Dŵr Cymru
Welsh Water

Enhanced Investment Case: WSH55-CW03 - Improving Quality of Tap Water - Treatment Works

Contents

Executive Summary

This investment will improve the acceptability and the overall quality of water to our customers from our treatment works. The risks addressed include ensuring water is treated to the highest standards and this is maintained despite deteriorating raw water quality, improving acceptability of water (particularly with respect to taste & odour, and discoloration), and adherence to Regulation 26 with disinfection resilience.

We have structured this document using the enhancement assessment criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A1. The enhancement assessment criteria are divided into four criteria groupings:

- Need for enhancement
- Best option for customers
- Cost efficiency
- Customer protection

Need: Climate change is negatively impacting the quality of our raw water sources. This has resulted in some of our treatment facilities being at risk of compromising our final water quality by not having adequate processes to treat the deteriorating water. These include processes to-:

1. remove increased solids loading.
2. ensure disinfection aligns with regulation.
3. remove taste and odour contributing compounds
4. remove carcinogenic disinfection by-product precursors.
5. remove manganese as low as practicable to reduce discoloration.

If we do not increase the level of investment due to deteriorating raw water quality at our treatment facilities in AMP8 we will:

- Compromise the quality and safety of our water supplied to customers.
- Not be able to achieve our DWI set target of 0.7 customer contacts/1000 due to discolouration by the end of AMP8.
- And not achieve our overall acceptability of water target at the end of AMP8 of 1.0 customer contacts/1000.

We have worked with specialists to not only develop strategies to treat the deteriorating raw water, but most importantly develop strategies to assess how the raw water quality can be improved by assessing the source catchments. We have a well-developed understanding of the statistics and science behind the observed trends and have been able to use this insight to effectively target our response.

Options: We have considered a range of intervention options both in the catchment and at our WTWs, including assessment of new treatment technologies. For example, for solids removal we have analysed; filtration, dissolved air flotation and counter current dissolved air flotation. Our chosen options include:

- Investigations and feasibility studies into raw water source deterioration.
- Additional solids removal process and dedicated Manganese removal at Cefn Dryscoed WTW. DWI supported project.
- Additional organic removal scheme at Mayhill WTW. DWI supported project
- Scheme at Capel Curig WTW to mitigate elevated and increasing levels of disinfection by-products. DWI supported project.
- New UV disinfection process at various WTWs. DWI supported project.
- Manganese intervention at various WTWs.
- Validation of outputs monitoring – Water regulation 26 assessments

What We Will Deliver:

Raw Water Deterioration and Customer Acceptability – Cefn Dryscoed WTW - This Enhancement Case will deliver a new counter current dissolved air flotation and filtration process, and a dedicated manganese removal process to treat the increasing concentrations of suspended solids and manganese within the raw water.

Manganese improvements at WTW - This enhancement will deliver a new dedicated manganese removal process (eg cartridge filters) to 4 WTW, and process optimisations and improvements to 6 other WTW to remove treat the increasing concentrations manganese within the raw water.

Regulation 26 Disinfection Strategy - This Enhancement Case will deliver new ultra -violet disinfection to 4 WTWs to meet regulation 26 compliance.

Raw Water Organics (Taste and Odour) - Mayhill WTW - This enhancement will deliver an increase in capacity to the existing organics removal process stream to treat the increasing concentrations of organics within the raw water ensuring that we achieve water quality standards.

Disinfection By-Products – Mayhill WTW - This enhancement will deliver a new process treatment unit (carbon filtration) to remove the disinfection by-product precursors (Tri-halo menthanes) and abandon an alternative raw water source.

Smaller schemes - Lastly this enhancement will deliver 2 smaller schemes (Bontgoch and Pendine raw water deterioration) and a feasibility study of disinfection by-products at Anglesey.

Efficient Costing: We will invest £42M (post efficiency, 2022/23 price base, overlap removed) on the required enhancements. We have built on insights gained through our previous programmes and in the development of investment models to generate efficient and cost beneficial schemes.

Customer Protection: Delivery of this work is overseen by the DWI to whom we have made commitments on maintaining quality. The impacts of the work will also have a small impact on the Compliance Risk Index (CRI) and remove a risk to the Event Risk Index (ERI) metric.

Benefits: This investment will improve the quality and acceptability of water to our customers and will be a progressive step in our journey to reduce our overall customer contacts to 0.5/1000 customers by the end of 2050, as part of our long term delivery plan.

Our approach has been independently assessed by Jacobs (Engineering and Costs) and Economic Insight (CBA).

Introduction

This enhancement investment will improve the quality of service we provide to our customers by delivering improved water quality outputs at our WTWs.

This investment will improve final water quality for customers by managing the risks to our water treatment works. The risks identified for this Enhancement Case are focused on meeting emerging regulatory requirements and managing the deterioration of raw water quality due to climate change.

The benefits include reducing compliance risks in accordance with CRI compliance, improving final water quality, and improved acceptability of water.

The DWI has issued letters of support for this programme in August 2023 (these will progress to create a legal requirement under Regulation 28) shown in summary within Table 1 below.

The overall AMP8 Enhancement TotEx for this Enhancement Case is £45.912M (post efficiency, 2022/23 price base). Further detail summarised below:

Table 1: List of DWI Support References/Notices for PR24 proposed schemes

Enhancement Case Spend Areas	Scheme details	AMP8 TotEx Investment	DWI Notice Reference
Raw Water Deterioration at Cen Dryscoed WTW	Scheme includes installation of a new Counter Current Dissolved Air Flotation plant (CoCoDAF) and dedicated manganese removal stage in response to heightened risk from increasing solids and manganese loading	£13.690M	DWR1
Regulation 26 Disinfection Strategy – Compliance & Validation	The installation of UV treatment at 4 treatment works in response to an industry leading piece of research to highlight the risk of existing processes capability of removing or reducing pathogen loading	£10.147M	DWR2
Disinfection By-products - Capel Curig WTW & Minor Investment	A scheme to address raw water deterioration of disinfection by-product precursors and future legislation change by abandonment of the WTW to supply from an alternative location. A feasibility study to further investigate disinfection by-products on Anglesey to produce a robust solution for investment in AMP9 or later	£5.519M	DWR4
Raw Water Organics (taste and odour) at Mayhill WTW	Increase removal capacity of taste & odour causing organic compounds following a deterioration of raw water quality and ineffectiveness of existing treatment process to remove	£2.918M	DWR5
Customer Acceptability - Manganese Improvements at WTW	Optimisation and improvements across a number of sites in response to raw water deterioration and increased manganese loading.	£7.961M	DWR6

Enhancement Case Spend Areas	Scheme details	AMP8 TotEx Investment	DWI Notice Reference
Raw Water deterioration at Bontgoch WTW	A scheme to partially address raw water deterioration	£1.524M	-
Raw Water deterioration at Pendine WTW	A scheme to address raw water deterioration of the existing source water	£4.153M	-
Total		**£45.912M**	

Structure of this Document

We have structured this document using the enhancement assessment criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A1.1:

ID from Appendix 9	Abbreviated Assessment Criterion		Investment Package 1 – Cefn Dryscoed	Investment Package 2 – Regulation 26 Disinfection Strategy	Investment Package 3 – Disinfection By-products	Investment Package 4 – Raw Water Organics at Mayhill WTW	Investment Package 5 – Customer Acceptability (Manganese)	Investment Package 6 – Raw Water Deterioration at Bontgoch	Investment Package 7 – Raw Water Deterioration at Pendine
A1.1.1 Need for enhancement investment	a	Is there evidence that the proposed investment is required?	Section 1.1.1	Section 2.1.1	Section 3.1.1	Section 4.1.1	Section 5.1.1	Section 6.1.1	Section 7.1.1
	b	Is the scale and timing of the investment fully justified?	Section 1.1.2	Section 2.1.2	Section 3.1.2	Section 4.1.2	Section 5.1.2	Section 6.1.2	Section 7.1.2
	c	Does the proposed investment overlap with base activities?	Section 1.1.3	Section 2.1.3	Section 3.1.3	Section 4.1.3	Section 5.1.3	Section 6.1.3	Section 7.1.3
	d	Does the need and/or proposed investment overlap/duplicate with previously funded activities or service levels?	Section 1.1.4	Section 2.1.4	Section 3.1.4	Section 4.1.4	Section 5.1.4	Section 6.1.4	Section 7.1.4
	e	Does the need clearly align to a robust long term delivery strategy within a defined core adaptive pathway?	Section 1.1.5	Section 2.1.5	Section 3.1.5	Section 4.1.5	Section 5.1.5	Section 6.1.5	Section 7.1.5
	f	Do customers support the need for investment?	Section 1.1.6	Section 2.1.6	Section 3.1.6	Section 4.1.6	Section 5.1.6	Section 6.1.6	Section 7.1.6

ID from Appendix 9	Abbreviated Assessment Criterion		Investment Package 1 – Cefn Dryscoed	Investment Package 2 – Regulation 26 Disinfection Strategy	Investment Package 3 – Disinfection By-products	Investment Package 4 – Raw Water Organics at Mayhill WTW	Investment Package 5 – Customer Acceptability (Manganese)	Investment Package 6 – Raw Water Deterioration at Bontgoch	Investment Package 7 – Raw Water Deterioration at Pendine
	g	Have steps been taken to control costs, including potential cost savings?	Section 1.1.7	Section 2.1.7	Section 3.1.7	Section 4.1.7	Section 5.1.7	Section 6.1.7	Section 7.1.7
A1.1.2 Best option for customers	a	Have a variety of options with a range of intervention types been explored?	Section 1.2.1	Section 2.2.1	Section 3.2.1	Section 4.2.1	Section 5.2.1	Section 6.2.1	Section 7.2.1
	b	Has a robust cost-benefit appraisal been undertaken to select the proposed option?	Section 1.2.2	Section 2.2.2	Section 3.2.2	Section 4.2.2	Section 5.2.2	Section 6.2.2	Section 7.2.2
	c	Has the carbon impact, natural capital and other benefits that the options can deliver been assessed?	Section 1.2.3	Section 2.2.3	Section 3.2.3	Section 4.2.3	Section 5.2.3	Section 6.2.3	Section 7.2.3
	d	Has the impact of the proposed option on the identified need been quantified?	Section 1.2.4	Section 2.2.4	Section 3.2.4	Section 4.2.4	Section 5.2.4	Section 6.2.4	Section 7.2.4
	e	Have the uncertainties relating to costs and benefit delivery been explored and mitigated?	Section 1.2.5	Section 2.2.5	Section 3.2.5	Section 4.2.5	Section 5.2.5	Section 6.2.5	Section 7.2.5
	f	Where required, has any forecast third party funding been shown to be reliable and appropriate?	Not applicable for this case						
	g	Has Direct Procurement for Customers (DPC) delivery been considered?	Please refer to WSH50-IP00 Our Approach to Investment Planning (Section 3.4.1)						

ID from Appendix 9	Abbreviated Assessment Criterion		Investment Package 1 – Cefn Dryscoed	Investment Package 2 – Regulation 26 Disinfection Strategy	Investment Package 3 – Disinfection By-products	Investment Package 4 – Raw Water Organics at Mayhill WTW	Investment Package 5 – Customer Acceptability (Manganese)	Investment Package 6 – Raw Water Deterioration at Bontgoch	Investment Package 7 – Raw Water Deterioration at Pendine
	h	Have customer views informed the selection of the proposed solution?	Please refer to Stepping up to the Challenge: Business Plan 2025-30 (Section 2.2)						
A1.1.3 Cost efficiency	a	Is it clear how the company has arrived at its option costs?	Section 1.3.1	Section 2.3.1	Section 3.3.1	Section 4.3.1	Section 5.3.1	Section 6.3.1	Section 7.3.1
	b	Is there evidence that the cost estimates are efficient?	Section 1.3.2	Section 2.3.2	Section 3.3.2	Section 4.3.2	Section 5.3.2	Section 6.3.2	Section 7.3.2
	c	Does the company provide third party assurance for the robustness of the cost estimates?	Section 1.3.2	Section 2.3.2	Section 3.3.2	Section 4.3.2	Section 5.3.2	Section 6.3.2	Section 7.3.2
A1.1.4 Customer protection	a	Are customers protected if the investment is cancelled, delayed or reduced in scope?	Section 1.4.1	Section 2.4.1	Section 3.4.1	Section 4.4.1	Section 5.4.1	Section 6.4.1	Section 7.4.1
	b	Does the protection cover all the benefits proposed to be delivered and funded?	Section 1.4.1	Section 2.4.1	Section 3.4.1	Section 4.4.1	Section 5.4.1	Section 6.4.1	Section 7.4.1
	c	Does the company provide an explanation for how third-party funding or delivery arrangements will work for relevant investments?	Not applicable for this case						

1. Investment Package 1: Cefn Dryscoed Raw Water Deterioration and Discolouration

1.1 Need for Enhancement Investment

This section will set out the drivers behind the Enhancement Case and describe the context within which it has arisen.

We describe the deterioration of raw water quality, the environmental factors (outside of management control) which are driving this and the implication to performance. The need to invest in AMP8 is quantified by presenting the increase in costs and reduction in service which would emerge without action. We set out overlaps with our Base Maintenance programme, which we have examined and removed from the Enhancement Case and give confidence that past allowances have been effectively invested.

The proposed investment aligns with our Long Term Delivery Strategy – responding to the need for long term stewardship and improvement in service. The five sub sections below correspond to the seven criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.1.

1.1.1 Evidence that Enhancement is Needed

> ***Is there evidence that the proposed enhancement investment is required?***
> ***Is the scale and timing of the investment justified?***
> ***Where appropriate, is there evidence that customers support the need for investment?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1a, A1.1.1b and A1.1.1f*

This Enhancement Case is driven by compliance with water quality regulations enforced by the DWI. Regulation 26 compliance, DWI notices and guidance, and reduced customer contacts are the key drivers for this Enhancement Case, and under each driver are various asset specific needs.

The overall risks are linked by deterioration of raw water quality which is further broken down into;

- organics and disinfection by-product precursors,
- raw water and coagulated water solids loading,
- microbiological risks which require improved resilience, and
- manganese.

Cefn Dryscoed WTW is subject to multiple enhancement drivers, we shall describe deterioration in raw water quality and high Manganese levels.

- **Deterioration of raw water quality**

Cefn Dryscoed is identified as a WTW at risk from raw water deterioration. Cefn Dryscoed is a direct filtration WTW supplied with water from Ystradfellte impounding reservoir, characterised as a highly coloured (caused by dissolved organic matter), low alkalinity upland reservoir source. The WTW treats the incoming raw water through coagulation, flocculation and direct rapid gravity filtration, but importantly currently without a clarification stage or a dedicated manganese removal stage.

Direct filtration has the benefit of reducing chemical usage, sludge volumes and plant footprint. However, a source is only suitable for direct filtration if the quality is consistent, and the combined solids loading (from raw water colour, turbidity, metals etc plus coagulant) remains low, ideally less than 20 mg/l.

When constructed, the raw water met these parameters meaning the level of treatment at the time was appropriate and a cost-effective solution. The figures below show the subsequent deterioration of raw water quality, with increasing levels of colour in the raw water over the last 10 years. This deterioration in raw water quality has increased chemical coagulant dosing requirements and

therefore increased overall solids loading beyond the 20 mg/l threshold on three occasions since 2019. The predicted solids loading to the end of 2050, based on current trends, is also shown and is forecast to breach the 20 mg/l, on an average basis, before the end of AMP8.

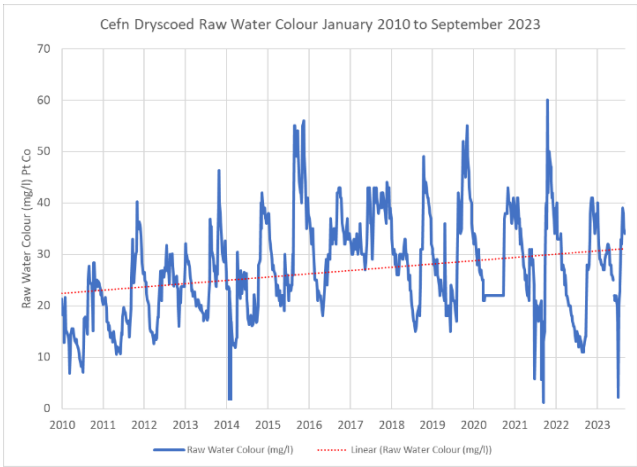

Figure 1: Cefn Dryscoed raw water quality deterioration (colour as proxy)

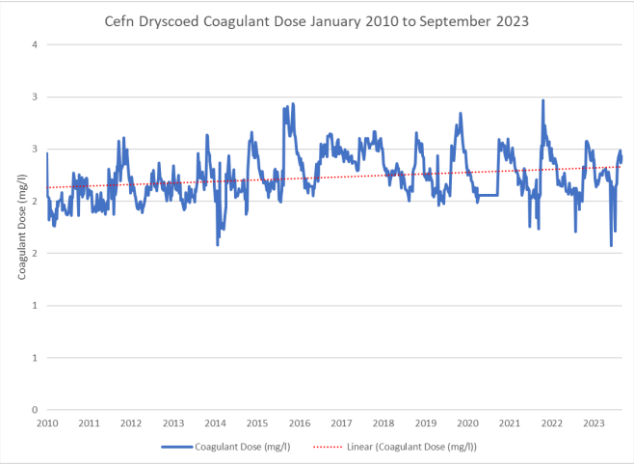

Figure 2: Cefn Dryscoed raw water quality deterioration (increased chemical usage)

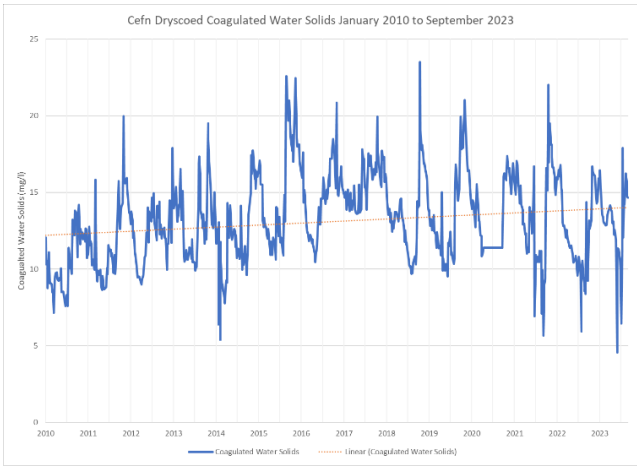

Figure 3: Cefn Dryscoed raw water quality deterioration (increasing overall solids loading)

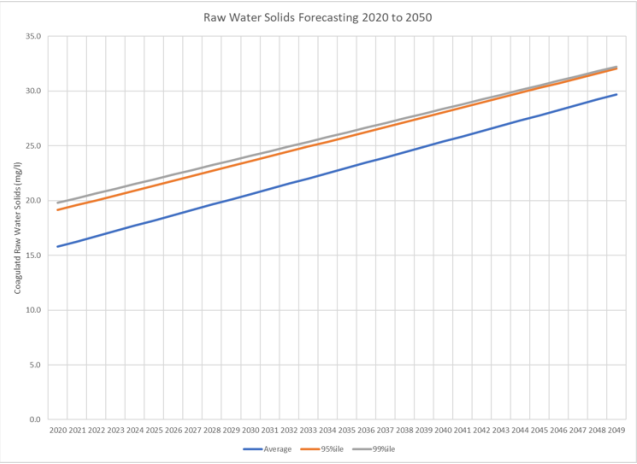

Figure 4: Predicted raw water quality (overall solids loading) to 2050 based on linear deterioration

The WRc produce guidelines for recommended treatment process based on overall solids loading. Table 2 below shows the coagulated raw water solids in combination with existing Cefn Dryscoed WTW treatment process is no longer suitable for Direct Filtration and an additional stage of DAF clarification is required.

Table 2: WRc guidance for recommended process treatment based on raw water overall solids range

Required Clarification Process	Inlet (Coagulated) Solids Range (mg/l)
Pre-Settlement	> 500
Floc Blanket Clarification	>50 to <500
Dissolved Air Flotation	<20 to 50

Required Clarification Process	Inlet (Coagulated) Solids Range (mg/l)
Direct Filtration	<20

- **Manganese & customer acceptability**

When Cefn Dryscoed WTW was designed in 1997, concentrations of manganese in the raw water were consistently below the 50 µg/l regulatory limit, meaning no dedicated manganese removal stage was required. However, since 1997, we have seen increasing instances of raw water manganese levels above the 50 µg/l threshold. While the existing process is effective at removing much of the manganese, it cannot now be relied upon to keep final water levels below the PCV. This was demonstrated in the summer of 2022 where a spike of manganese in the raw water led to a breach of PCV in the downstream system.

