could lead to a significant public health event. If we experience a cryptosporidium breakthrough then all customers supplied by the works would be issued with an immediate boil water notice whilst management controls are implemented. Based on the experiences of United Utilities in the Franklaw WTW incident this could involve a significant logistical exercise, deploying mobile UV disinfection across the network.

There is also a risk that we will be forced to introduce supply restrictions in order for us to manage the risk of cryptosporidium breakthrough during a peak demand event. This would not be well received in a region where customers perceive their water supplies to be very secure. If we had to shut down Mosswood WTW to prevent cryptosporidium breakthrough being carried forward into supply then 99,821 properties supplied by the Derwent North main will likely experience a loss of supply or an enforced restriction of their water supply due to a lack of strategic storage in the network. The first customer impact is possible within 6-8 hours. A further 70,404 properties supplied by the Derwent South main could also experience a loss of supply if the shutdown lasted over 24 hours.

If strategic storage capacity is depleted there would be a wide scale depressurisation of the water distribution network, leading to subsequent water quality issues. The full 170,225 properties supplied by Mosswood WTW would experience discoloration, aeration and taste and odour issues. If ingress was identified this may leave us with no alternative but to issue a widescale boil notice until the system has been purged and flushed through.

A supply failure event at Mosswood WTW would likely attract widespread political and media interest, especially as customers in our region perceive their water supplies to be very secure. It would have a significant regional wide socio-economic impact on the day to day lives of our commercial and domestic customers as well as presenting a significant logistical and resource challenge for our business. It's highly probable that we would require support via mutual aid from other water companies and government agencies. It is likely that there would be an impact on the level of trust in NWG as the provider of essential public services.

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.

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, this research showed that there are limits to what would be considered acceptable or reasonable. An extended supply interruption lasting several days would not be acceptable and could lead to a loss of trust. It is clear that supply disruption caused by a serious water quality failing would be even less acceptable and could have an even more damaging impact on 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." 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 Derwent reservoir has already started to impact on the security of supplies by constraining the treatment capacity at Mosswood WTW. This has led to increased use of the Kielder transfer system but has also impacted on levels at Derwent reservoir and this is not sustainable.

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 'do not use' notice or supply interruption from occurring as a consequence of raw water deterioration at Derwent reservoir.

In March 2018 we conducted six deliberative workshops in our Northumbrian Water operating region to explore participants' acceptability of a shortlist of 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 Mosswood Treatment Works. Participants were told that:

> *100,000 properties in Wearside and Durham are supplied by a water treatment works called Mosswood, which mostly takes water from Derwent reservoir.*
>
> *The water quality in the Derwent area has changed recently and it isn't as good as it used to be. This means that Mosswood can't treat as much water, as such 100,000 properties may be at risk of experiencing a shortage.*

We told participants that we would like to make improvements to Mosswood WTW so that can treat the lower quality water from Derwent, to a high standard for the long term.

Participants were asked whether or not they accepted this scheme along with two others (a new water main and pumping station to connect the Durham and Teesside water networks; and a new service reservoir and interconnected main at Springwell in Gateshead) in return for taking 0.66% less of the 10% bill decrease we had committed to giving. They were told that this would be equivalent to £2.57 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 92% 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, overall “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]

The deterioration of raw water quality at Mosswood WTW cannot compromise the disinfection process and so to protect disinfection a supply reduction is made. This restriction reduces system resilience and introduces supply challenges that could result in supply issues.

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.

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

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 in our Northumbrian Water supply zones. Alongside this we still face 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.*

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

A number of treatment based options are available which could provide the required level of cryptosporidium removal, including:

- Coagulation;
- Clarification and filtration;
- Ozone, membrane ultra-filtration and UV irradiation.

Currently Mosswood WTW already treats cryptosporidium through coagulation, clarification and filtration treatment processes. The site requires a further treatment stage to sufficiently address the risks posed by the increased levels of cryptosporidium in Derwent Reservoir.