In the summer of 2022, when the levels of manganese in the raw water exceeded the removal capacity of the treatment process, this also caused a discolouration event in the downstream distribution system. This impacted our customers and operation for several weeks and was reported to the DWI. We await the outcome of the DWI investigation into this event but it is expected that this enhanced treatment process will be mandated to prevent a reoccurrence.

We also now understand the link between manganese levels and discolouration contacts in the downstream system and as such we have set an internal target of 2 ug/L in AMP7 and 1 ug/L for AMP8. The final water at Cefn Dryscoed regularly exceeds the target of 2 ug/L leading to high levels of contacts in the downstream system, see graph below. The average for the three calendar years 2020 to 2022 was 7.7 µg/l. We now understand that increased concentrations of manganese contribute significantly to levels of customer contacts in the distribution system. Therefore, improvements in final water manganese fall under the acceptability of water need which are further detailed in the section below.

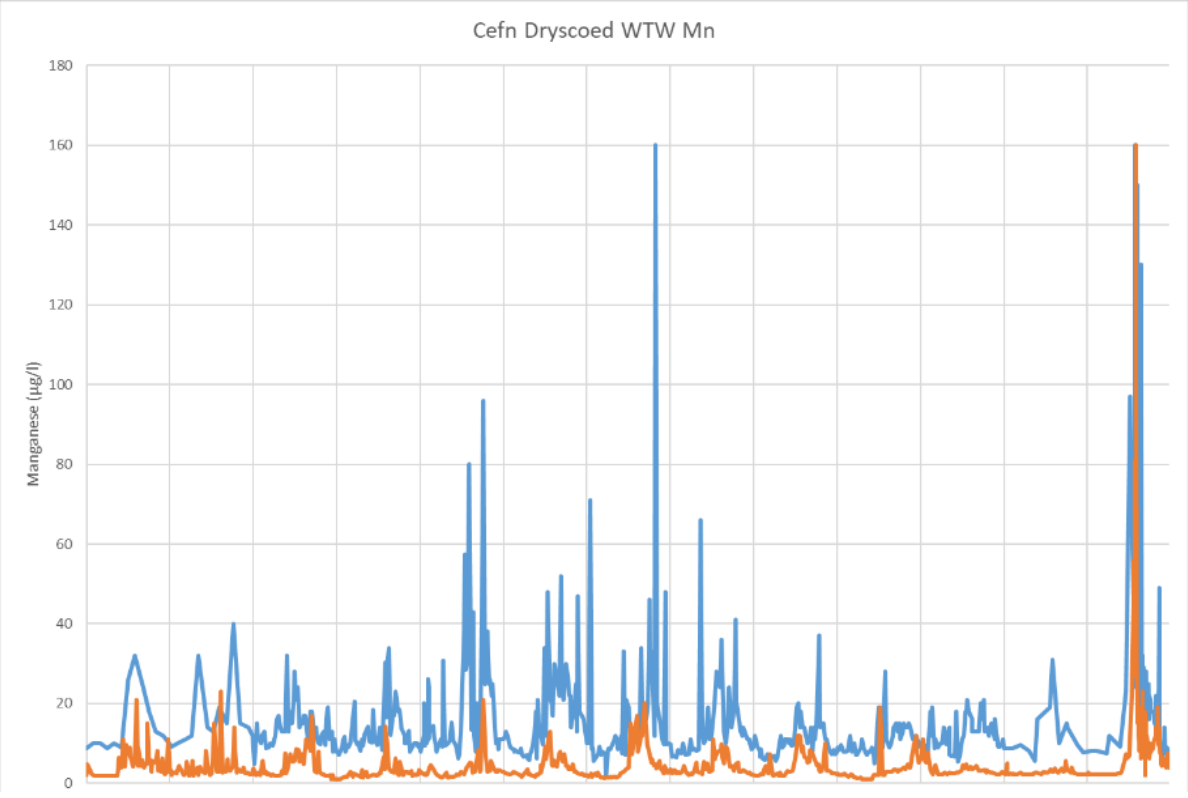

Figure 5: Cefn Dryscoed Mn

1.1.2 Scale and Timing of Investment

The scale of investment and activity has been selected to balance the reduction of the appropriate level of risk, affordability and deliverability in AMP8. We have approached DWI as part of the PR24 process to propose support this scheme within this programme of investment. DWI has indicated an appropriate level of support for this scheme through a Regulation 28 Legal Instrument. The next step will be for Welsh Water to complete the draft copy of the Notice and submit to the DWI within their timeframe. This Notice will outline the actions and the timescales for completion. We will work with DWI to produce the notices for this scheme, with an expected timescale for delivery by the end of AMP8.

The scheme set out in the table below are DWI driven based on observed deterioration in raw water quality and increasing regulatory standards. These will be governed by a legal mechanism with the DWI, building on the DWI published letters of support and will be in place according to timescales outlined by the DWI's PR24 process.

Table 3: DWI Scheme

DWI Scheme Reference:	Project Description	Legal Instrument Required	Timescale	Supporting Documentation
DWR1: supporting the delivery of this scheme to secure or maintain drinking water quality.	Cefn Dryscoed WTW - manganese, turbidity, customer acceptability and discolouration	Regulation 28(4) notice	Within AMP 8	PR24 submission, regulation 28(1) risk assessments.

1.1.3 Overlap with Activities to be Delivered through Base

Does the proposed enhancement investment overlap with activities to be delivered through base?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.1c

We have a standard approach for assessing base/enhancements splits set out in a fair regulatory treatment within WSH50-IP00 Our Approach to Investment Planning (Section 3.4.2).

The enhancements required to mitigate the deterioration of the raw water quality are new, and in line with WRc guidance. The existing process has been optimised as much as possible, with trials of pre filter chlorine making some improvements but the raw water deterioration being seen means the evidence demonstrates these levels will be beyond the design capacity of the existing process by the end of AMP8. Enhancement is required to construct additional treatment stages for dedicated solids and manganese removal processes.

1.1.4 Overlap with Funding from Previous Price Reviews

Does the need and/or proposed enhancement investment overlap with activities or service levels already funded at previous price reviews?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.1d

The investments proposed in this case are the result of raw water quality deterioration reaching a critical inflection point. Cefn Dryscoed has not previously been funded for a solids or manganese removal stage of the type now required.

1.1.5 Alignment with the Long Term Delivery Strategy

Is the need clearly identified in the context of a robust long term delivery strategy within a defined core adaptive pathway?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.1e

Welsh Water have a long term output targeting a CRI score of 0, while this will be practically very difficult, minimising the score each year is of great importance both internally and to our external stakeholders. The quality of final water at our treatment works is a key contributor to achieving this long term ambition.

Welsh Water's core pathway has identified a range of interventions that are required to achieve this ambition. The schemes identified in this Enhancement Case are a key contributor to this. Welsh Water have identified alternative pathways focused on changing legislation, primarily associated with Welsh Government adopting EU drinking water legislation along with forecasts of raw water deterioration and their impact on our asset's treatment capabilities.

Further details can be seen in WSH01 Long Term Delivery Strategy.

1.1.6 Evidence of Customer Support

Our approach to customer engagement is set out in Stepping up to the Challenge: Business Plan 2025-30 (Section 2.2).
Customers are generally supportive of investment to improve water quality.

1.1.7 Management Control of Costs

Is the investment driven by factors outside of management control? Is it clear that steps been taken to control costs and have potential cost savings been accounted for?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.1g

The factors that are driving these Enhancement Cases that are outside of management control are raw water deterioration (THM precursors, additional solids loadings, and increased Mn) linked to climate change and continued adherence to disinfection directives by adding disinfection resilience to the highest risk WTW that were not addressed in previous AMPs.

The increase in raw water organic matter and manganese over time are now challenging the design capabilities of the existing treatment process which, when installed in 1997, were designed around specific raw water conditions to include some deterioration in the future. However, given the extent that raw water deterioration has occurred since 1997, along with changes to regulatory standards and industry best practice guidance, the existing treatment process will shortly be incapable of treating water, as that deterioration continues as we have forecast.

We now know that any levels of final water manganese passing through existing removal processes, although compliant with Regulatory standards, will continue to coat treated water mains. This coating then becomes disturbed following transient flow changes in the network.

This leads to unacceptable discolouration for our customers. As there is no dedicated manganese removal stage at Cefn Dryscoed and it is one of our last remaining direct filtration WTW our ability to sustain treatment levels without further investment is limited. Raw water deterioration and the increasing concentration of raw water organic matter and manganese will inevitably lead to increases in concentrations in the final water quality.

1.2 Best Option for Customers

Our overarching approach is described in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

The three sub sections below correspond to the eight criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.2.

1.2.1 Identification of Solution Options

> ***Has the company considered an appropriate number of options over a range of intervention types to meet the identified need?***
> ***Is there evidence that the proposed solution represents best value for customers, communities, and the environment over the long term?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2a and A1.1.2b*

A longlist of possible interventions that could reduce the impact of raw water deterioration was developed. These possibilities were reviewed by an experienced panel during a 'longlist workshop' to eliminate the options that:

- will not give sufficient improvement,
- have been tried previously and have not been successful,
- experience elsewhere has shown to be poor, providing little benefit.

The options developed for each of the investment schemes in this section are as follows:

When assessing the risks at Cefn Dryscoed against our investment hierarchy it was evident that additional resources are required to mitigate the risk.

Three longlist options were identified to reduce the existing risk of raw water deterioration and the impact on tap water quality compliance and customer acceptability.

Table 4: Long list of options considered for Cefn Dryscoed

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
1	**Eliminating, reducing or delaying the need for change:** Manage demand	**Not Viable -** Although we may be able to manage demand during certain periods of the year, this is not a viable and sustainable approach for the long term, considering raw water deterioration is forecast to worsen even further in the future.	✗
2	**Eliminating, reducing or delaying the need for change:** *Manage operation or use of the existing asset or service*	Optimisation of the existing coagulant dosing system which has no proper control. This would improve (and should minimise) the dosage of the coagulant to keep total solids to the lowest level	✓

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
3	**Eliminating, reducing or delaying the need for change:** *Maintain the existing asset or service*	**Not Viable -** We would need to continue to maintain the current works but unfortunately this would not resolve the risk we have identified with raw water deterioration affecting both solids loading and manganese performance.	✗
4	**Maintaining the effective risk controls already in place:** *Replace the existing asset like-for-like*	**Not Viable -** The existing treatment process does not have sufficient capability to manage or reduce the identified risk with raw water deterioration. Replacing the asset with a like for like equivalent would not resolve the risk and would be cost inhibitive.	✗
5a	***Enhance/upgrade the existing asset or service*** CoCoDAFF (20Ml/d) + pH and chlorination to existing primary filter	Installation of CoCoDAFF with associated pumps as the first stage of treatment. This will remove colour, turbidity and Manganese from the raw water via flotation and filtration inside the CoCoDAFF. Then add pH correction and chlorination prior to the existing primary filters. CoCoDAFF will be able to handle increased total solids due to climate change, the existing sand filters will be converted to Manganese removal filters. By increasing the pH and using chlorination the dissolved Manganese is oxidised, it is then removed from the existing sand filters. A new sludge treatment facility would be required to accommodate sludge/dirty backwash water from the CoCoDAFF.	✓
5b	***Enhance/upgrade the existing asset or service*** DAF + pH + chlorination + new 2nd stage filters	A conventional DAF would be constructed prior to the existing primary filters to handle increased total solids due to climate change. Two stage filtration will be provided; therefore new 2nd stage filters will be constructed as a Manganese removal stage. New pH correction and chlorination will be added prior to the new 2nd stage filters. A new sludge treatment facility would be required to accommodate sludge/dirty backwash water from the new DAF and new stage of filters.	✓

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
5c	***Manage operation or use of the existing asset or service*** Optimising existing coagulant control and new Manganese filter	Optimisation of the existing coagulant dosing system which has no proper control. This would improve (and should minimise) the dosage of the coagulant to keep total solids to the lowest level. A new Manganese filter will be provided by adding a 2nd stage sand filter and pH correction plus Chlorination dosing. A new sludge treatment facility would be required to accommodate sludge/dirty backwash water from the new Manganese filters.	✓

1.2.2 Assessment and Selection of Solution Options

Our approach to cost benefit appraisal and its role in decision making is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

The table below has been completed using data from our cost benefit spreadsheets to illustrate the value generated by the proposed investment (All monetary values are expressed in 2022/23 prices and are prior to portfolio adjustments for corporate overheads and efficiency challenge. Welsh Water ref: SMF version 5).

Table 5: Cost benefit appraisal for Cefn Dryscoed selected shortlisted options

Solution Option	Option Name	CapEx	Present Value Whole Life Costs (WLC)	Present Value Whole Life Benefits (WLB)	Benefit/ Cost Ratio	Net Present Value (=WLB - WLC)
Option S1	CoCoDAFF + PH + chlorination + sludge treatment facilities	£13.817M	£21.492M	£36.598M	1.703	£15.106M
Option S2	Optimization on existing Coag control + new PH + new chlorination + new 2nd stage filters + sludge treatment	£11.073M	£16.808M	£21.783M	1.296	£4.975M

Based on our CBA analysis Option S1 was recommended for implementation. S1 was selected as it addresses both the drivers of solids removal and manganese reduction in the least cost approach. The separate DAF and Filters were not costed in detail as they would be expected to be more expensive and not suitable for the limited space available on site. S2 would not meet the requirements of reduced solids loading in the long term as it would still rely on the direct filtration stage as primary solids removal.

Third-party technical assurance of cost–benefit appraisal has been completed by Economic Insight who have confirmed that our approach is robust and in line with Ofwat expectations. Full details are given in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

1.2.3 Quantification of Benefits

Has the company fully considered the carbon impact, natural capital and other benefits that the options can deliver?
Has the impact (incremental improvement) of the proposed option on the identified need been quantified, including the impact on performance commitments where applicable?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.2c and A1.1.2d

The benefits of a scheme have been calculated by our asset planning and engineering teams based on the best available information and have been used to forecast the impact a scheme will have on service measures in comparison to the pre investment position/do nothing position.

Benefits are quantified against our service measure framework (SMF) meaning they are well understood and trackable through regular business activity. For more detail on this approach see WSH50-IP00 Our Approach to Investment Planning (Section 5.4). We have included an excerpt from the SMF showing the categories of benefit that roll up to the Ofwat drivers identified as part of the overall case. The table below shows how we have apportioned the benefits, with improved drinking water quality carrying the largest weight.

Table 6: Benefits from AMP8 Spend relative to baseline for Preferred Programme

Scenario	Benefits from AMP8 Spend relative to baseline								
	Unplanned network interruptions	Loss of production	Greenhouse Gas Emissions Reduction	Legal Compliance	Drinking water quality	Pressure	Health and Safety	Customer Contacts	Total
Preferred –	11.2%	0.00%	-0.3%	0.1%	**50%**	31.4%	7.5%	0.1%	100%

1.2.4 Quantifying the Impact on Need and Performance Commitments

The identified schemes will resolve the issues raised by the DWI. The proposed work has been discussed with the quality regulator and they are supportive of the activities proposed.

The schemes will impact on the resilience of performances against the CRI. They will reduce the likelihood of performances deterioration, but not in a way which is visible to the measure.

We have assessed the impact of enhancement on CRI, ERI and Acceptability of Water performance commitments.

From our analysis the proposed option will make the following impacts:

- Improve acceptability of water by reducing the final water Manganese concentration to produce a benefit to overall acceptability of water metric of 0.08.
- Reduces the risk of an increase to CRI based on inability to treat increasing raw water, coagulated solids
- Eliminates the risk of another water quality event at site impacting ERI for manganese breakthrough to the final water.

1.2.5 Uncertainties relating to cost and benefit delivery

> ***Have the uncertainties relating to costs and benefit delivery been explored and mitigated? Have flexible, lower risk and modular solutions been assessed – including where forecast option utilisation will be low?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2e*

Our methodology is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3). This includes commentary on our approach to optioneering, costing and cost benefit analysis.

For this Enhancement Case we have evaluated a wide range of options in line with our TotEx hierarchy approach. We have aimed to balance most efficient solution with risk and innovation in all instances.

We have highlighted areas in which the calculation of costs or benefits are unusual or uncertain and how we have mitigated for this in our evaluation. Innovation and new approaches such as nature-based work is inherently more uncertain than tried and tested engineering approaches. Our identified shortlist options for Cefn Dryscoed are as follows -

Option 5a: New CoCoDAFF Treatment Process

This option involves:

1. Construction of a new CoCoDAFF prior to the existing primary sand filters
2. A new pH correction and Chlorination system for the existing primary sand filter to convert it to a Manganese removal filter
3. Additional sludge/dirty backwash water treatment and holding tanks

Table 7: Option 5a

Advantages	Disadvantages
CoCoDAFF will address high raw water colour caused by climate change, which requires higher coagulation dosage and thus results in higher total solids applied to the existing primary sand filters This is innovative technology which includes both flotation and filtration in the system, but it is of proven efficiency and is relatively familiar to WELSH WATER Options for Manganese removal were also considered, and this option is the most cost effective by utilising existing assets with added pH correction and Chlorination to existing sand filters	High embodied carbon – As with conventional engineering solutions such as this chosen option, due to the materials involved, embodied carbon will be high Construction space on site – Although we believe construction of the new asset is feasible,

Option 5c: Optimising existing coagulant control and new dedicated manganese removal stage
This option involves:

1. The installation of an automatic coagulant dosing system
2. A new 2nd stage sand filter with associated pumps and pipework
3. A new pH correction and chlorination system
4. A new sludge/ dirty backwash water treatment and holding tanks system

Table 8: Option 5c

Advantages	Disadvantages
Will improve existing primary filters performance by optimising the coagulant control system. This could potentially reduce the solids load applied to the existing primary filters. In turn, the resilience against future increased total solids will be increased	Total solids handling capacity is only partially offset by potentially decreased solids load
Manganese removal is realised by adding a new stage of filtration	No dedicated clarification stage in response to elevated solids loading
Will provide opportunity to investigate new control method for coagulant dosing and result in savings on chemical dosing	Risk of failure due to overloading of primary filters remains
Conventional sand filter with proven reliability	

Chosen Option

The chosen option for inclusion in the PR24 business plan is Option 1 for a new CoCoDAFF, conversion of the existing stage of filtration and washwater improvements. A Risk and Value session was held between the key stakeholders to discuss the details of each scheme put forward for risk and value assessment to determine the most appropriate and relevant benefits of each. Although the cost of Option 1 is more expensive than Option 3, the overall benefits of Option 1 are higher and will have distinct advantages over the scheme of Option 3 over the long term life of the asset.

With the addition of a dedicated manganese removal stage, as included in Option 3, although manganese performance would improve significantly the option is unlikely to address current concerns with raw water quality both to current and future forecasts of trends.

Option 1 however, with the addition of a dedicated clarification stage and a dedicated manganese removal stage by converting the existing rapid gravity filters, would not only address issues with raw water quality but also manganese performance and performance for customer contacts for discolouration.

As previously stated, raw water quality has already surpassed standards laid out in our engineering design standards and the addition of a dedicated clarification stage would improve water quality performance based on raw water quality thus presenting the water for downstream treatment processes including disinfection to a standard which would not compromise compliance.

1.3 Cost efficiency

In this section we give specific details on our approach to costing and benchmarking. Our overarching approach to developing efficient costs is set out in WSH50-IP00 Our Approach to Investment Planning (Sections 4.10 and 7).

The two sub sections below correspond to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.3.

1.3.1 Developing a cost for WTW Interventions

Is it clear how the company has arrived at its option costs? Is there supporting evidence on the calculations and key assumptions used and why these are appropriate? Does the company provide third party assurance for the robustness of the cost estimates?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.3a and A1.1.3c

We have costed the schemes using our UCD C&CET as described in WSH50-IP00 Our Approach to Investment Planning (Section 4.10). This approach utilises like-for-like (top down) costing of process assets and construction related costs to forecast and estimate future project and programme costs.

An individual specific scope was developed for each of the schemes, as part of the optioning process which identified the assets for construction, modification and upgrade along with any site specifics, which formed the basis of our estimates.

Much of the scope is for items of work which has been constructed throughout previous AMPs, and therefore we have a rich source of historical cost data. For these items of work we have developed cost models based on the most important cost drivers, e.g., the most influential driver to cost for a tank is volume. This costing approach forms the direct works and site-specific costs. We apply construction indirect costs and project oncosts based on the work stream, in this instance this is Water Non-Infrastructure, which applies modelled percentages to the cost of the direct works and site specifics.

The scope is aligned to our Work breakdown Structure (WBS), which was developed to support our data capture process of historical project cost against delivered assets, into a scope input sheet. Within this, sizing of the assets based on the relevant yardstick, which is dictated by the WBS, is provided following calculation in the previous engineering stages. Our costs models are developed in line with our WBS and this allows us to input this information into the C&CET and generate a project estimate. WBS details the inclusions and exclusions of works under each cost model and the limitations of the model, so we can ensure all project costs are captured and there is also no over costing.

The costing was carried out by Welsh Water Costing Team. The Governance procedures, as outlined in Section 5 Costing Methodology were adhered to with the appropriate use of cost models being confirmed and all manual allowances verified prior to providing sign offs throughout the different iterations of the costings.

Along with our overall costing strategy being reviewed and assured by Jacobs, we have also employed third party consultants to review single Enhancement Cases to provide confidence that the estimates within them are robust, efficient and deliverable. Please refer to WSH50-IP00 Our Approach to Investment Planning (Section 6) for more information regarding the review and assurance undertaken.

1.3.2 Benchmarking our approach

Is there evidence that the cost estimates are efficient (for example using similar scheme outturn data, industry and/or external cost benchmarking)?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.3b

The cost estimates for schemes have been based on Welsh Water's unit cost database and its associated Cost and Carbon tool to generate cost estimates for schemes. The costs generated are based on internal outturn costs collected by Welsh Water as described in WSH50-IP00 Our Approach to Investment Planning (Section 4.10).

1.4 Customer Protection

In this section we set out how oversight will be provided by the DWI on the proposed works.

The sub sections below corresponds to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.4. There is no third-party funding for this Enhancement Case.

1.4.1 Providing Customer Protection

> ***Are customers protected (via a price control deliverable or performance commitment) if the investment is cancelled, delayed or reduced in scope?***
> ***Does the protection cover all the benefits proposed to be delivered and funded (e.g. primary and wider benefits)?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.4a and A1.1.4b*

Customers will be protected via two mechanisms:

1. The regulatory oversight from the DWI. The delivery of performance improvement is inherent to the DWI Notices. The legal mechanism within which the DWI will hold the company to account will be in place in accordance with timescales outline by DWI. Failure to meet these targets could result in prosecution, and
2. The existing performances commitment for customer contacts about water quality (and CRI) agreed with and regulated by Ofwat.

Section 1.1 above sets out clear reporting requirements which the DWI have put in place to monitor progress both in terms of programme development and performance improvement.

For the performance commitment Welsh Water will report progress each year through the Annual Performances Report (APR). The common performance commitments include 'Customer contacts about water quality' which will report on the number of consumer contacts per 1,000 population and the Compliance Risk Index (CRI).

The work will deliver resilience and prevent deterioration in the Performances Commitment for CRI

We have forecast an improvement of 0.08 contacts against the Performances Commitment for customer contacts for water quality driven by the work in this programme. This benefit when combined with that in Enhancement Case CW02 will deliver the step change in contacts we have committed to.

2. Investment Package 2: Regulation 26 Disinfection Strategy

2.1 Need for Enhancement Investment

This section will set out the drivers behind the Enhancement Case and describe the context within which it has arisen.

We describe the deterioration of raw water quality, the environmental factors (outside of management control) which are driving this and the implication to performance. The need to invest in AMP8 is quantified by presenting the increase in costs and reduction in service which would emerge without action. We set out overlaps with our Base Maintenance programme, which we have examined and removed from the Enhancement Case and give confidence that past allowances have been effectively invested.

The proposed investment aligns with our Long Term Delivery Strategy – responding to the need for long term stewardship and improvement in service. The five sub sections below correspond to the seven criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.1.

2.1.1 Evidence that Enhancement is Needed

> ***Is there evidence that the proposed enhancement investment is required?***
> ***Is the scale and timing of the investment justified?***
> ***Where appropriate, is there evidence that customers support the need for investment?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1a, A1.1.1b and A1.1.1f*

This Enhancement Case is driven by compliance with water quality regulations enforced by the DWI. Regulation 26 compliance, DWI notices and guidance, and reduced customer contacts are the key drivers for this Enhancement Case, and under each driver are various asset specific needs.

The risk is driven by deterioration of raw water quality related to microbiological risks which require improved resilience.

The Water Supply (Water Quality) Regulations 2018, Regulation 4, wholesomeness, states that water supplied for human consumption must not contain any micro-organism or parasite at a concentration that would constitute a potential danger to human health.

'The Water Supply (Water Quality) Regulations (Wales) 2018', provision 26 states that:

> *A water undertaker or supplementary licensee must—*
> - *disinfect the water.*
> - *where necessary, subject the water to sufficient preliminary treatment to prepare it for disinfection.*
> - *verify the effectiveness of the disinfection process for all pathogens.*
>
> *"Adequate treatment process" means a process which removes; or renders harmless the value or concentration of, any property of, organism or substance in, water, so that supplies do not constitute a potential danger to human health.*

To ensure our disinfection processes are fit for purpose, we undertook to update our Regulation 26 Disinfection Strategy with an industry best practice approach. We then reviewed all our sites against that standard and identified any gaps. Instead of relying on theoretical analysis, we have focused on practical evidence to determine how "pathogen loaded" our raw waters are and then how much disinfection they require. This approach has positioned us as industry leaders, and while there haven't been changes to the regulation, DWI may consider making our approach a standard practice for all water companies.

We have assessed current and forecast risk using the World Health Organisation (WHO) parameters: a health-based target of 1 x 10^{-6} Disability Adjusted Life Years (DALY) per person per year for each pathogen as a tolerable level of risk of disease burden for the consumption of drinking water. The Welsh Water risk assessment for WTW disinfection identification of investment need is based on the ability to achieve this health-based target.

The revised Dŵr Cymru Welsh Water Disinfection at Water Treatment Works (Regulation 26) Strategy seeks to meet these requirements by adapting best practices for disinfection from WHO guidance which set out clear requirements for treatment performance to achieve a health-based target. The Water Safety Assessment assesses WTW based on 4 levels of risk as shown in Table 4 below -

Table 9: Water safety assessment and risk capture

Water Safety Risk Status	12-Month Log Credit	DWSP Score	DALY	Control Measure	Period for Capital Investment	Management Review Frequency
High	-3	5	$1x10^{-3}$	New control measure required	Within current AMP	Monthly DWSP
	-2.5		$1x10^{-3.5}$			
Medium	-2	4	$1x10^{-4}$	Improve source protection Enhance treatment	By end of AMP 8	
	-1.5		$1x10^{-4.5}$			
Low	-1	3	$1x10^{-5}$	Reduce uncertainty Improve operation	Within 2 AMPs	
	-0.5		$1x10^{-5.5}$			
Negligible	0	2	$1x10^{-6}$	Maintain current operation and review	N/A	Annual DWSP review
	1	1	$1x10^{-7}$			
	2		$1x10^{-8}$			
	3		$1x10^{-9}$			

Using 5 years of raw water E. coli data, along with information related to each water treatment works (from internal documents including each site's disinfection strategy), a total log removal capability score was assigned to each site. When compared against the log removal required for cryptosporidium, to meet a health-based target set out in the Disinfection Strategy, this identified assets with a log deficit for that parameter. Assets with greater than a 1 log deficit have been identified for further intervention to improve the disinfection capacity of those sites.

Our approach has been endorsed by the DWI in Reference Letter DWR 2. These high risk WTWs that require disinfection enhancements within AMP8 have been included in this Investment Case where following review, Ultraviolet (UV) treatment has been identified as the chosen solution. A number of sites will require validation of their performance against the standards expected in this study through the application of additional monitoring and small improvements to existing treatment processes.

Four WTW have been identified with log credit status between -1.5 and -2.0 which will require asset investment within AMP 8 to achieve greater pathogen log removal. This proactive approach will prevent a potential water quality event occurring, leading to an impact on CRI and ERI and significant reputational damage. We have historical experience of suspected cryptosporidium in our water supply and cannot not allow a similar circumstance to arise in future. During the last 5 years we have installed UV systems at two of our surface water treatment works, in response to the detection of very low numbers of cryptosporidium oocysts in treated water. While these were not at a level to impact public health it highlighted a weak point in our multi barrier approach for river sources.

This investment, through the installation of UV treatment, will protect a further 4 direct river sources from a gross contamination event that could overwhelm the disinfection process.

Table 10: WTW with log credit status between -1.5 and -2.0

WTW with ≤zero log deficit	2016-2021 Raw E.coli loading (90th percentile)	Raw water category	Credit compared to 5 year requirement
Bretton	2000	Heavily contaminated 2000-20000	-1.5
Broomy Hill	2000	Heavily contaminated 2000-20000	-1.5
Mayhill	2000	Heavily contaminated 2000-20000	-1.5
Whitbourne	3000	Heavily contaminated 2000-20000	-1.5

The current disinfection treatment at these sites would have been acceptable when constructed, however, standards are now higher and as such are put forward for enhancement.

Also included in this investment

2.1.2 Scale and Timing of Investment

The scale of investment and activity has been selected to balance the reduction of the appropriate level of risk, affordability and deliverability in AMP8. We have approached DWI as part of the PR24 process to propose support this scheme within this programme of investment. DWI has indicated an appropriate level of support for this scheme through a Regulation 28 Legal Instrument. The next step will be for Welsh Water to complete the draft copy of the Notice and submit to the DWI within their timeframe. This Notice will outline the actions and the timescales for completion. We will work with DWI to produce the notices for this scheme, with an expected timescale for delivery by the end of AMP8.

The scheme set out in the table below are DWI driven based on observed deterioration in raw water quality and increasing regulatory standards. These will be governed by a legal mechanism with the DWI, building on the DWI published letters of support and will be in place according to timescales outlined by the DWI's PR24 process.

Table 11: DWI notice of support

DWI Scheme Reference:	Project Description	Legal Instrument Required	Timescale	Supporting Documentation
DWR2: supporting the delivery of works of regulation 26 compliance.	Bretton, Broomy Hill, Mayhill and Whitbourne Regulation 26 compliance. UV installation	Regulation 28(4) notice	Within AMP 8	PR24 submission, regulation 28(1) risk assessments.

2.1.3 Overlap with Activities to be Delivered through Base

> ***Does the proposed enhancement investment overlap with activities to be delivered through base?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1c*

We have a standard approach for assessing base/enhancements splits set out in a fair regulatory treatment within WSH50-IP00 Our Approach to Investment Planning (Section 3.4.2).

The options that were put forward to shortlisting, and the option that was ultimately recommended all require new infrastructure and are therefore not part of base. This is part of an “industry leading” piece of research highlighting where the existing site assets cannot deliver the required standard. The options are further detailed in sections below.

In addition, there are investments proposed for a programme of smaller schemes related to validating our existing treatment processes. This will identify whether further investment is required in the future. Any recommendation out of these investigations would form part of our AMP9 plans. This investment compliments the larger programme of installing UV treatment at 4 sites to ensure disinfection resilience is in accordance with revised guidance and expectations from DWI.

2.1.4 Overlap with Funding from Previous Price Reviews

> ***Does the need and/or proposed enhancement investment overlap with activities or service levels already funded at previous price reviews?***
> *– Ofwat’s final methodology for PR24, Appendix 9, A1.1.1d*

The investments proposed in this case are the result of raw water quality deterioration reaching a critical inflection point. Meeting our obligations under Reg 26 disinfection guidance, at these sites, has not been funded previously. These risks will deteriorate through the effects of climate change, the impacts of which are already being felt, with more frequent heavy rainfall and extended hot and dry periods, being experienced more frequently since 2010.

2.1.5 Alignment with the Long Term Delivery Strategy

> ***Is the need clearly identified in the context of a robust long term delivery strategy within a defined core adaptive pathway?***
> *– Ofwat’s final methodology for PR24, Appendix 9, A1.1.1e*

Welsh Water have a long term output targeting a CRI score of 0, while this will be practically very difficult, minimising the score each year is of great importance both internally and to our external stakeholders. The quality of final water at our treatment works is a key contributor to achieving this long term ambition.

Welsh Water’s core pathway has identified a range of interventions that are required to achieve this ambition. The schemes identified in this Enhancement Case are a key contributor to this. Welsh Water have identified alternative pathways focused on changing legislation, primarily associated with Welsh Government adopting EU drinking water legislation along with forecasts of raw water deterioration and their impact on our asset’s treatment capabilities.

Further details can be seen in WSH01 Long Term Delivery Strategy.

2.1.6 Evidence of Customer Support

Our approach to customer engagement is set out in Stepping up to the Challenge: Business Plan 2025-30 (Section 2.2).

Customers are generally supportive of investment to improve water quality.

2.1.7 Management Control of Costs

> ***Is the investment driven by factors outside of management control? Is it clear that steps been taken to control costs and have potential cost savings been accounted for?***
> *– Ofwat’s final methodology for PR24, Appendix 9, A1.1.1g*

The factors that are driving these Enhancement Cases that are outside of management control are raw water deterioration (increased pathogens) linked to climate change and continued adherence to disinfection directives by adding disinfection resilience to the highest risk WTW that were not addressed in previous AMPs.

All 4 identified WTW are supplied by river sources, which are derived from catchments of mixed land use. This includes widespread livestock and poultry farming and a number of private and public wastewater releases. There issues are very difficult to mitigate at source, although our catchment first approach will always look for these solutions. Ultraviolet treatment has been identified as one of the only solutions currently available with the capability to fill the gap in treatment at these sites so that the final water meets the outlined standard. If a breakthrough of pathogens (including cryptosporidium) occurred in the absence of these processes being installed, we would be required to inform customers to boil their water which would not be considered an acceptable approach by customers or the DWI. This situation has occurred in the recent past with another company and this investment will prevent any repeat at our sites which would likely lead to a prosecution.

2.2 Best Option for Customers

Our overarching approach is described in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

The three sub sections below correspond to the eight criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.2.

2.2.1 Identification of Solution Options

> ***Has the company considered an appropriate number of options over a range of intervention types to meet the identified need?***
> ***Is there evidence that the proposed solution represents best value for customers, communities, and the environment over the long term?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2a and A1.1.2b*

A longlist of possible interventions that could reduce the impact of raw water deterioration was developed. These possibilities were reviewed by an experienced panel during a 'longlist workshop' to eliminate the options that:

- will not give sufficient improvement,
- have been tried previously and have not been successful,
- experience elsewhere has shown to be poor, providing little benefit.

The options developed for each of the investment schemes in this section are as follows:

We have considered a number of options to implement our Regulation 26 Disinfection Strategy. A long list of the considered options are as follows –

Table 12: Long list of options considered

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
1	**Eliminating, reducing or delaying the need for change:** Manage demand	**Not Viable –** Managing demand at the identified WTWs is not deemed viable to mitigate the risk. Even with lower demand, the risk to water quality remains without sufficient treatment.	✗

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
2	**Eliminating, reducing or delaying the need for change:** *Manage operation or use of the existing asset or service*	**Not Viable –** Following an assessment, the capability of the existing treatment assets at each of the sites has been quantified. These assets cannot be managed in alternative way to improve their performance and already performing as expected and to their limit.	✗
3	**Eliminating, reducing or delaying the need for change:** *Maintain the existing asset or service*	**Not Viable** – The capability of the existing asset is finite. Further maintenance of these assets would not improve their capability.	✗
4	**Maintaining the effective risk controls already in place:** *Replace the existing asset like-for-like*	**Not Viable –** The current treatment assets have been assessed to determine the treatment capability for disinfection as part of this assessment. The replacement of these assets with a like for like equivalent would not improve their performance and would still require enhanced investment for additional treatment.	✗
5a	**Enhancing existing or adding new resources:** Installation of UV treatment	We have identified that an enhanced solution is required to meet the expectations set out in our Regulation 26 Disinfection Strategy. We have extensive experience of installing, operating and maintaining UV treatment for this purpose and is deemed the most conventional solution to reduce the risk sufficiently,	✓
5b	**Enhancing existing or adding new resources:** Installation of alternative/ emerging technologies	An alternative treatment process such as ultra or nanofiltration would sufficiently reduce the risk but are not considered viable due to their significantly higher capital cost, the need for interstage pumping also increases OpEx significantly. Additionally, the maintenance costs for nano and ultrafiltration would be inhibitive due to the frequency of replacement of the membranes.	✓
6	**Maintaining the effective risk controls already in place:** *Mothball/dispose of the existing asset or service*	**Not Viable –** The sites we have identified that require additional treatment to meet expectations in our disinfection strategy are strategically critical works that cannot be mothballed to reduce the risk. These sites are larger works that provide a significant population with water that cannot be supported from elsewhere by managing demand or via the use of an alternative supply.	✗

On the basis of membrane technology being cost prohibitive, only ultraviolet disinfection was progressed to feasibility design and UCD. The technology is also widely used within WELSH WATER, has a well established operation and maintenance regime, and is not considered a problematic process to use.

Timescale for delivery is within the next AMP, as deemed appropriate by our Disinfection Strategy.

The preferred solution will address the risk identified as the UV units selected are validated for cryptosporidium log inactivation and are referenced as such in the WHO guidance and in the Welsh Water Disinfection Strategy.

2.2.2 Assessment and Selection of Solution Options

Our approach to cost benefit appraisal and its role in decision making is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

The tables below has been completed using data from our cost benefit spreadsheets to illustrate the value generated by the proposed investment (All monetary values are expressed in 2022/23 prices and are prior to portfolio adjustments for corporate overheads and efficiency challenge. Welsh Water ref: SMF version 5).

- **Bretton**

Solution Option	Option Name	CapEx	Present Value Whole Life Costs (WLC)	Present Value Whole Life Benefits (WLB)	Benefit/ Cost Ratio	Net Present Value (=WLB - WLC)
Option S1	UV Installation	£2.592M	£4.009M	£242.954M	60.603	£238.945M

- **Broomy Hill**

Solution Option	Option Name	CapEx	Present Value Whole Life Costs (WLC)	Present Value Whole Life Benefits (WLB)	Benefit/ Cost Ratio	Net Present Value (=WLB - WLC)
Option S1	UV Installation	£3.361M	£5.154M	£501.106M	97.221	£495.952M

- **Mayhill**

Solution Option	Option Name	CapEx	Present Value Whole Life Costs (WLC)	Present Value Whole Life Benefits (WLB)	Benefit/ Cost Ratio	Net Present Value (=WLB - WLC)
Option S1	UV Installation	£1.436M	£2.186M	£51.632M	23.620	£49.446M

- **Whitbourne**

Solution Option	Option Name	CapEx	Present Value Whole Life Costs (WLC)	Present Value Whole Life Benefits (WLB)	Benefit/ Cost Ratio	Net Present Value (=WLB - WLC)
Option S1	UV Installation	£1.566M	£2.681M	£85.033M	31.719	£82.352M

Based on our CBA analysis Option S1 was recommended for implementation at each of the sites given the other options were discounted at the long listing stage. S1 was selected as it addresses the driver of fulfilling our Regulation 26 Disinfection Strategy at each of the identified sites. UV is the industry standard for this type of disinfection.

2.2.3 Quantification of Benefits

> ***Has the company fully considered the carbon impact, natural capital and other benefits that the options can deliver?***
> ***Has the impact (incremental improvement) of the proposed option on the identified need been quantified, including the impact on performance commitments where applicable?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2c and A1.1.2d*

The benefits of a scheme have been calculated by our asset planning and engineering teams based on the best available information and have been used to forecast the impact a scheme will have on service measures in comparison to the pre investment position/do nothing position.

Benefits are quantified against our service measure framework (SMF) meaning they are well understood and trackable through regular business activity. For more detail on this approach see WSH50-IP00 Our Approach to Investment Planning (Section 5.4). We have included an excerpt from the SMF in section 1.2.3 showing the categories of benefit that roll up to the Ofwat drivers identified as part of the overall case. The table below shows how we have apportioned the benefits, with improved drinking water quality carrying the largest weight.

2.2.4 Quantifying the Impact on Need and Performance Commitments

The identified schemes will resolve the issues raised by the DWI. The proposed work has been discussed with the quality regulator and they are supportive of the activities proposed.

The schemes will impact on the resilience of performances against the CRI. They will reduce the likelihood of performances deterioration, but not in a way which is visible to the measure.