Discussions with ozone technology suppliers indicated that it would be too costly to achieve the required cryptosporidium log10 removal with ozone alone. Membrane ultra-filtration would also be an expensive solution as it would normally be employed as an alternative to the current filtration system. UV is known to be a cost effective solution for reliable reduction in risk from cryptosporidium through the inactivation of cryptosporidium oocyst. Therefore UV, which can be used in a number of different ways, was considered to be the only solution to progress to optioneering.

In a summary report on Mosswood UV produced by Interserve and Amec, Foster, Wheeler a total of six UV installation options were considered and are summarised in Table 3.

Table 3: Mosswood WTW Options

Option 0 – Do nothing	
Due to this deteriorating water quality in Derwent Reservoir, treatment output from Mosswood WTW has been reduced. This means that treatment capacity across the supply area would be insufficient in a period of peak demand. Therefore, doing nothing is not considered a viable option.	
Option 1	£7.10m
Install duty/standby UV reactors downstream of existing rapid gravity filters. Relocate chlorine dosing downstream of new UV reactors and install new pumping station (with dry and wet wells) to maintain flow to and from UV reactors.	
Option 2	£6.10m
Install duty/standby UV reactors downstream of existing rapid gravity filters. Relocate chlorine dosing downstream of new UV reactors and install new pumping station (wet well only) to maintain flow to and from UV reactors.	
Option 3	£5.75m
Install duty only UV reactors downstream of existing rapid gravity filters and chlorine. Install new pumping station (wet well only) to maintain flow to and from UV reactors.	
Option 4	£4.76m
Install a duty only UV reactor downstream of the disinfection contact tank on each outlet main prior to pH conditioning and before entry to the distribution system. This option is very similar to option 5, but as there is no duty standby provision for the UV reactors, they could not be maintained whilst also continuing to supply water to the distribution system.	
Option 5	£7.90m
Install a duty standby UV reactor downstream of the disinfection contact tank on each outlet main prior to pH conditioning and before entry to the distribution system, to allow maintenance to take place.	
Option 6	£5.16m
Install secondary rapid gravity filtration downstream of existing primary filters.	

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 2018[2].

In June 2019 NWG commissioned a shadow pricing exercise by our contractor partners and commercial consultants for 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% more efficient 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 robust and 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 170,225 properties that are reliant on Mosswood 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 4.

Table 4: Risk reduction and benefit cost ratio 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	170225.00	7.10	41.71	52.82	0.53	52.29	23.14
Option 2	170225.00	6.10	35.83	52.82	1.06	51.76	25.25
Option 3	170225.00	5.75	33.78	52.82	2.11	50.70	25.65
Option 4	170225.00	4.76	27.96	52.82	10.56	42.25	35.85
Option 5	170225.00	7.90	46.41	52.82	5.28	47.53	26.71
Option 6	170225.00	5.16	30.31	52.82	39.61	13.20	12.03

The cost benefit analysis suggests that Option 4 should be taken forward. However, as Option 4 provides no standby provision for the UV reactors this would make it impossible to carry out maintenance on the UV reactors without temporarily suspending treatment. It is important to clarify that the two outlet mains from Mosswood are not a twin arrangement that would negate the need for standby UV reactors. One main supplies Washington (the Derwent North main); the other supplies Durham (the Derwent South Main). These are entirely separate areas of the distribution system. Therefore, failure of a single UV unit on either outlet

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

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

would result in an instantaneous shortfall to the distinct area supplied by that main or a disinfection failure and undisinfected water entering supply. This must be prevented as The Water Supply (Water Quality) Regulations 2016 require all water to be disinfected. The decision to stop water entering supply would cause huge network consequences. Therefore, Option 4 is not considered viable as the risk this would pose to service is unacceptable. Option 5 is the preferred option as it has the highest BCR out of all the remaining viable options. A duty/standby arrangement is required to allow for proactive or reactive maintenance to take place.

Based on our approach to CBA, we estimate total customer benefits of £217.9m with the deployment of Option 5. 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 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 £13.1m, which implies a benefit cost ratio (BCR) of 16.62. 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 £397. 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 1.39, indicating that customer benefits would exceed costs by 39% even when this more conservative value is used.