From our analysis the proposed option will make the following impacts:

We have assessed the impact of enhancement on CRI, ERI and Acceptability of Water performance commitments :

Reduces the risk of being unable to disinfect the water satisfactorily in accordance with our Regulation 26 disinfection strategy. A breach of disinfection would result in advice to customer to boil their water. This could lead to enforcement action from the DWI and an impact to our ERI performance measure.

2.2.5 Uncertainties relating to cost and benefit delivery

> ***Have the uncertainties relating to costs and benefit delivery been explored and mitigated? Have flexible, lower risk and modular solutions been assessed – including where forecast option utilisation will be low?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2e*

Our methodology is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3). This includes commentary on our approach to optioneering, costing and cost benefit analysis.

For this Enhancement Case we have evaluated a wide range of options in line with our TotEx hierarchy approach. We have aimed to balance most efficient solution with risk and innovation in all instances.

Option 5a – Installation of UV Treatment

This option involves:

- Size appropriate Xylem Ultraviolet Reactors fitted with appropriate sized lamps each operating on a duty/standby basis
- Variable speed, centrifugal interstage feed pumps operating on a duty/assist/standby basis over the flow range depending on the site
- reinforced concrete interstage covered pump sump (c/w concrete roof)
- GRP Ultraviolet Reactor building, housing UV plant assembly including local MCC and ballast cabinets, interconnecting pipework and cabling

Table 13: Advantages and Disadvantages of Option 5a

Advantages	Disadvantages
Most cost beneficial solution compared with more emerging technologies. A well-established technology with the capability of treating water to the required target as indicated in our disinfection strategy on a site-by-site basis Increases resilience of supply in relatively confined water supply zones with little opportunity for conjunctive use	Possible requirement to upgrade the existing site power supply depending on the energy requirements of each of the schemes. The chosen solution is not the most efficient in terms of carbon emissions due to the higher energy use. Limited availability on site for installation at particular sites

Chosen Option

The chosen option for this scheme is Option 5a for inclusion in the PR24 business plan, the reasons behind this chosen option are as follows -

1. Highest benefit to cost ratio
2. Lowest CapEx, repeat CapEx and OpEx
3. Resolves current issue of limitations meeting the standards set out in our Regulation 26 Disinfection Strategy.
4. Seen as an industry leading approach to disinfection by the Drinking Water Inspectorate

2.3 Cost efficiency

In this section we give specific details on our approach to costing and benchmarking. Our overarching approach to developing efficient costs is set out in WSH50-IP00 Our Approach to Investment Planning (Sections 4.10 and 7).

The two sub sections below correspond to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.3.

2.3.1 Developing a cost for WTW Interventions

> ***Is it clear how the company has arrived at its option costs? Is there supporting evidence on the calculations and key assumptions used and why these are appropriate? Does the company provide third party assurance for the robustness of the cost estimates?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.3a and A1.1.3c*

We have costed the schemes using our UCD C&CET as described in WSH50-IP00 Our Approach to Investment Planning (Section 4.10). This approach utilises like-for-like (top down) costing of process assets and construction related costs to forecast and estimate future project and programme costs.

An individual specific scope was developed for each of the schemes, as part of the optioning process which identified the assets for construction, modification and upgrade along with any site specifics, which formed the basis of our estimates.

Much of the scope is for items of work which has been constructed throughout previous AMPs, and therefore we have a rich source of historical cost data. For these items of work we have developed cost models based on the most important cost drivers, e.g., the most influential driver to cost for a tank is volume. This costing approach forms the direct works and site-specific costs. We apply construction indirect costs and project oncosts based on the work stream, in this instance this is Water Non-Infrastructure, which applies modelled percentages to the cost of the direct works and site specifics.

The scope is aligned to our Work breakdown Structure (WBS), which was developed to support our data capture process of historical project cost against delivered assets, into a scope input sheet. Within this, sizing of the assets based on the relevant yardstick, which is dictated by the WBS, is provided following calculation in the previous engineering stages. Our costs models are developed in line with our WBS and this allows us to input this information into the C&CET and generate a project estimate. WBS details the inclusions and exclusions of works under each cost model and the limitations of the model, so we can ensure all project costs are captured and there is also no over costing.

Surveys are to be undertaken and establishment of other conditions need to be determined.

The costing was carried out by Welsh Water Costing Team. The Governance procedures, as outlined in Section 5 Costing Methodology were adhered to with the appropriate use of cost models being confirmed and all manual allowances verified prior to providing sign offs throughout the different iterations of the costings.

Along with our overall costing strategy being reviewed and assured by Jacobs, we have also employed third party consultants to review single Enhancement Cases to provide confidence that the estimates within them are robust, efficient and deliverable. Please refer to WSH50-IP00 Our Approach to Investment Planning (Section 6) for more information regarding the review and assurance undertaken.

2.3.2 Benchmarking our approach

Is there evidence that the cost estimates are efficient (for example using similar scheme outturn data, industry and/or external cost benchmarking)?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.3b

The cost estimates for schemes have been based on Welsh Water's unit cost database and its associated Cost and Carbon tool to generate cost estimates for schemes. The costs generated are based on internal outturn costs collected by Welsh Water as described in WSH50-IP00 Our Approach to Investment Planning (Section 4.10).

2.4 Customer Protection

In this section we set out how oversight will be provided by the DWI on the proposed works.

The sub section below corresponds to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.4. There is no third-party funding for this Enhancement Case.

2.4.1 Providing Customer Protection

Are customers protected (via a price control deliverable or performance commitment) if the investment is cancelled, delayed or reduced in scope?
Does the protection cover all the benefits proposed to be delivered and funded (e.g. primary and wider benefits)?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.4a and A1.1.4b

Customers will be protected via two mechanisms:

1. The regulatory oversight from the DWI. The delivery of performance improvement is inherent to the DWI Notices. The legal mechanism within which the DWI will hold the company to account will be in place in accordance with timescales outline by DWI. Failure to meet these targets could result in prosecution, and
2. The existing performances commitment for customer contacts about water quality (and CRI) agreed with and regulated by Ofwat.

Section 2.1 above sets out clear reporting requirements which the DWI have put in place to monitor progress both in terms of programme development and performance improvement.

For the performance commitment Welsh Water will report progress each year through the Annual Performances Report (APR). The common performance commitments include 'Customer contacts about water quality' which will report on the number of consumer contacts per 1,000 population and the Compliance Risk Index (CRI).

The work will deliver resilience and prevent deterioration in the Performances Commitment for CRI

3. Investment Package 3: Disinfection By-Products – Capel Curig WTW & other Minor Investment

3.1 Need for Enhancement Investment

This section will set out the drivers behind the Enhancement Case and describe the context within which it has arisen.

We describe the deterioration of raw water quality, the environmental factors (outside of management control) which are driving this and the implication to performance. The need to invest in AMP8 is quantified by presenting the increase in costs and reduction in service which would emerge without action. We set out overlaps with our Base Maintenance programme, which we have examined and removed from the Enhancement Case and give confidence that past allowances have been effectively invested.

The proposed investment aligns with our Long Term Delivery Strategy – responding to the need for long term stewardship and improvement in service. The five sub sections below correspond to the seven criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.1.

3.1.1 Evidence that Enhancement is Needed

> ***Is there evidence that the proposed enhancement investment is required?***
> ***Is the scale and timing of the investment justified?***
> ***Where appropriate, is there evidence that customers support the need for investment?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1a, A1.1.1b and A1.1.1f*

This Enhancement Case is driven by compliance with water quality regulations enforced by the DWI. Regulation 26 compliance, DWI notices and guidance, and reduced customer contacts are the key drivers for this Enhancement Case, and under each driver are various asset specific needs.

The risks is deterioration of raw water quality related to organics and disinfection by-product precursors.

Disinfection by-products, with trihalomethanes (THMs) as the most common, are regulated chemical compounds, formed as a byproduct of the disinfection of water. Chlorine, our primary disinfectant, reacts with precursors (dissolved organic matter) that remain in the water following pre-treatment processes. THMs are currently regulated under the Water Supply (Water Quality) regulations at the supply point (consumers' taps) to a limit of 100 µg/l.

In addition to this, the Drinking Water Inspectorate (DWI) has set out further guidance (2011) regarding THMs where concentrations greater than 50 µg/l should be recorded as a risk in Drinking Water Safety Plans and the risk mitigated and managed accordingly. There is also a Regulatory requirement to keep disinfection byproducts as low as possible.

Capel Curig WTW's historical THM data demonstrates the WTWs ability to meet the PCV value of 100 µg/l as it leaves the treatment works, however the regulatory requirement is to meet the standard at the customer tap. The THM values, as they leave the works frequently exceed the risk mitigation guidance value of 50 µg/l, leading to levels at the customer tap close to the PCV, this can be seen in Figure 6 below.

Furthermore, Figure 7 and Figure 8 show that the raw water quality with respect to colour (a surrogate for organic compounds) and total organics (precursors for THM production) are deteriorating. This trend can be expected to continue with climate change, which will also contribute to increased rates of formation due to its temperature dependency.

Capel Curig is our worst performing WTW for this parameter, therefore an enhancement is required.

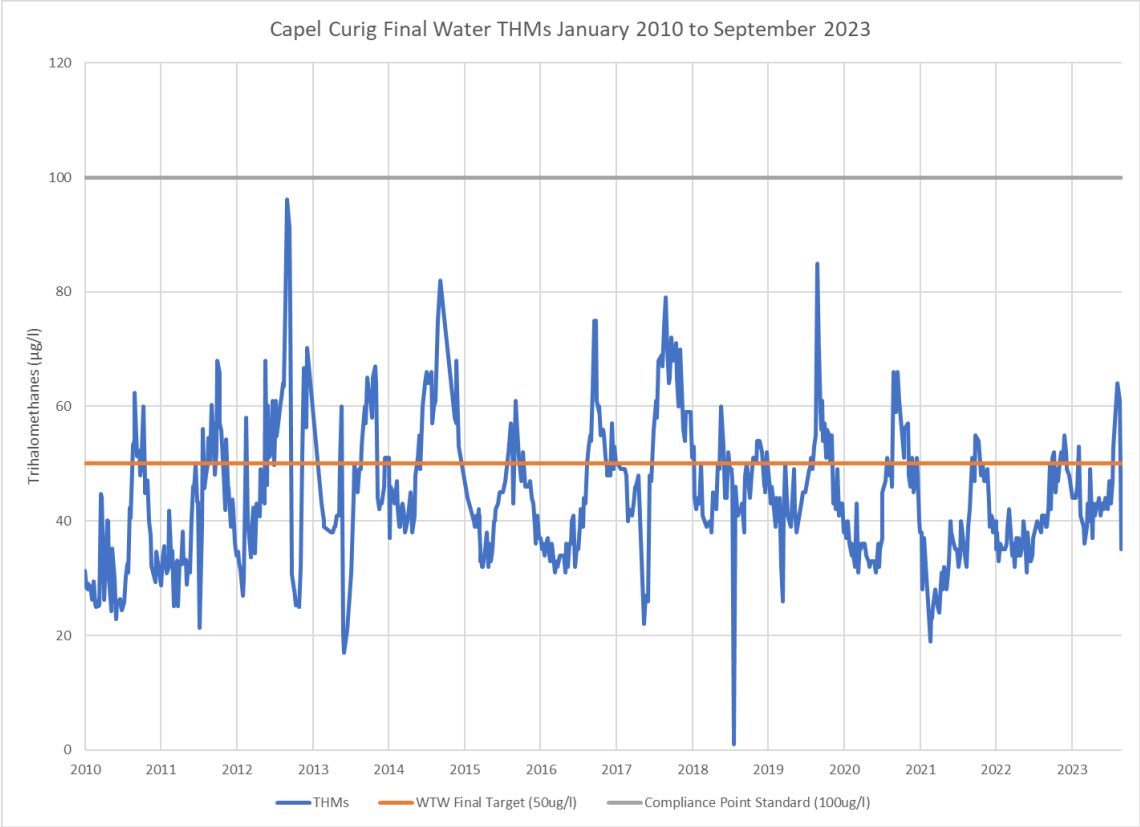

Figure 6: Capel Curig THM concentration vs WTW THM target value, and PCV value

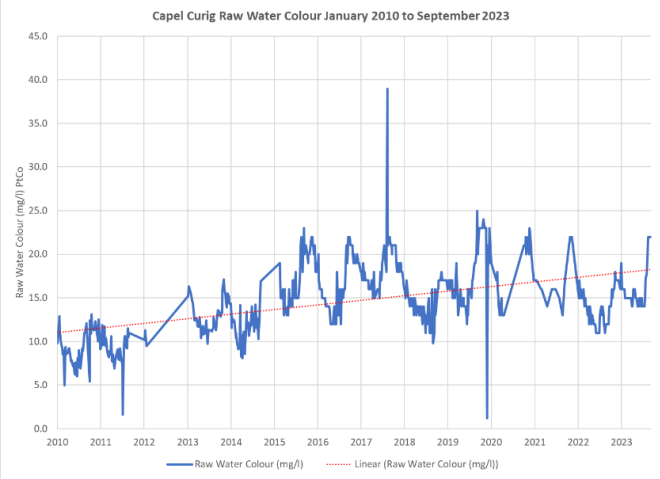

Figure 7: Capel Curig historical raw water colour

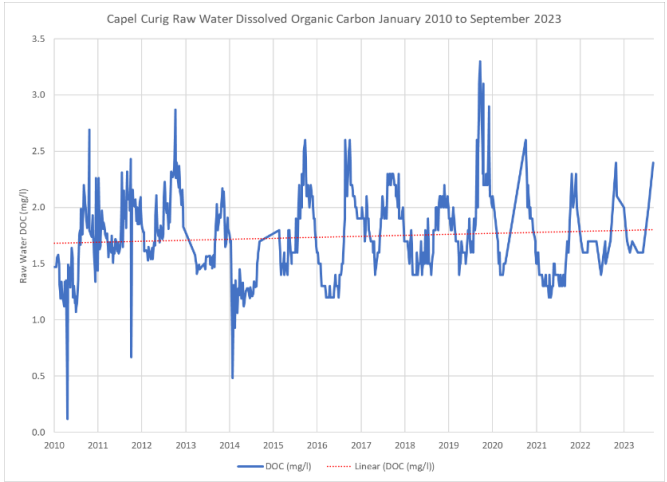

Figure 8: Capel Curig historical raw water DOC

Although the trend for THMs at the compliance point is high and slowly deteriorating there is a further risk at Capel Curig, namely Haloacetic Acids (HAAs).

Compliance related to HAAs has been proposed for adoption into the Water Supply Regulations within the next 10 years. Like THMs, HAAs have been identified as a potential carcinogenic parameter in drinking water over moderate to prolonged periods of time. The additional risk for HAAs presents an additional driver for intervention for which the proposed solution will also address.

As indicated in Figure 9 below the proposed compliance limit for HAAs is 60 µg/l, we have taken 58 samples over the last 6 years, these have resulted in 25 breaches of the current proposed compliance value.

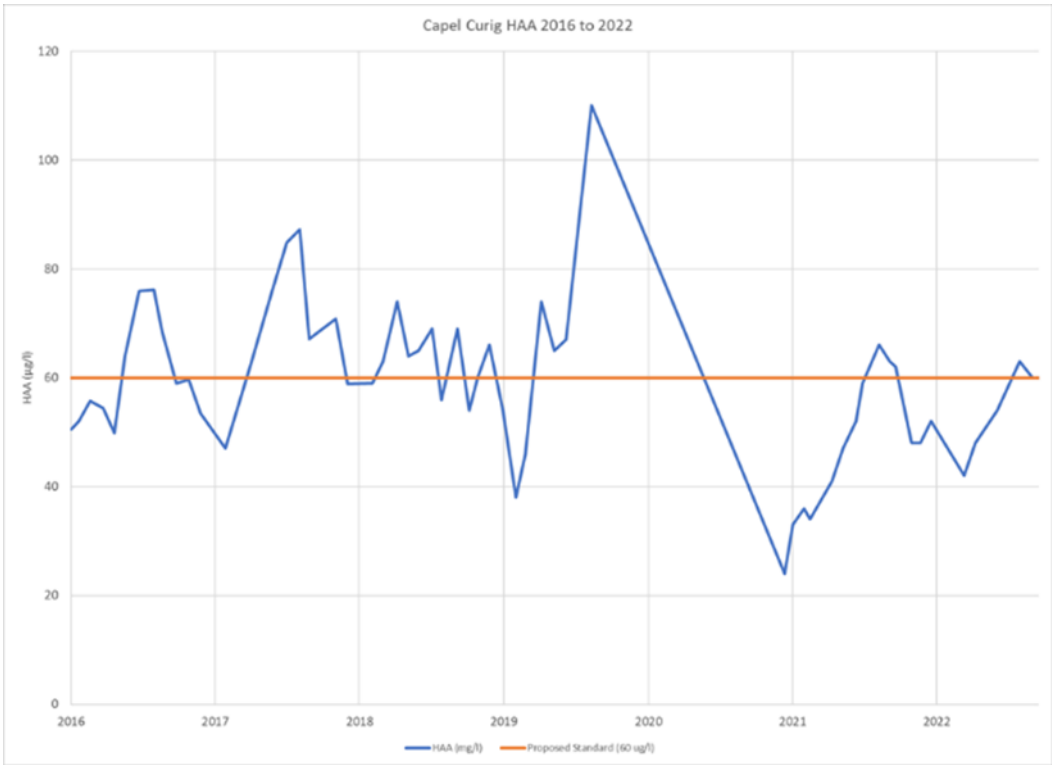

Figure 9: Capel Curig Haloacetic Acids

As per Figure 6 above, Capel Curig treatment works is already regularly producing water that has concentration of THMs that are within 50% of the PCV value and are above the DWI target value for risk mitigation. Furthermore, the raw water deterioration shown in Figure 7 and Figure 8, demonstrate an escalating risk. Further to this THM risks we have recently discovered elevated levels of chlorate in the final water at Capel Curig related to deterioration in raw water quality. While this does not have its own PCV, the DWI have taken an active interest in this parameter recently prosecuting Southern Water for breaches of Regulation 31 in relation to handling of sodium hypochlorite – the chemical used at Capel Curig for disinfection.

It is noted, we did consider this investment in the PR19 price review process, however since this time we have gathered furthered evidence from enhanced monitoring and analysis which indicates a further deterioration of the risk and therefore has garnered support from the DWI.

Also included in this Investment Package is a need for further intervention on Anglesey for management of disinfection by-products. Our analysis indicates that trihalomethanes are very difficult to manage in this area using conventional treatment which coupled with forecasted raw water deterioration, will only deteriorate in the future. Raw water organics in this part of the country are quite unique in terms of characteristics which contributes towards them being very difficult to reduce or remove using conventional treatment processes including coagulation and clarification. Although we are currently managing THM levels within regulatory limits, there is an indication that a more comprehensive solution will be required for Anglesey in the future.

3.1.2 Scale and Timing of Investment

The scale of investment and activity has been selected to balance the reduction of the appropriate level of risk, affordability and deliverability in AMP8. We have approached DWI as part of the PR24 process to propose support for 4 schemes within this programme of investment. DWI has indicated an

appropriate level of support for this scheme through a Regulation 28 Legal Instrument. The next step will be for Welsh Water to complete the draft copy of the Notice and submit to the DWI within their timeframe. This Notice will outline the actions and the timescales for completion. We will work with DWI to produce the notices for this scheme, with an expected timescale for delivery by the end of AMP8.

The scheme set out in the table below are DWI driven based on observed deterioration in raw water quality and increasing regulatory standards. These will be governed by a legal mechanism with the DWI, building on the DWI published letters of support and will be in place according to timescales outlined by the DWI's PR24 process.

Table 14: DWI notices of support

DWI Scheme Reference:	Project Description	Legal Instrument Required	Timescale	Supporting Documentation
DWR4: supporting the delivery of works to reduce the concentration of disinfection by-products.	Capel Curig-Disinfection by-products	Regulation 28(4) notice	Within AMP 8	PR24 submission, regulation 28(1) risk assessments.

3.1.3 Overlap with Activities to be Delivered through Base

Does the proposed enhancement investment overlap with activities to be delivered through base?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.1c

We have a standard approach for assessing base/enhancements splits set out in a fair regulatory treatment within WSH50-IP00 Our Approach to Investment Planning (Section 3.4.2).

The options that were put forward to shortlisting, and the option that was ultimately recommended all require new infrastructure and are not part of base. The existing site assets cannot deliver the required standard. These are detailed in below paragraphs.

3.1.4 Overlap with Funding from Previous Price Reviews

Does the need and/or proposed enhancement investment overlap with activities or service levels already funded at previous price reviews?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.1d

The investments proposed in this case are the result of raw water quality deterioration reaching a critical inflection point. While funding has been provided in the past for treatment at Capel Curig, the deterioration will take this process beyond the capability of the installed process. The risk will deteriorate through the effects of climate change, the impacts of which are already being felt, with more frequent heavy rainfall and extended hot and dry periods, being experienced more frequently since 2010.

3.1.5 Alignment with the Long Term Delivery Strategy

Is the need clearly identified in the context of a robust long term delivery strategy within a defined core adaptive pathway?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.1e

Welsh Water have a long term output targeting a CRI score of 0, while this will be practically very difficult, minimising the score each year is of great importance both internally and to our external stakeholders. The quality of final water at our treatment works is a key contributor to achieving this long term ambition.

Welsh Water's core pathway has identified a range of interventions that are required to achieve this ambition. The schemes identified in this Enhancement Case are a key contributor to this. Welsh Water have identified alternative pathways focused on changing legislation, primarily associated with Welsh Government adopting EU drinking water legislation along with forecasts of raw water deterioration and their impact on our asset's treatment capabilities.

Further details can be seen in WSH01 Long Term Delivery Strategy.

3.1.6 Evidence of Customer Support

Our approach to customer engagement is set out in Stepping up to the Challenge: Business Plan 2025-30 (Section 2.2).
Customers are generally supportive of investment to improve water quality.

3.1.7 Management Control of Costs

> ***Is the investment driven by factors outside of management control? Is it clear that steps been taken to control costs and have potential cost savings been accounted for?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1g*

The factors that are driving these Enhancement Cases that are outside of management control are raw water deterioration (THM precursors) linked to climate change and continued adherence to regulatory parameters.

The increase in raw water organic matter and colour over time are now challenging the design capabilities of the existing treatment process, which were designed around specific raw water conditions. Although we have optimised the existing process, given the extent that raw water deterioration has occurred over the last 10 years the existing treatment process will shortly be incapable of treating water should the deterioration in raw water trend continue as we have forecast. Further proposed changes to disinfection byproducts will strengthen the case of improvement as the existing treatment process will not reduce the production of Haloacetic Acids.

3.2 Best Option for Customers

Our overarching approach is described in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

The three sub sections below correspond to the eight criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.2.

3.2.1 Identification of Solution Options

> ***Has the company considered an appropriate number of options over a range of intervention types to meet the identified need?***
> ***Is there evidence that the proposed solution represents best value for customers, communities, and the environment over the long term?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2a and A1.1.2b*

A longlist of possible interventions that could reduce the impact of raw water deterioration was developed. These possibilities were reviewed by an experienced panel during a 'longlist workshop' to eliminate the options that:

- will not give sufficient improvement,
- have been tried previously and have not been successful,
- experience elsewhere has shown to be poor, providing little benefit.

The options developed for each of the investment schemes in this section are as follows:

When assessing the risks at Capel Curig WTW against our investment hierarchy it was evident that additional resources are required to mitigate the risk.

Table 15: Long list of options considered for Capel Curig

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
1	**Eliminating, reducing or delaying the need for change:** Manage demand	**Not Viable –** Due to the nature of the risk impacting on water quality, demand management is not a viable solution. Although we can tanker clean water to this site from an alternative site, for short term issues, it is not considered a long term sustainable approach.	✗
2	**Eliminating, reducing or delaying the need for change:** *Manage operation or use of the existing asset or service*	**Not Viable –** Although we have a history of treated water tankering to this site, it is not considered a long term sustainable solution. The remote location of the site together with inaccessibility in winter months reduces the attraction of this option.	✗
3	**Eliminating, reducing or delaying the need for change:** *Maintain the existing asset or service*	**Not Viable –** The asset is maintained to current standards but continuation of this maintenance would not reduce the risk sufficiently. The need has identified that raw water deterioration is contributing to a deterioration in treated water quality which the existing asset is not capable of reducing.	✗
4	**Maintaining the effective risk controls already in place:** *Replace the existing asset like-for-like*	**Not Viable –** The capability of the existing works is insufficient to manage or reduce the identified risk with disinfection by-products. Replacing the asset with a like for like equivalent would not reduce the risk.	✗
5a	**Enhancing existing or adding new resources:** Upgrade existing	• pH correction and coagulant dosing system to be installed	✗

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
	WTW assets to achieve current 50 ug/l THM limit	• 1No. new pressure filter to be installed • Existing 2No. pressure filters to be upgraded with auto backwash, and top up media from 400 mm to 1200 mm • 2No. new GAC to be installed and upgrade existing GAC with auto backwash. Redundancy procedure to be established • 1No. Clean Washwater Tank, and 1No. Dirty Washwater Tank to be provided Option discounted at longlisting	

5b	**Enhancing existing or adding new resources:** Replace current process with FYNE Nanofiltration to achieve current 50 ug/l THM limit	• 2No. modular FYNE Nanofiltration packs
		• 1No. Building (prefabricated modular package plant)
		  • Sodium Hypochlorite dosing system.
		  • UV (optional)
		Accepted as a shortlisted option
			✓

5c	**Enhancing existing or adding new resources:** Replace current process with FYNE Nanofiltration and Reverse Osmosis to achieve potential future 25 ug/l THM limit	• 2No. modular FYNE Nanofiltration packs • 1No. Building (prefabricated modular package plant) • Sodium Hypochlorite dosing system. • UV (optional) • Reverse Osmosis package plant Accepted as a shortlisted option	✓
5d	**Enhancing existing or adding new resources:** Resin Ion Exchange before existing Pressure Filters and increased GAC retention time	• Resin Ion Exchange before existing Pressure Filters • Extra GACs Option discounted at longlisting	✗
5e	**Enhancing existing or adding new resources:** Treated water pumped in from	• Treated water pumped from existing Llyn Conwy Distribution Network at Betws-y-Coed direct into eastern end of existing Capel Curig Distribution Network	✓

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
	Llyn Conwy Distribution Network	• 2 stages of pumping and intermediate storage required due to high static/dynamic head • Approx. 6 km rising main in total, majority in main A5 trunk road • 24-hour storage tank (250m^3) at intermediate pumping stage • Standby generator and surge vessel at each pumping stage • Local booster to serve properties to north side of Capel Curig (currently fed by gravity from existing works) Accepted as a shortlisted option	

3.2.2 Assessment and Selection of Solution Options

Our approach to cost benefit appraisal and its role in decision making is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

The table below has been completed using data from our cost benefit spreadsheets to illustrate the value generated by the proposed investment (All monetary values are expressed in 2022/23 prices and are prior to portfolio adjustments for corporate overheads and efficiency challenge. Welsh Water ref: SMF version 5).

Table 16: Value generated by the proposed investment

Solution Option	Option Name	CapEx	Present Value Whole Life Costs (WLC)	Present Value Whole Life Benefits (WLB)	Benefit/ Cost Ratio	Net Present Value (=WLB - WLC)
Option S1	Replace current Process by FYNE nanofiltration	£8.105M	£11.543M	£11.573M	1.003	£0.030M
Option S2	Replace current Process by FYNE nanofiltration and Reverse Osmosis	£8.511M	£14.718M	£11.631M	0.790	-£3.087M
Option S3	Treated Water Pumped from Llyn Conwy Distribution Network	£5.160M	£9.048M	£14.511M	1.604	£5.463M

Based on our CBA analysis Option S3 was recommended for implementation. S3 was selected as it addresses the driver of reducing the risk for disinfection by-products through abandonment of the WTW with a supply from an alternative site. The advantage of this solution reduces the post risk score to zero while also being the cheapest cost option compared to Option S1 and S2.

3.2.3 Quantification of Benefits

> ***Has the company fully considered the carbon impact, natural capital and other benefits that the options can deliver?***
> ***Has the impact (incremental improvement) of the proposed option on the identified need been quantified, including the impact on performance commitments where applicable?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2c and A1.1.2d*

The benefits of a scheme have been calculated by our asset planning and engineering teams based on the best available information and have been used to forecast the impact a scheme will have on service measures in comparison to the pre investment position/do nothing position.

Benefits are quantified against our service measure framework (SMF) meaning they are well understood and trackable through regular business activity. For more detail on this approach see WSH50-IP00 Our Approach to Investment Planning (Section 5.4). We have included an excerpt from the SMF in section 1.2.3 showing the categories of benefit that roll up to the Ofwat drivers identified as part of the overall case. The table below shows how we have apportioned the benefits, with improved drinking water quality carrying the largest weight.

3.2.4 Quantifying the Impact on Need and Performance Commitments

The identified schemes will resolve the issues raised with the DWI. The proposed work has been discussed with the quality regulator and they are supportive of the activities proposed.

The schemes will impact on the resilience of performances against the CRI. They will reduce the likelihood of performances deterioration, but not in a way which is visible to the measure.

From our analysis the proposed option will make the following impacts:

We have assessed the impact of enhancement on CRI, ERI and Acceptability of Water performance commitments

- Reduces the risk of an impact on CRI following the inability to treat water sufficiently to remove disinfection by-products including THMs and HAAs

3.2.5 Uncertainties relating to cost and benefit delivery

> ***Have the uncertainties relating to costs and benefit delivery been explored and mitigated? Have flexible, lower risk and modular solutions been assessed – including where forecast option utilisation will be low?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2e*

Our methodology is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3). This includes commentary on our approach to optioneering, costing and cost benefit analysis.

For this Enhancement Case we have evaluated a wide range of options in line with our TotEx hierarchy approach. We have aimed to balance most efficient solution with risk and innovation in all instances.

Capel Curig WTW

From the 5 longlist options, Options 2, 3 and 5 were taken forward for shortlisting where they were costed and went through the Risk & Value process, details of those 3 options including cost and benefit are as follows -

Option 5b: Replace current process with FYNE Nanofiltration

This option involves:

1. Installation of a FYNE Nanofiltration package plant to replace the existing on-site processes and to achieve to achieve current 50 ug/l THM limit
2. Package would be installed before disinfection stage to remove disinfection by-product precursor chemicals as well as other contaminants, producing treated water to the required drinking water quality standards

Table 17: Advantages and disadvantages of Option 5b

Advantages	Disadvantages
This will eliminate the THM issues completely and achieve 50 ug/l THM max. in treated water	Works located in National Park; therefore new installation is constrained by existing site boundary, which is very limited
Nanofiltration process could potentially be enhanced to achieve future 25 ug/l standard (additional filter packs)	National Park planning requirements may be an issue
.	
Other existing risks associated with existing process that will be replaced are also eliminated	Potential repeat CapEx for membrane replacement

Option 5c: Replace current process with FYNE Nanofiltration and Reverse Osmosis

This option involves:

1. Installation of a FYNE Nanofiltration and Reverse Osmosis package plant to replace the existing on-site processes and to achieve potential future 25 ug/l THM limit
2. Package would be installed before disinfection stage to remove disinfection by-product precursor chemicals as well as other contaminants, producing treated water to the required drinking water quality standards

Table 18: Advantages and disadvantages of Option 5c

Advantages	Disadvantages
This will eliminate the THM issues completely and achieve 50 ug/l THM max. in treated water	Works located in National Park; therefore new installation is constrained by existing site boundary, which is very limited
Process would achieve potential future 25 ug/l standard.	National Park planning requirements may be an issue
	Potential repeat CapEx for membrane replacement
Other existing risks associated with existing process that will be replaced are also eliminated	Potential power requirement increase for Reverse Osmosis stage

Option 5e: Treated water pumped in from Llyn Conwy Distribution Network

This option involves:

- Treated water pumped from existing Llyn Conwy Distribution Network at Betws-y-Coed direct into eastern end of existing Capel Curig Distribution Network
- 2 stages of pumping and intermediate storage required due to high static/dynamic head
- Approx. 6 km of 75 mm OD HDPE rising main in total, majority in main A5 trunk road
- 24-hour storage tank (273m3) at intermediate pumping stage
- Standby generator and surge vessel at each pumping stage
- Local booster to serve properties to north side of Capel Curig (currently fed by gravity from existing works)

Table 19: Advantages and disadvantages of Option 5e

Advantages	Disadvantages
Highest benefit cost ratio of 71.340	High static/dynamic head requires 2 stages of pumping
No current or foreseeable Disinfection By-product issues with Llyn Conwy treated water	Potential single point of failure supplying Capel Curig Distribution Network
Allows complete abandonment of existing Capel Curig WTW	Rising main route constrained by topography – realistically limited to A5 trunk road only, with potential for extensive rock in excavation
	National Park planning requirements may be an issue
	Wide range of flows means that compliance with Welsh Water Standard Specification MS104 Pipework not possible for all flows

Chosen Option

The chosen option for this scheme is Option 5e for inclusion in the PR24 business plan, the reasons behind this chosen option are as follows -

1. Highest benefit to cost ratio
2. Lowest CapEx, repeat CapEx and OpEx
3. Resolves current problems of THM formation at Capel Curig WTW
4. Would allow existing Capel Curig WTW to be abandoned (note: no allowance currently in costs for abandonment/demolition of existing assets). Discussion on going for the future of Capel Curig and whether it would remain as a standby or emergency treatment works

Other DBP Issues on Anglesey (Alaw and Cefni WTWs)

The levels of disinfection byproducs on Anglesey are also high. Our chosen solution for Anglesey at our Alaw and Cefni WTW will be to complete a detailed feasibility study in AMP8 to inform the cost of a more robust solution in the future. We have investigated the scope and cost of this solution during the production of the PR24 business plan which has indicated the future solution is likely to be a resin ion-exchange process. We do not have the experience of constructing and operating such a process at Dŵr Cymru so have deferred a more permanent scheme to AMP9 or later. We will complete a detailed feasibility study in order to provide more solution and cost certainty as well as align with long term water supply strategies for this region.

3.3 Cost efficiency

In this section we give specific details on our approach to costing and benchmarking. Our overarching approach to developing efficient costs is set out in WSH50-IP00 Our Approach to Investment Planning (Sections 4.10 and 7).

The two sub sections below correspond to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.3.

3.3.1 Developing a cost for WTW Interventions

> ***Is it clear how the company has arrived at its option costs? Is there supporting evidence on the calculations and key assumptions used and why these are appropriate? Does the company provide third party assurance for the robustness of the cost estimates?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.3a and A1.1.3c*

We have costed the schemes using our UCD C&CET as described in WSH50-IP00 Our Approach to Investment Planning (Section 4.10). This approach utilises like-for-like (top down) costing of process assets and construction related costs to forecast and estimate future project and programme costs.

An individual specific scope was developed for each of the schemes, as part of the optioning process which identified the assets for construction, modification and upgrade along with any site specifics, which formed the basis of our estimates.

Much of the scope is for items of work which has been constructed throughout previous AMPs, and therefore we have a rich source of historical cost data. For these items of work, we have developed cost models based on the most important cost drivers, e.g., the most influential driver to cost for a tank is volume. This costing approach forms the direct works and site-specific costs. We apply construction indirect costs and project oncosts based on the work stream, in this instance this is Water Non-Infrastructure, which applies modelled percentages to the cost of the direct works and site specifics.

The scope is aligned to our Work breakdown Structure (WBS), which was developed to support our data capture process of historical project cost against delivered assets, into a scope input sheet. Within this, sizing of the assets based on the relevant yardstick, which is dictated by the WBS, is provided following calculation in the previous engineering stages. Our costs models are developed in line with our WBS and this allows us to input this information into the C&CET and generate a project estimate. WBS details the inclusions and exclusions of works under each cost model and the limitations of the model, so we can ensure all project costs are captured and there is also no over costing.

The costing was carried out by Welsh Water Costing Team. The Governance procedures, as outlined in Section 5 Costing Methodology were adhered to with the appropriate use of cost models being confirmed and all manual allowances verified prior to providing sign offs throughout the different iterations of the costings.

Along with our overall costing strategy being reviewed and assured by Jacobs, we have also employed third party consultants to review single Enhancement Cases to provide confidence that the estimates within them are robust, efficient and deliverable. Please refer to WSH50-IP00 Our Approach to Investment Planning (Section 6) for more information regarding the review and assurance undertaken.

3.3.2 Benchmarking our approach

Is there evidence that the cost estimates are efficient (for example using similar scheme outturn data, industry and/or external cost benchmarking)?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.3b

The cost estimates for schemes have been based on Welsh Water's unit cost database and its associated Cost and Carbon tool to generate cost estimates for schemes. The costs generated are based on internal outturn costs collected by Welsh Water as described in WSH50-IP00 Our Approach to Investment Planning (Sections 4.10 and 7).

3.4 Customer Protection

The sub section below corresponds to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.4. There is no third-party funding for this Enhancement Case.

3.4.1 Providing Customer Protection

In this section we set out how oversight will be provided by the DWI on the proposed works.

Are customers protected (via a price control deliverable or performance commitment) if the investment is cancelled, delayed or reduced in scope?
Does the protection cover all the benefits proposed to be delivered and funded (e.g. primary and wider benefits)?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.4a and A1.1.4b

Customers will be protected via two mechanisms:

1. The regulatory oversight from the DWI. The delivery of performance improvement is inherent to the DWI Notices. The legal mechanism within which the DWI will hold the company to account will be in place in accordance with timescales outline by DWI. Failure to meet these targets could result in prosecution, and
2. The existing performances commitment for customer contacts about water quality (and CRI) agreed with and regulated by Ofwat.

Section 3.1 above sets out clear reporting requirements which the DWI have put in place to monitor progress both in terms of programme development and performance improvement.

For the performance commitment Welsh Water will report progress each year through the Annual Performances Report (APR). The common performance commitments include 'Customer contacts about water quality' which will report on the number of consumer contacts per 1,000 population and the Compliance Risk Index (CRI).

The work will deliver resilience and prevent deterioration in the Performances Commitment for CRI

4. Investment Package 4: Raw Water Organics (Taste & Odour) – Mayhill WTW

4.1 Need for Enhancement Investment

This section will set out the drivers behind the Enhancement Case and describe the context within which it has arisen.

We describe the deterioration of raw water quality, the environmental factors (outside of management control) which are driving this and the implication to performance. The need to invest in AMP8 is quantified by presenting the increase in costs and reduction in service which would emerge without action. We set out overlaps with our Base Maintenance programme, which we have examined and removed from the Enhancement Case and give confidence that past allowances have been effectively invested.

The proposed investment aligns with our Long Term Delivery Strategy – responding to the need for long term stewardship and improvement in service. The five sub sections below correspond to the seven criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.1.

4.1.1 Evidence that Enhancement is Needed

> ***Is there evidence that the proposed enhancement investment is required?***
> ***Is the scale and timing of the investment justified?***
> ***Where appropriate, is there evidence that customers support the need for investment?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1a, A1.1.1b and A1.1.1f*

This Enhancement Case is driven by compliance with water quality regulations enforced by the DWI. Regulation 26 compliance, DWI notices and guidance, and reduced customer contacts are the key drivers for this Enhancement Case, and under each driver are various asset specific needs.

The overall risks are linked by deterioration of raw water quality which is further broken down into;

- Raw Water Organics that contribute towards taste and odour issues for customers

In June 2021, we saw a Taste & Odour event in which resulted in a significant number of customers contacts being received for unusual taste and odour over a short period of 4 days for the area supplied by Mayhill WTW. Details of this event can be found in Question 7 below but it was determined to be due to a spillage of an unknown organic material into the River Wye which supplies Mayhill WTW. This, along with ineffective removal through the existing treatment process resulted in an elevated number of contacts.

Following an investigation of the event in June 2021, it has been determined that there is insufficient Empty Bed Contact Time under all flow and operating conditions at Mayhill WTW to meet our best practice standard. Although the WTW has GAC adsorption treatment, it has been recently established that the treatment is insufficient against certain types of compounds and parameters. Our design and operational standards stipulate that GAC treatment should provide up 12.5 minutes of EBCT for taste & odour compounds and 15 minutes for pesticides, herbicides and other pollution parameters.

The following table summarises current EBCT under different flow and operational conditions including when 1 filter is out of service for maintenance –

Table 20: Current Empty Bed Contact Time for Mayhill with all filters in service and 1 out of service for backwash/maintenance

	Empty Bed Contact Time (Minutes)	
WTW Flow (Ml/d)	All Filters in Service	1 Filter Out of Service for Maintenance
2.5	21.3	14.2
3.5	15.4	10.2
5.5	9.7	6.5

The information in Table 8 illustrates that required EBCT is met only under average and minimum flow when all filters are in service and only up to 14 minutes for minimum flow when 1 filter is out of service for maintenance.