Our preferred plan/option

Our preferred option is to install duty/standby UV reactors on each outlet main downstream of disinfection and pH conditioning treatments. It has acceptable costs and offers a robust resilient solution. It results in lower additional UV power costs and additional pumping in the outlet mains. It provides validated treatment for cryptosporidium and E.coli, with potential for future proofing should higher levels of treatment be required. There is no significant impact on WTW production, although maximum peak flow in one outlet main could be reduced from 86 Ml/d to 82 Ml/d. It does not introduce significant risk to water quality through disinfection byproducts.

Summary of totex

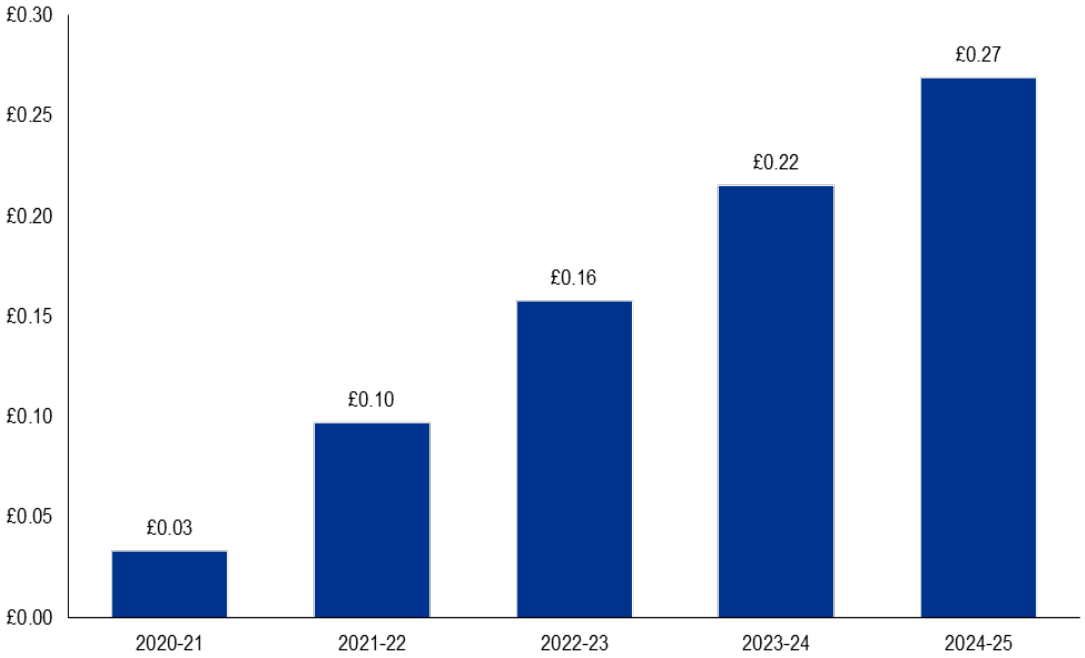
We are restating our expenditure requirement for £7.9m to construct an UV irradiation duty/standby treatment system at Mosswood WTW. This is included along with the Layer DAF scheme on Line 13 ‘Investment to address raw water deterioration’ of data table WS2. Together the schemes total £34.8m.

Affordability

The impact of these enhancement investments on customer bills are shown below with this scheme costing customers a one off cost of £0.27 on their bill between 2020 and 2025[5].

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

[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.



This is set within an overall bill drop 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.

Alignment with stakeholder needs

Regulators and other stakeholders

The quality of Mosswood WTW's main water source has deteriorated and an asset intervention is required to continue to process and supply wholesome water. The Drinking Water Inspectorate require all companies to produce wholesome water and support the expenditure need. Their Final Decision Letter is provided alongside this business case.

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.

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

The DWI have issued Final Decision Letters supporting the need for this expenditure. The scheme will be formalised into a legal Undertaking and this offers an additional protection for customers.

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[7].

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[8].

[7] 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'

[8] See Board Assurance Statement