4.1.2 Scale and Timing of Investment

The scale of investment and activity has been selected to balance the reduction of the appropriate level of risk, affordability and deliverability in AMP8. We have approached DWI as part of the PR24 process to propose support this scheme within this programme of investment. DWI has indicated an appropriate level of support for this scheme through a Regulation 28 Legal Instrument. The next step will be for Welsh Water to complete the draft copy of the Notice and submit to the DWI within their timeframe. This Notice will outline the actions and the timescales for completion. We will work with DWI to produce the notices for this scheme, with an expected timescale for delivery by the end of AMP8.

The scheme set out in the table below are DWI driven based on observed deterioration in raw water quality and increasing regulatory standards. These will be governed by a legal mechanism with the DWI, building on the DWI published letters of support and will be in place according to timescales outlined by the DWI's PR24 process.

Table 21: DWI Scheme details

DWI Scheme Reference:	Project Description	Legal Instrument Required	Timescale	Supporting Documentation
DWR5: supporting the delivery of works for Mayhill organics removal	Mayhill – organics (Taste & Odour)	Regulation 28(4) notice	Within AMP 8	PR24 submission, regulation 28(1) risk assessments.

4.1.3 Overlap with Activities to be Delivered through Base

> ***Does the proposed enhancement investment overlap with activities to be delivered through base?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1c*

We have a standard approach for assessing base/enhancements splits set out in a fair regulatory treatment within WSH50-IP00 Our Approach to Investment Planning (Section 3.4.2).

The options that were put forward to shortlisting, and the option that was ultimately recommended all require new infrastructure and are not part of base. The existing site assets cannot deliver the required standard. These are detailed in below paragraphs.

4.1.4 Overlap with Funding from Previous Price Reviews

Does the need and/or proposed enhancement investment overlap with activities or service levels already funded at previous price reviews?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.1d

The investments proposed in this case are the result of raw water quality deterioration reaching a critical inflection point. All these risks will deteriorate through the effects of climate change, the impacts of which are already being felt, with more frequent heavy rainfall and extended hot and dry periods, being experienced more frequently since 2010. While Mayhill WTW has had a GAC removal stage since construction in the early 90s, the impact of deteriorating raw water quality, coupled with developments in understanding, industry best practice, customer and regulatory expectations we are seeing a robust challenge to the treatment capability of the existing process which now requires upgrading in order to mitigate these challenges.

4.1.5 Alignment with the Long Term Delivery Strategy

Is the need clearly identified in the context of a robust long term delivery strategy within a defined core adaptive pathway?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.1e

Welsh Water have a long term output targeting a CRI score of 0, while this will be practically very difficult, minimising the score each year is of great importance both internally and to our external stakeholders. The quality of final water at our treatment works is a key contributor to achieving this long term ambition.

Welsh Water's core pathway has identified a range of interventions that are required to achieve this ambition. The schemes identified in this Enhancement Case are a key contributor to this. Welsh Water have identified alternative pathways focused on changing legislation, primarily associated with Welsh Government adopting EU drinking water legislation along with forecasts of raw water deterioration and their impact on our asset's treatment capabilities.

Further details can be seen in WSH01 Long Term Delivery Strategy.

4.1.6 Evidence of Customer Support

Our approach to customer engagement is set out in Stepping up to the Challenge: Business Plan 2025-30 (Section 2.2).
Customers are generally supportive of investment to improve water quality.

4.1.7 Management Control of Costs

Is the investment driven by factors outside of management control? Is it clear that steps been taken to control costs and have potential cost savings been accounted for?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.1g

The factors that are driving these Enhancement Cases that are outside of management control are raw water deterioration (THM precursors, additional solids loadings, and increased Mn) linked to climate change and continued adherence to disinfection directives by adding disinfection resilience to the highest risk WTW that were not addressed in previous AMPs.

The River Wye has an extensive catchment of approximately 3,400 km^2 upstream of Mayhill WTW. A large proportion of the catchment is farmland which brings extensive pollution from chemicals, pesticides and slurry runoff risk. There is also extensive food and chemical manufacturing within the catchment including within the upstream city of Hereford and in and around Monmouth town. Finally,

the River Wye catchment contains a number of major trunk roads including the A470, A40 and M50 motorway. Considering the presence of such varied land use and potential influences on the River Wye, pollution related parameters are not uncommon in elevated concentrations and why GAC treatment was installed at the treatment works when constructed. However, changes in industry best practice, better understanding of the effectiveness of GAC adsorption treatment and potentially a higher frequency and concentration of pollution causing parameters in the River Wye led to a network based event for Taste & Odour in 2021. We have since installed a temporary PAC dosing system to supplement the GAC and upstream monitoring to give an early warning but this is not expected to sufficient to deal with the risk in the long term.

4.2 Best Option for Customers

Our overarching approach is described in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

The three sub sections below correspond to the eight criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.2.

4.2.1 Identification of Solution Options

> ***Has the company considered an appropriate number of options over a range of intervention types to meet the identified need?***
> ***Is there evidence that the proposed solution represents best value for customers, communities, and the environment over the long term?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2a and A1.1.2b*

A longlist of possible interventions that could reduce the impact of raw water deterioration was developed. These possibilities were reviewed by an experienced panel during a 'longlist workshop' to eliminate the options that:

- will not give sufficient improvement,
- have been tried previously and have not been successful,
- experience elsewhere has shown to be poor, providing little benefit.

The options developed for each of the investment schemes in this section are as follows:

We have considered a number of options to reduce the risk at Mayhill to raw water events such as the one we saw in June 2021. A long list of the considered options are as follows –

Table 22: Long list of options considered for Mayhill

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
1	**Eliminating, reducing or delaying the need for change:** Manage demand	**Not Viable –** The supply zone for Mayhill is relatively confined and although we can supply the zone through the use of tankering during lower periods of demand, this is not a sustainable approach for periods of higher demand or for the long term.	✗

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
2	**Eliminating, reducing or delaying the need for change:** *Manage operation or use of the existing asset or service*	**Not Viable –** The current GAC filter is designed to remove taste & odour substances and contaminants from the water. However, it was designed to meet earlier standards and best practice which have since moved on and are now far more advanced. The existing asset cannot be managed in alternative way to reduce the identified risk.	✗
3	**Eliminating, reducing or delaying the need for change:** *Maintain the existing asset or service*	**Not Viable** – The capability of the existing asset is limited and has been tested to its limit within the last 2 years following the raw water pollution event we experienced in June 2021. Further maintenance of this asset would not improve the capability during a similar event.	✗
4	**Maintaining the effective risk controls already in place:** *Replace the existing asset like-for-like*	**Not Viable –** We believe the current GAC adsorption filters are functioning as they were designed. Unfortunately, as scientific understanding has progressed since their installation over 30 years ago, their capability is now understood to be insufficient. Replacing with a like for like asset would not improve the capability of the filters.	✗
5a	**Enhancing existing or adding new resources:** Enhanced monitoring and early warning system	Enhanced upstream monitoring to indicate the presence of pollution parameters in the raw water. Monitoring would allow the cessation of abstraction during a potential pollution event, preserving treated water quality and supply. This is currently being installed.	✓
5b	**Enhancing existing or adding new resources:** Bankside storage of raw water	Bankside storage to impound raw water for between 24 and 48 hours to provide a buffer of consistent raw water quality. Storage would allow more dynamic operation of raw water pumping which would prevent the abstraction of potential polluted water.	✓
5c	**Enhancing existing or adding new resources:** Alternative supply during raw events and peak demand	An alternative supply has been considered for the water supply area during periods which may increase the risk of a taste & odour event for customers. However, the water supply zone in this area is relatively confined with little resilience from other areas. There is a small proportion of blending within this zone from another WTW is very limited during peak demand.	✓

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
5d	**Enhancing existing or adding new resources:** Enhance existing GAC treatment process	Increased GAC capacity of the existing GAC filters or through the addition of extra filters would increase EBCT to beyond 15 minutes under all flow and operational conditions i.e. max flow with 1 filter out of service for maintenance. We have determined that to increase EBCT using this solution, the media depth of the existing filters would need to be increased, construction of additional filters or a combination of both of these approaches.	✓
5e	**Enhancing existing or adding new resources:** Enhance Existing Asset Alternative treatment solutions using emerging technologies	We have considered the use of advanced organic removal solutions including the use of ozone, peroxide, ultraviolet treatment or a combination of these treatment processes upstream of the existing GAC filters. However, due to the uncertain nature of the effectiveness of these solutions in removing organic parameters as well as the need to potentially also increase GAC capacity to remove by-products from these processes makes this solution abortive in terms of cost and cost benefit.	✓
6	**Maintaining the effective risk controls already in place:** *Mothball/dispose of the existing asset or service*	**Not Viable** – We do not consider this a viable solution due to the strategic nature of both the GAC treatment stage and Mayhill WTW.	✗

The chosen solution for Mayhill is additional GAC capacity through both the increase of capacity of the existing GAC to allow a greater depth of media and 2 additional GAC contactors.

The addition of extra EBCT through the chosen solution would increase EBCT under all operating conditions including maximum flow with 1 filter out for service to 15 minutes. Under minimum flow conditions with all GACs in service, EBCT would increase to 33 minutes.

4.2.2 Assessment and Selection of Solution Options

Our approach to cost benefit appraisal and its role in decision making is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

The table below has been completed using data from our cost benefit spreadsheets to illustrate the value generated by the proposed investment (All monetary values are expressed in 2022/23 prices and are prior to portfolio adjustments for corporate overheads and efficiency challenge. Welsh Water ref: SMF version 5).

Table 23: Value generated by the proposed investment options

Solution Option	Option Name	CapEx	Present Value Whole Life Costs (WLC)	Present Value Whole Life Benefits (WLB)	Benefit/ Cost Ratio	Net Present Value (=WLB - WLC)
Option S1	Construction of additional GAC (1 or 2 additional GAC filters)	£2.776M	£2.515M	£6.618M	2.631	£4.103M
Option S2	Installation of sand grade GAC media into existing RGF filters	£0.272M	£0.727M	£1.655M	2.275	£0.927M

Based on our CBA analysis Option S1 was recommended for implementation. S1 was selected as it addresses the risk of mitigating the increase in raw water organics causing taste & odour events. Option S2 was discounted due to the lower reduction in risk and remaining residual risk once the scheme has been delivered.

4.2.3 Quantification of Benefits

> ***Has the company fully considered the carbon impact, natural capital and other benefits that the options can deliver?***
> ***Has the impact (incremental improvement) of the proposed option on the identified need been quantified, including the impact on performance commitments where applicable?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2c and A1.1.2d*

The benefits of a scheme have been calculated by our asset planning and engineering teams based on the best available information and have been used to forecast the impact a scheme will have on service measures in comparison to the pre investment position/do nothing position.

Benefits are quantified against our service measure framework (SMF) meaning they are well understood and trackable through regular business activity. For more detail on this approach see WSH50-IP00 Our Approach to Investment Planning (Section 5.4). We have included an excerpt from the SMF in section 1.2.3 showing the categories of benefit that roll up to the Ofwat drivers identified as part of the overall case. The table below shows how we have apportioned the benefits, with improved drinking water quality carrying the largest weight.

4.2.4 Quantifying the Impact on Need and Performance Commitments

The identified schemes will resolve the issues raised by the DWI. The proposed work has been discussed with the quality regulator and they are supportive of the activities proposed.

The schemes will impact on the resilience of performances against the CRI. They will reduce the likelihood of performances deterioration, but not in a way which is visible to the measure.

From our analysis the proposed option will make the following impacts:

We have assessed the impact of enhancement on CRI, ERI and Acceptability of Water performance commitments

- Eliminates the risk of another water quality event at site impacting ERI for T&O breakthrough to the final water

4.2.5 Uncertainties relating to cost and benefit delivery

Have the uncertainties relating to costs and benefit delivery been explored and mitigated? Have flexible, lower risk and modular solutions been assessed – including where forecast option utilisation will be low?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.2e

Our methodology is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3). This includes commentary on our approach to optioneering, costing and cost benefit analysis.

For this Enhancement Case we have evaluated a wide range of options in line with our TotEx hierarchy approach. We have aimed to balance most efficient solution with risk and innovation in all instances.

Option 5d – Enhance existing GAC Treatment Process

This option involves:

- Increasing the depth of media in the 3 existing GAC filters at Mayhill to increase the adsorption capacity and Empty Bed Contact Time (EBCT)
- Installation of 2 additional GAC filters to increase the total carbon adsorption capacity of the works.
- Installation of additional pipework, valves, instrumentation, and civils requirements to support the additional filters.

Table 24: Advantages and disadvantages of Option 5d

Advantages	Disadvantages
Most cost beneficial solution compared with more emerging technologies. A well-established technology with the capability of treating water to historical background levels of contamination and pollution load for taste & odour causing organic Will increase the EBCT of the existing WTW to comply with Welsh Water technical specification and industry best practice. Increases resilience of supply in a relatively confined water supply zone with little opportunity for conjunctive use	May not be the most effective solution if we start to see an increased frequency of raw water pollution events in the future Carbon adsorption and contact time is limited depending on loading of the media from contaminants or substances. Limited availability on site for installation may

Chosen Option

The chosen option for this scheme is Option 4 for inclusion in the PR24 business plan, the reasons behind this chosen option are as follows -

1. Highest benefit to cost ratio
2. Lowest CapEx, repeat CapEx and OpEx
3. Resolves current issue of limitations with Empty Bed Contact Time and adsorption capacity of the existing GAC filters.

4.3 Cost efficiency

In this section we give specific details on our approach to costing and benchmarking. Our overarching approach to developing efficient costs is set out in WSH50-IP00 Our Approach to Investment Planning (Sections 4.10 and 7).

The two sub sections below correspond to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.3.

4.3.1 Developing a cost for WTW Interventions

> ***Is it clear how the company has arrived at its option costs? Is there supporting evidence on the calculations and key assumptions used and why these are appropriate? Does the company provide third party assurance for the robustness of the cost estimates?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.3a and A1.1.3c*

We have costed the schemes using our UCD C&CET as described in WSH50-IP00 Our Approach to Investment Planning (Section 4.10)'. This approach utilises like-for-like (top down) costing of process assets and construction related costs to forecast and estimate future project and programme costs.

An individual specific scope was developed for each of the schemes, as part of the optioning process which identified the assets for construction, modification and upgrade along with any site specifics, which formed the basis of our estimates.

Much of the scope is for items of work which has been constructed throughout previous AMPs, and therefore we have a rich source of historical cost data. For these items of work, we have developed cost models based on the most important cost drivers, e.g., the most influential driver to cost for a tank is volume. This costing approach forms the direct works and site-specific costs. We apply construction indirect costs and project oncosts based on the work stream, in this instance this is Water Non-Infrastructure, which applies modelled percentages to the cost of the direct works and site specifics.

The scope is aligned to our Work breakdown Structure (WBS), which was developed to support our data capture process of historical project cost against delivered assets, into a scope input sheet. Within this, sizing of the assets based on the relevant yardstick, which is dictated by the WBS, is provided following calculation in the previous engineering stages. Our costs models are developed in line with our WBS and this allows us to input this information into the C&CET and generate a project estimate. WBS details the inclusions and exclusions of works under each cost model and the limitations of the model, so we can ensure all project costs are captured and there is also no over costing.

The costing was carried out by Welsh Water Costing Team. The Governance procedures, as outlined in WSH50-IP00 Our Approach to Investment Planning (Section 4.10) Costing Methodology were adhered to with the appropriate use of cost models being confirmed and all manual allowances verified prior to providing sign offs throughout the different iterations of the costings.

Along with our overall costing strategy being reviewed and assured by Jacobs, we have also employed third party consultants to review single Enhancement Cases to provide confidence that the estimates within them are robust, efficient and deliverable. Please refer to WSH50-IP00 Our Approach to Investment Planning (Section 6) for more information regarding the review and assurance undertaken.

4.3.2 Benchmarking our approach

> ***Is there evidence that the cost estimates are efficient (for example using similar scheme outturn data, industry and/or external cost benchmarking)?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.3b*

The cost estimates for schemes have been based on Welsh Water's unit cost database and its associated Cost and Carbon tool to generate cost estimates for schemes. The costs generated are based on internal outturn costs collected by Welsh Water as described in WSH50-IP00 Our Approach to Investment Planning (Section 4.10).

4.4 Customer Protection

In this section we set out how oversight will be provided by the DWI on the proposed works.

The sub section below corresponds to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.4. There is no third-party funding for this Enhancement Case.

4.4.1 Providing Customer Protection

> ***Are customers protected (via a price control deliverable or performance commitment) if the investment is cancelled, delayed or reduced in scope?***
> ***Does the protection cover all the benefits proposed to be delivered and funded (e.g. primary and wider benefits)?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.4a and A1.1.4b*

Customers will be protected via two mechanisms:

1. The regulatory oversight from the DWI. The delivery of performance improvement is inherent to the DWI Notices. The legal mechanism within which the DWI will hold the company to account will be in place in accordance with timescales outline by DWI. Failure to meet these targets could result in prosecution, and
2. The existing performances commitment for customer contacts about water quality (and CRI) agreed with and regulated by Ofwat.

Section 2.1 above sets out clear reporting requirements which the DWI have put in place to monitor progress both in terms of programme development and performance improvement.

For the performance commitment Welsh Water will report progress each year through the Annual Performances Report (APR). The common performance commitments include 'Customer contacts about water quality' which will report on the number of consumer contacts per 1,000 population and the Compliance Risk Index (CRI).

The work will deliver resilience and prevent deterioration in the Performances Commitment for CRI

5. Investment Package 5: Customer Acceptability – Manganese at WTW

5.1 Need for Enhancement Investment

This section will set out the drivers behind the Enhancement Case and describe the context within which it has arisen.

We describe the deterioration of raw water quality, the environmental factors (outside of management control) which are driving this and the implication to performance. The need to invest in AMP8 is quantified by presenting the increase in costs and reduction in service which would emerge without action. We set out overlaps with our Base Maintenance programme, which we have examined and removed from the Enhancement Case and give confidence that past allowances have been effectively invested.

The proposed investment aligns with our Long Term Delivery Strategy – responding to the need for long term stewardship and improvement in service. The five sub sections below correspond to the seven criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.1.

5.1.1 Evidence that Enhancement is Needed

> ***Is there evidence that the proposed enhancement investment is required?***
> ***Is the scale and timing of the investment justified?***
> ***Where appropriate, is there evidence that customers support the need for investment?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1a, A1.1.1b and A1.1.1f*

This Enhancement Case is driven by compliance with water quality regulations enforced by the DWI. Regulation 26 compliance, DWI notices and guidance, and reduced customer contacts are the key drivers for this Enhancement Case, and under each driver are various asset specific needs.

The risk is a deterioration of raw water quality related to manganese and the level to which it must now be removed to reduce customer contacts.

Customer contacts are the primary metric to define the acceptability of the water being supplied to customers. Discolouration or taste concerns from customers are a metric against which Welsh Water and other water companies are measured and compared. We are actively trying to reduce the number of customer contacts. There are various root causes which can result in a customer contact, one of which is discolouration of the water.

The causes of discolouration in our distribution system can be due to two principal factors,

- disturbance of internal corrosion of cast iron mains in the network (this need is addressed in CW02 Improving the taste, colour and odour of tap water), and
- the introduction of manganese, organic matter and other metals from the treatment works into the distribution system.

Manganese, organic matter and other material, present in the raw water needs to be effectively removed through the treatment process to prevent a significant proportion entering the treated water network. The effectiveness of the removal process is different for each site dependent upon the degree of raw water loading and the original design of the WTW.

For works constructed in the latter half of the last century, manganese concentrations in final water quality up to the PCV of 50µg/l was acceptable. It is only recently the impacts on downstream discolouration have become fully understood. We now understand and can demonstrate (through our experience and that of other companies) that reducing levels to as low as 1µg/l can continue to impact

performance. The levels of reduction when below 10µg/l show a close to 1:1 relationship, i.e., a 50% reduction in manganese can lead to a 50% reduction in contacts in the downstream system. This holds when all other improvement measures and risk factors (e.g. unlined cast iron mains) remain equal. The most likely mechanism is that particles of manganese, not removed at the works, become embedded within biofilms present on the pipe walls. These biofilms are normally translucent but become darkly colour with the manganese embedded in its layers. When these layers become detached, with flow variations, visible “discolouration” occurs at our customers taps.

Welsh Water has identified a general deterioration in raw water quality driven by climate change. These effects are leading to increasing manganese, iron and organics relative to historical levels. This makes existing processes on WTWs, which target the removal of manganese, iron and organics, less effective which in turn increases the potential for higher concentrations in the final water and downstream network. As raw water continues to deteriorate Welsh Water are looking to improve the understanding of the effect climate change is having and could continue to have in the future. This will also include a more detailed link between manganese concentrations (as one of many contributory factors) and the impacts on customer contacts.

The following graph (Figure 10) illustrates the relationship between manganese in the distribution system (measured at the customer tap) and overall performance for discoloured water (contacts received for brown, black or orange water). As mentioned, due to the deterioration in raw water quality (including manganese) and the gradual decline in effectiveness of our existing treatment processes, there is a general trend across the industry where the higher the manganese concentration in the network as a result, leads to a general elevated contact rate for discolouration. It is clear that this is contributing to the overall performance challenge beyond what asset maintenance may resolve.

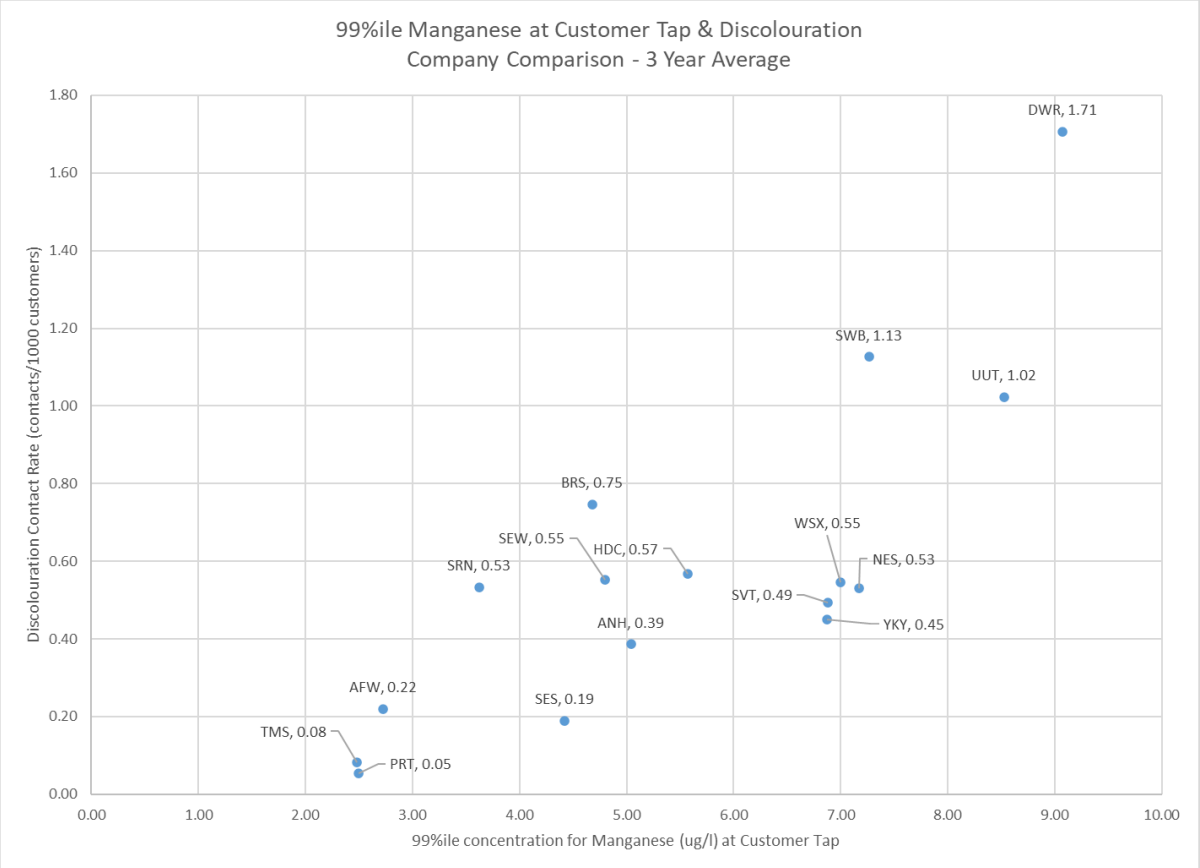

Figure 10: 99%ile Manganese at Customer Tap & Discolouration, Company Comparison (3 year average)

The geology of the west coast of the UK and Wales in particular, have higher instances of manganese deposits in rocks and soils. Under certain conditions, manganese becomes soluble in water. As a result, much of Welsh Water's raw water is higher in manganese than other parts of the UK. Previous investments, in AMP1 and AMP2, installed manganese removal processes to meet the 50µg/L regulatory standard. We now understand that manganese is a direct contributor to water discolouration when it becomes concentrated at pipe walls and is then mobilised during a sudden flow change. Levels as low as 1µg/L can be seen to have a direct correlation with rates of customer contacts for discolouration.

Figure 11 shows a representation of manganese deposits in stream sediments overlaid with water company boundaries (British Geological Survey). The map clearly shows a difference in manganese concentrations in Wales and western areas compared with other regions where many of these streams will directly feed upland reservoirs but also rivers where there are abstractions and interaction with groundwater sources also. This highlights the additional challenge of manganese removal at treatment works in these areas which have shown to have a direct impact on discolouration and acceptability of water.

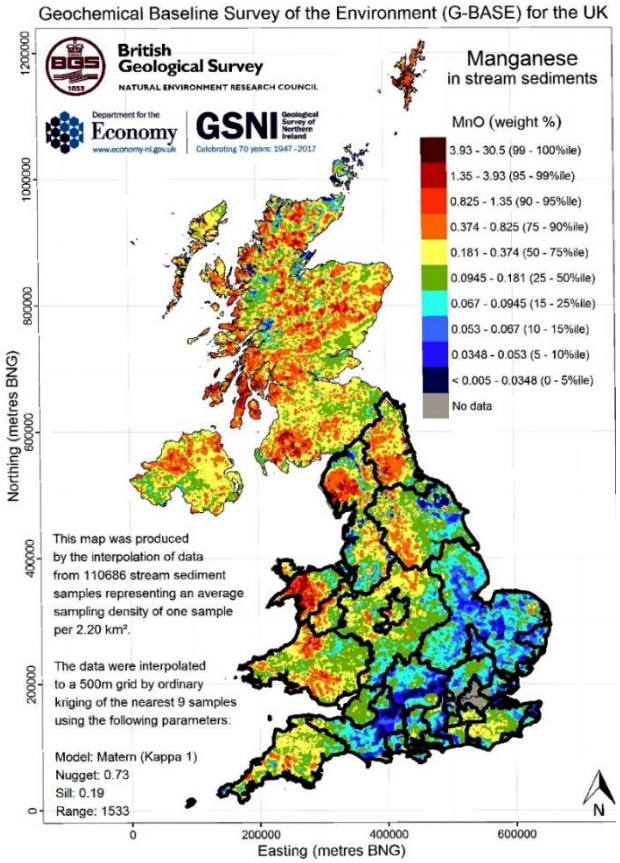

Figure 11: Manganese in Stream Sediments (British Geological Survey) overlaid with water company boundaries

The charts below show the deterioration in raw water manganese as both an average and the 95%ile (which shows the peak levels being experienced).

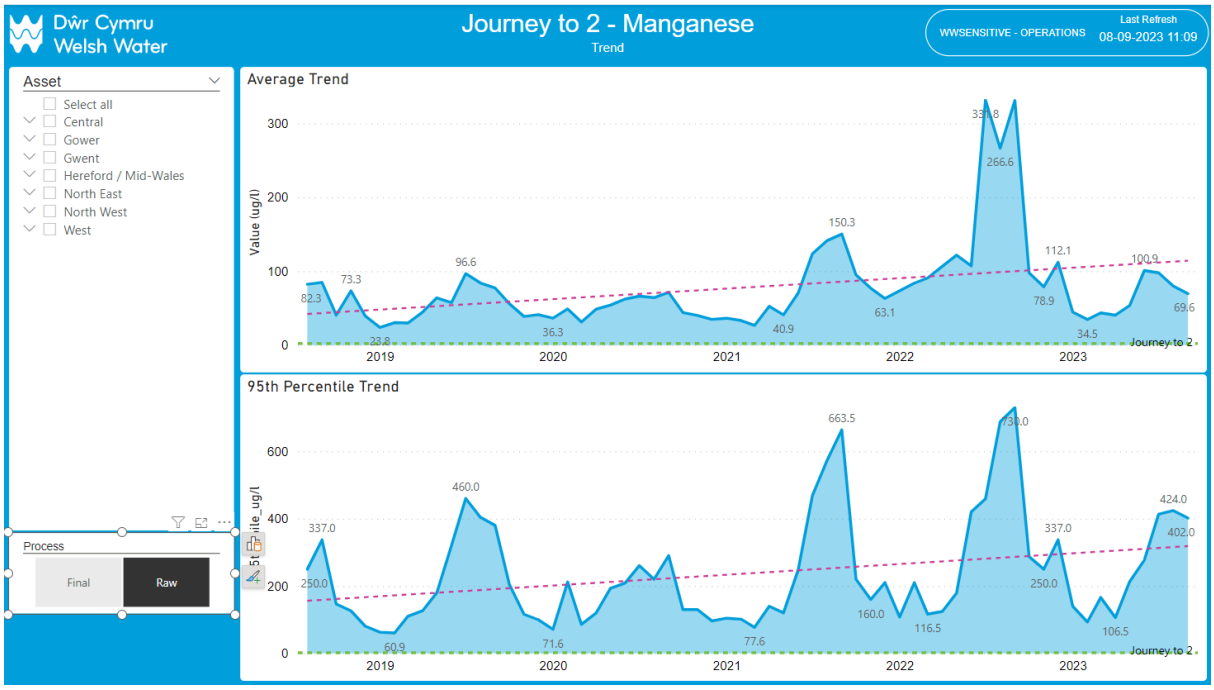

Figure 12: Raw trends for manganese concentrations from WTW final SPN taken on purpose code RP

The benefits of our focus on the maximisation of manganese removal and the installation of additional treatment at some of our treatment works is shown in the final water charts below. This reduction to lowest possible levels is now a requirement of the Discolouration Notice issues in March of this year by the DWI, **reference number DWR-2022-00004**. Performance and optimisation actions need to be reported and evidenced annually.

Our work over the course of AMP6 and AMP7 have reduced manganese levels in our final water as shown below. The average trend is skewed by the change in reporting of the minimum level of detection at the laboratory between mid 2019 and mid 2023. However, there is a clear reduction in the latter part of 2023 in the “average” trend line when compared with 2019. In the “95% percentile” line the progress is even more evident, with the higher peaks being significantly reduced.

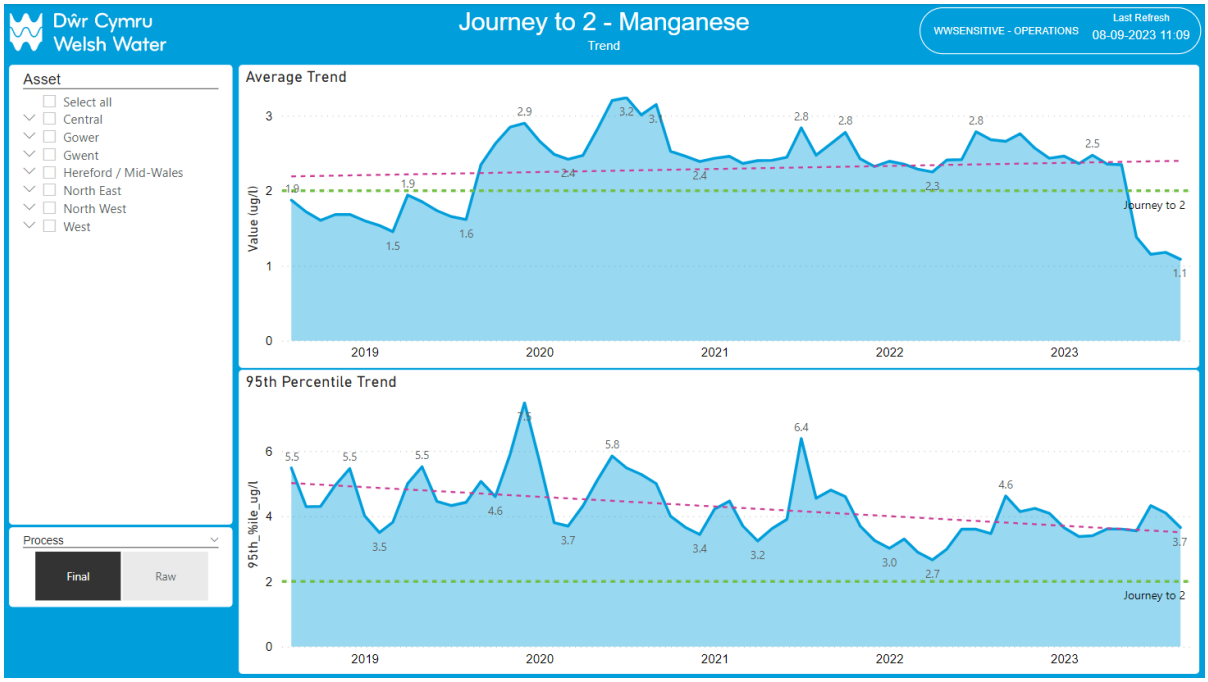

Figure 13: Final trends for manganese concentrations from WTW final SPN taken on purpose codes CP/CV.

Despite this success there remains work to be completed at a number of sites, detailed below, to drive further improvements, from our previous target to 2ug/l to 1ug/l.

The summary of risks that are to be addressed are tabulated below.

Table 25: Description of the hazards, hazardous events, and/or parameters covered by this notice, including the Hazard I D numbers and the description of risks

Description of Risk	Hazard/ Hazardous Event/Parameter
Consumer acceptability (discolouration)	Manganese
Consumer acceptability (discolouration)	Discolouration

The DWI guidance note on Long Term Planning for the Quality of Water (July 2022), Section 6.6.9, states

"The Inspectorate noted that changes in company sampling regimes in 2020 (primarily driven by public health COVID-19 restrictions) highlighted the presence of metals in networks, and this identifies some ongoing challenges associated with treatment works optimisation to reduce concentrations of aluminium, iron and manganese to a minimum in the final water."

The Notice now in place for Acceptability of Water also mandates annual reporting of optimisation of treatment works, feeding zones covered by the Notice, for metals removal.

Following the improvements made with our Journey to 2µg/l in AMP7, we have now updated our target level to 1 µg/l for AMP8, to further minimise customer discolouration and improve overall quality of our final water.

An extensive study into all WTW that are not currently implementing Mn improvements during AMP7 have identified the following sites which require improvement to their final water Mn levels within AMP 8.

Table 26: Sites with highest Mn levels in the treated water (where no intervention in AMP7 is planned)

WTWs	Zonal Contact Rate (Nr/1000 Popu)	Population	Raw Water 95%ile µg/l	Final Water 95%ile (Oct 2020 to Dec 2021) µg/l	Mn Removal Rate (%)
Broomy Hill	3	126,575	227	4.37	95%
Alaw	6	38,425	237	9.40	97%
Cefn Dryscoed	4	44,167	6.04	2.34	79%
Preseli	2	20,371	211	4.68	96%
Maerdy	2	19,462	216	5.69	97%
Pen y Cefn	5	4,995	293	6.59	94%
Garregllwyd	3	6,973	188	2.30	80%
Pendine	3	7,625	2.2	7.18	50%
Strata Florida	1	16,830	25	2.84	96%
Capel Dewi	1	28,812	20.5	3.60	94%
Cefni	2	14,949	33.6	3.80	98%

Snapshots of the several of the above WTW final water manganese concentrations are shown below. Note values are in mg/l therefore target value is 0.001mg/l, indicated by the red lines on the graphics.

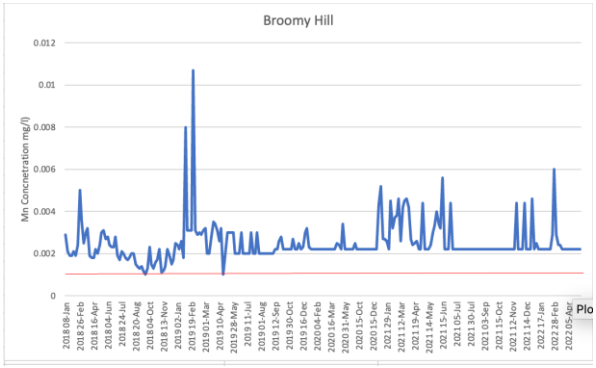

Figure 14: Broomy Hill

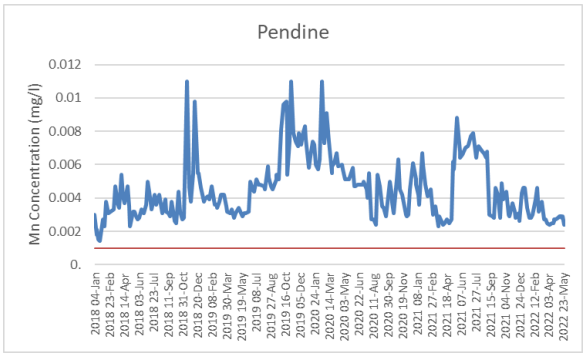

Figure 15: Pendine

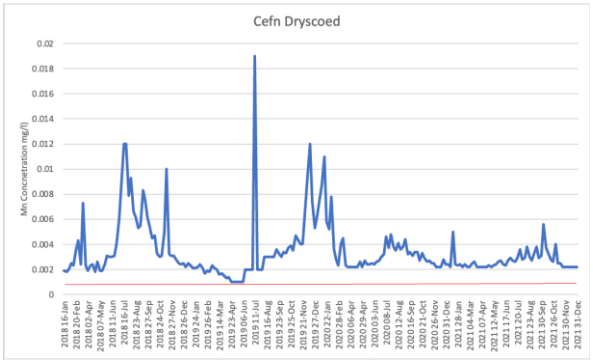

Figure 16: Cefn Dryscoed

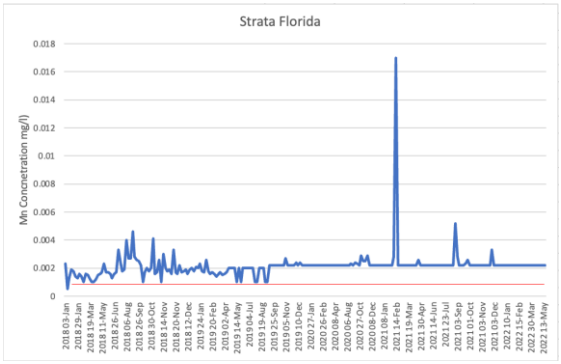

Figure 17: Strata Florida

The list of sites in Table 10 above was generated internally following review of historic issues, current factors that may be temporarily impacting upon performance, and future long term strategic. This provided a priority list of 11 sites where interventions, during AMP 8, to address manganese removal

will be beneficial to achieve 1 µg/l of manganese leaving the WTW. This list will be updated with new data from the recent improvement in the minimum detection limit at the laboratory. We will continue to review this data and refine this list to ensure that we continue to invest in the right areas. It is expected that this journey of manganese reduction will continue into AMP9 and may need to include significant upgrades to large treatment works to reach the lowest possible levels.

Several of our largest sites do not have a dedicated manganese removal stage but have performed well against the target of 2ug/L. The types of work planned within AMP8 include improvements to enhance chemical mixing, enhanced filter flow control, management of supernatant return, moving away from higher Mn lime dosing and cartridge filter removal. All these interventions are being trialled and introduced in AMP7.

5.1.2 Scale and Timing of Investment

The scale of investment and activity has been selected to balance the reduction of the appropriate level of risk, affordability and deliverability in AMP8. We have approached DWI as part of the PR24 process to propose support for 4 schemes within this programme of investment. DWI has indicated an appropriate level of support for this scheme through a Regulation 28 Legal Instrument. The next step will be for Welsh Water to complete the draft copy of the Notice and submit to the DWI within their timeframe. This Notice will outline the actions and the timescales for completion. We will work with DWI to produce the notices for this scheme, with an expected timescale for delivery by the end of AMP8.

The scheme set out in the table below are DWI driven based on observed deterioration in raw water quality and increasing regulatory standards. These will be governed by a legal mechanism with the DWI, building on the DWI published letters of support and will be in place according to timescales outlined by the DWI's PR24 process.

Table 27: DWI Scheme

DWI Scheme Reference:	Project Description	Legal Instrument Required	Timescale	Supporting Documentation
DWR6: Discolouration and consumer acceptability - Discolouration	Manganese at WTW	Regulation 28(4) notice	Within AMP8	PR24 submission, regulation 28(1) risk assessments.

5.1.3 Overlap with Activities to be Delivered through Base

> ***Does the proposed enhancement investment overlap with activities to be delivered through base?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1c*

We have a standard approach for assessing base/enhancements splits set out in a fair regulatory treatment within the WSH50-IP00 Our Approach to Investment Planning (Section 3.4.2).

The existing assets, listed in this investment case, are maintained to ensure compliance with the PCV value of 50 ug/L and to get as close to the current target of 2 ug/l. The requirements to meet the DWI guidance and the 1 µg/l target value are new and further investment for upgraded processes are required to reduce the level of manganese entering our distribution network and minimising the impact this has on discolouration contacts.

5.1.4 Overlap with Funding from Previous Price Reviews

Does the need and/or proposed enhancement investment overlap with activities or service levels already funded at previous price reviews?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.1d

The investments proposed in this case are the result of raw water quality deterioration reaching a critical inflection point. Adherence to newly introduced DWI acceptability of water notices (2023) and have not been funded previously. All these risks will deteriorate through the effects of climate change, the impacts of which are already being felt, with more frequent heavy rainfall and extended hot and dry periods, being experienced more frequently since 2010 beyond the treatment capability of the existing process and impacting customer acceptability.

5.1.5 Alignment with the Long Term Delivery Strategy

Is the need clearly identified in the context of a robust long term delivery strategy within a defined core adaptive pathway?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.1e

Welsh Water have a long term output targeting a CRI score of 0, while this will be practically very difficult, minimising the score each year is of great importance both internally and to our external stakeholders. The quality of final water at our treatment works is a key contributor to achieving this long term ambition.

Welsh Water's core pathway has identified a range of interventions that are required to achieve this ambition. The schemes identified in this Enhancement Case are a key contributor to this. Welsh Water have identified alternative pathways focused on changing legislation, primarily associated with Welsh Government adopting EU drinking water legislation with associated impacts on PFAS removal from treated water and more stringent limits of disinfection byproducts.

Reduction in customer contacts are also a key part of our LTDS where we aim to strive towards improving service by moving away from bottom of the league table in AMP7 to upper quartile or industry leading by 2050 through our approach of strategic interventions using a source to tap approach.

Further details can be seen in WSH01 Long Term Delivery Strategy.

5.1.6 Evidence of Customer Support

Our approach to customer engagement is set out in Stepping up to the Challenge: Business Plan 2025-30 (Section 2.2).
Customers are generally supportive of investment to improve water quality.

5.1.7 Management Control of Costs

Is the investment driven by factors outside of management control? Is it clear that steps been taken to control costs and have potential cost savings been accounted for?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.1g

The factors that are driving these Enhancement Cases that are outside of management control are raw water deterioration (increased Mn) linked to climate change that was not addressed in previous AMPs.

We have identified that manganese and organic matter in raw water is deteriorating across the majority of our sources. Although our treatment works have the capability to treat these parameters so that there is no impact on regulatory compliance, many of our treatment works are ineffective at consistent removal of these parameters to the very low levels required to minimise impact on

discolouration. As some sites do not have dedicated removal stages for manganese, any optimization is a compromise with removal of other parameters. Although we have optimised treatment processes at all of our treatment works, where we have identified the impact of elevated concentrations of manganese, treatment processes continue to be challenged considering the deterioration of raw water quality. As a result, we require investment to improve the treatment processes, beyond what is achievable now at the highest risk sites, to ensure sufficient removal of manganese to reduce the impact on customers from discoloured water.

5.2 Best Option for Customers

Our overarching approach is described in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

The three sub sections below correspond to the eight criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.2.

5.2.1 Identification of Solution Options

> ***Has the company considered an appropriate number of options over a range of intervention types to meet the identified need?***
> ***Is there evidence that the proposed solution represents best value for customers, communities, and the environment over the long term?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2a and A1.1.2b*

A longlist of possible interventions that could reduce the impact of raw water deterioration was developed. These possibilities were reviewed by an experienced panel during a 'longlist workshop' to eliminate the options that:

- will not give sufficient improvement,
- have been tried previously and have not been successful,
- experience elsewhere has shown to be poor, providing little benefit.

The options developed for each of the investment schemes in this section are as follows:

The Options solutions considered for manganese reductions will be site specific but will be selected from the following list -

- Improved chemical mixing to enhance the manganese removed during primary coagulation and filtration process.
- Upgrading filter flow control to minimise manganese passing through filters (both primary and secondary)
- Reducing use of lime at final water dosing points at this contributed manganese through impurities with no possibility to remove again downstream of dosing
- Use of cartridge filters to remove manganese that passes through upstream processes.

Table 28: Longlist of possible interventions

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e., progress to shortlisting?
1	**Eliminating, reducing or delaying the need for change:** Manage demand	**Not Viable –** The sites identified for investment are strategically critical where clean water tankering or an alternative source is not a long term sustainable approach.	✗

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e., progress to shortlisting?
2	**Eliminating, reducing or delaying the need for change:** *Manage operation or use of the existing asset or service*	**Not Viable –** The existing assets have been optimised over the last 5 years in response to changeable raw water quality and expectations set out in our water quality strategy. However, we consider that there is a threshold as to how much optimisation can achieve and therefore identified that we cannot now improve performance of the asset in response to ongoing raw water deterioration.	✗
3	**Eliminating, reducing or delaying the need for change:** *Maintain the existing asset or service*	**Not Viable** – We will continue to maintain the existing assets along with any additional assets we install to meet the performance improvements. However, additional maintenance of the existing assets will not improve performance over the current level of maintenance.	✗
4	**Maintaining the effective risk controls already in place:** *Replace the existing asset like-for-like*	**Not Viable –** Replacement of the existing assets with a like for like replacement would not improve performance given the identified risk. Any like for like replacement would still require additional investment to improve performance.	✗
5a	**Enhancing existing or adding new resources:** ***Improve chemical mixing and use of chemical***	Improved chemical mixing to enhance the manganese removed during primary coagulation and filtration process. Reducing use of lime at final water dosing points at this contributed manganese through impurities with no possibility to remove again downstream of dosing	✓
5b	**Enhancing existing or adding new resources:** ***Upgrading filter flow control***	Upgrading filter flow control to minimise manganese passing through filters (both primary and secondary). This will include control system enhancements to improve filter performance.	✓
5c	**Enhancing existing or adding new resources:** Use of cartridge filters	Use of cartridge filters to remove manganese that passes through upstream processes. This solution is more appropriate on smaller more discreet treatment works due to the constraints on footprint on some of the larger sites identified in this programme.	✓

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e., progress to shortlisting?
5d	**Enhancing existing or adding new resources:** Replacement of filter media	Replacement of filter media ahead of maintenance thresholds due to saturation with oxidised manganese. Filter media is being exhausted at a much quicker rate due to deterioration in raw water quality resulting in a deterioration in performance. Filter media replacement for this solution would be replaced more frequently than we would ordinarily do so considering the deterioration of raw water quality.	✓
6	**Maintaining the effective risk controls already in place:** *Mothball/dispose of the existing asset or service*	**Not Viable** – The assets we have identified are strategically important assets which cannot be disposed of. A solution is required at each of the sites in order to reduce the heightened risk	✗

5.2.2 Assessment and Selection of Solution Options

Our approach to cost benefit appraisal and its role in decision making is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

The table below has been completed using data from our cost benefit spreadsheets to illustrate the value generated by the proposed investment (All monetary values are expressed in 2022/23 prices and are prior to portfolio adjustments for corporate overheads and efficiency challenge. Welsh Water ref: SMF version 5).

Table 29: Process Optimisation

Solution Option	Option Name	CapEx	Present Value Whole Life Costs (WLC)	Present Value Whole Life Benefits (WLB)	Benefit/ Cost Ratio	Net Present Value (=WLB - WLC)
Option S1	Optimisation of Process	£5.346M	£4.984M	£30.950M	6.210	£25.966M
Option S2	Media Replacement & Optimisation	£15.694M	£24.057M	£30.950M	1.287	£6.894M

The CBA analysis for the 6 WTW where cartridge filters was deemed unsuitable to the physical footprint of the solution indicates that optimisation of the existing process through the enhancement of filter operation, and chemical control. Option S1 has been deemed significantly more cost beneficial than media replacement of existing filters coupled with optimisation mostly sue to the significantly lower CapEx cost compared to the same risk reduction. Although option S2 may be required in the future, due to the current understanding that both these options will reduce risk sufficiently, Option S2 was discounted due to the lower cost benefit ratio.

Table 30: Cartridge Filters

Solution Option	Option Name	CapEx	Present Value Whole Life Costs (WLC)	Present Value Whole Life Benefits (WLB)	Benefit/ Cost Ratio	Net Present Value (=WLB - WLC)
Option S1	Filter Install at 4 WTWs	£3.053M	£7.453M	£7.060M	0.947	-£0.394M

The CBA analysis for cartridge filter installation at 4 WTWs has been chosen due to the smaller size of each of these sites and the smaller footprint of a such a solution compared to the 6 larger sites where an alternative option was considered. The cartridge filter approach has been deemed appropriate to reduce the risk sufficiently at these sites for a relatively low CapEx cost compared with a more significant complex and expensive solution.

5.2.3 Quantification of Benefits

Has the company fully considered the carbon impact, natural capital and other benefits that the options can deliver?
Has the impact (incremental improvement) of the proposed option on the identified need been quantified, including the impact on performance commitments where applicable?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.2c and A1.1.2d

The benefits of a scheme have been calculated by our asset planning and engineering teams based on the best available information and have been used to forecast the impact a scheme will have on service measures in comparison to the pre investment position/do nothing position.

Benefits are quantified against our service measure framework (SMF) meaning they are well understood and trackable through regular business activity. For more detail on this approach see WSH50-IP00 Our Approach to Investment Planning (Section 5.4). We have included an excerpt from the SMF in section 1.2.3 showing the categories of benefit that roll up to the Ofwat drivers identified as part of the overall case. The table below shows how we have apportioned the benefits, with improved drinking water quality carrying the largest weight.

5.2.4 Quantifying the Impact on Need and Performance Commitments

The identified schemes will resolve the issues raised with the DWI. The proposed work has been discussed with the quality regulator and they are supportive of the activities proposed.

The schemes will impact on the resilience of performances against the CRI. They will reduce the likelihood of performances deterioration, but not in a way which is visible to the measure.

From our analysis the proposed option will make the following impacts:

We have assessed the impact of enhancement on CRI, ERI and Acceptability of Water performance commitments

- Improve acceptability of water by reducing the final water Manganese concentration at 10 sites.

5.2.5 Uncertainties relating to cost and benefit delivery

> ***Have the uncertainties relating to costs and benefit delivery been explored and mitigated? Have flexible, lower risk and modular solutions been assessed – including where forecast option utilisation will be low?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2e*

Our methodology is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3). This includes commentary on our approach to optioneering, costing and cost benefit analysis.

For this Enhancement Case we have evaluated a wide range of options in line with our TotEx hierarchy approach. We have aimed to balance most efficient solution with risk and innovation in all instances.

5.3 Cost efficiency

In this section we give specific details on our approach to costing and benchmarking. Our overarching approach to developing efficient costs is set out in WSH50-IP00 Our Approach to Investment Planning (Sections 4.10 and 7).

The two sub sections below correspond to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.3.

5.3.1 Developing a cost for WTW Interventions

> ***Is it clear how the company has arrived at its option costs? Is there supporting evidence on the calculations and key assumptions used and why these are appropriate? Does the company provide third party assurance for the robustness of the cost estimates?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.3a and A1.1.3c*

We have costed the schemes using our UCD C&CET as described in WSH50-IP00 Our Approach to Investment Planning (Section 4.10). This approach utilises like-for-like (top down) costing of process assets and construction related costs to forecast and estimate future project and programme costs.

An individual specific scope was developed for each of the schemes, as part of the optioning process which identified the assets for construction, modification and upgrade along with any site specifics, which formed the basis of our estimates.

Much of the scope is for items of work which has been constructed throughout previous AMPs, and therefore we have a rich source of historical cost data. For these items of work, we have developed cost models based on the most important cost drivers, e.g., the most influential driver to cost for a tank is volume. This costing approach forms the direct works and site-specific costs. We apply construction indirect costs and project oncosts based on the work stream, in this instance this is Water Non-Infrastructure, which applies modelled percentages to the cost of the direct works and site specifics.

The scope is aligned to our Work breakdown Structure (WBS), which was developed to support our data capture process of historical project cost against delivered assets, into a scope input sheet. Within this, sizing of the assets based on the relevant yardstick, which is dictated by the WBS, is provided following calculation in the previous engineering stages. Our costs models are developed in line with our WBS and this allows us to input this information into the C&CET and generate a project estimate. WBS details the inclusions and exclusions of works under each cost model and the limitations of the model, so we can ensure all project costs are captured and there is also no over costing.

The costing was carried out by Welsh Water Costing Team. The Governance procedures, as outlined in Section 5 Costing Methodology were adhered to with the appropriate use of cost models being confirmed and all manual allowances verified prior to providing sign offs throughout the different iterations of the costings.

Along with our overall costing strategy being reviewed and assured by Jacobs, we have also employed third party consultants to review single Enhancement Cases to provide confidence that the estimates within them are robust, efficient and deliverable. Please refer to WSH50-IP00 Our Approach to Investment Planning (Section 6) for more information regarding the review and assurance undertaken.

5.3.2 Benchmarking our approach

> ***Is there evidence that the cost estimates are efficient (for example using similar scheme outturn data, industry and/or external cost benchmarking)?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.3b*

We have undertaken benchmarking for our manganese programme.

Manganese Filters & WTW optimisation for manganese

To provide cost assurance of the manganese removal programme a benchmark exercise of the CapEx output was undertaken by an independent agency. All the options for manganese removal were benchmarked to provide confidence in our costing approach for schemes and a Cost Envelope was produced for our preferred solutions taken forward.

The benchmarking exercise identified that out pre-efficiency costing was in line with the industry, being within the benchmark range and 7.6% above the average.

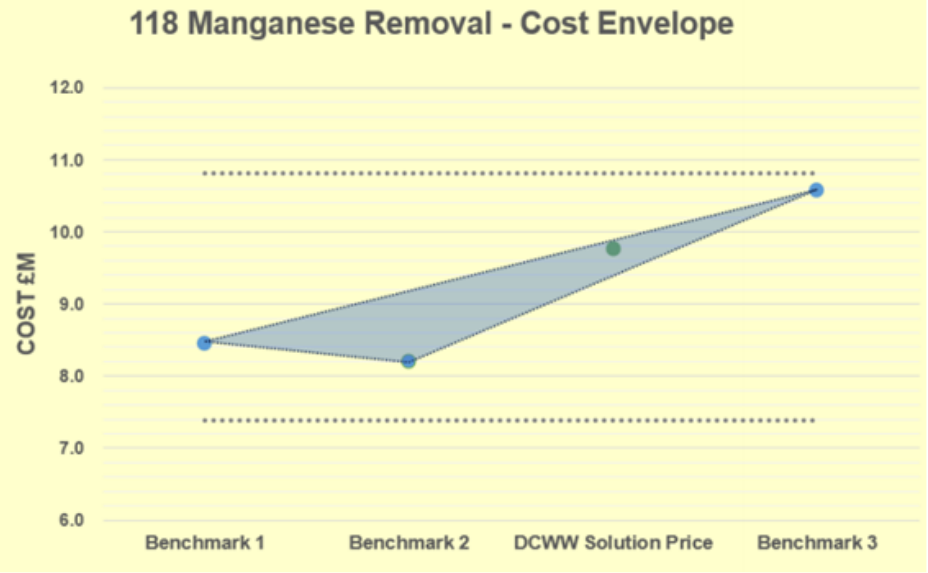

Figure 18: Extract from the Manganese Removal Benchmarking

In this instance the benchmarking work which was undertaken by independent consultants provided review and challenge of the costs put forward. Any costs which were derived from the UCD have also been through the internal assurance process that determines their accuracy and relative efficiency.

The cost estimates for schemes have been based on Welsh Water's unit cost database and its associated Cost and Carbon tool to generate cost estimates for schemes. The costs generated are based on internal outturn costs collected by Welsh Water as described in WSH50-IP00 Our Approach to Investment Planning (Section 4.10).

5.4 Customer Protection

In this section we set out how oversight will be provided by the DWI on the proposed works.

The sub section below corresponds to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.4. There is no third-party funding for this Enhancement Case.

5.4.1 Providing Customer Protection

> ***Are customers protected (via a price control deliverable or performance commitment) if the investment is cancelled, delayed or reduced in scope?***
> ***Does the protection cover all the benefits proposed to be delivered and funded (e.g. primary and wider benefits)?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.4a and A1.1.4b*

Customers will be protected via two mechanisms:

1. The regulatory oversight from the DWI. The delivery of performance improvement is inherent to the DWI Notices. The legal mechanism within which the DWI will hold the company to account will be in place in accordance with timescales outline by DWI. Failure to meet these targets could result in prosecution, and
2. The existing performances commitment for customer contacts about water quality (and CRI) agreed with and regulated by Ofwat.

Section 5.1 above sets out clear reporting requirements which the DWI have put in place to monitor progress both in terms of programme development and performance improvement.

For the performance commitment Welsh Water will report progress each year through the Annual Performances Report (APR). The common performance commitments include 'Customer contacts about water quality' which will report on the number of consumer contacts per 1,000 population and the Compliance Risk Index (CRI).

The work will deliver resilience and prevent deterioration in the Performances Commitment for CRI

We have forecast an improvement of 0.08 contacts against the Performances Commitment for customer contacts for water quality driven by the work in this programme. This benefit when combined with that in Enhancement Case CW02 will deliver the step change in contacts we have committed to.

6. Investment Package 6: Raw Water Deterioration at Bontgoch

6.1 Need for Enhancement Investment

This section will set out the drivers behind the Enhancement Case and describe the context within which it has arisen.

We describe the deterioration of raw water quality, the environmental factors (outside of management control) which are driving this and the implication to performance. The need to invest in AMP8 is quantified by presenting the increase in costs and reduction in service which would emerge without action. We set out overlaps with our Base Maintenance programme, which we have examined and removed from the Enhancement Case and give confidence that past allowances have been effectively invested.

The proposed investment aligns with our Long Term Delivery Strategy – responding to the need for long term stewardship and improvement in service. The five sub sections below correspond to the seven criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.1.

6.1.1 Evidence that Enhancement is Needed

> ***Is there evidence that the proposed enhancement investment is required?***
> ***Is the scale and timing of the investment justified?***
> ***Where appropriate, is there evidence that customers support the need for investment?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1a, A1.1.1b and A1.1.1f*

This Enhancement Case is driven by compliance with water quality regulations enforced by the DWI. Regulation 26 compliance, DWI notices and guidance, and reduced customer contacts are the key drivers for this Enhancement Case, and under each driver are various asset specific needs.

The risk is related to deterioration of raw water quality for coagulated water solids loading,

A recent study has investigated the capability of individual processes at all treatment works to meet in house engineering standards (using industry-recognised best practice) based on current raw water performance and future deterioration, while also accounting for the impact of climate change. The study has specifically focussed on an assessment of raw water solids loading (including coagulant dose) on primary treatment processes, taking account of the coagulant type and process type specific to each individual site considering the type of treatment process and coagulant that is used.

The output of the study based on recent modelled data shows that raw water solids (mg/l) at Bontgoch are currently close to the recommended standard (20 mg/l) for the type of primary treatment process (in this case, Direct Filtration).

The model proceeds further to assess the impact of a 1/200 year drought event at the reservoirs that support Bontgoch and illustrates that, for a short period, solids would increase by as much as 1.5 times the predicted increase in response to climate change over the next six investment periods. This would mean that the filters would become increasing overloaded impacting on their ability to operate.

6.1.2 Scale and Timing of Investment

The scale of investment and activity has been selected to balance the reduction of the appropriate level of risk, affordability and deliverability in AMP8.

6.1.3 Overlap with Activities to be Delivered through Base

> ***Does the proposed enhancement investment overlap with activities to be delivered through base?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1c*

We have a standard approach for assessing base/enhancements splits set out in a fair regulatory treatment within the WSH50-IP00 Our Approach to Investment Planning (Section 3.4.2).

The options that were put forward to shortlisting, and the option that was ultimately recommended all require new infrastructure and are not part of base in response to raw water deterioration.

6.1.4 Overlap with Funding from Previous Price Reviews

The investment proposed in this case is the result of raw water quality deterioration reaching a critical inflection point. While funding has been provided in the past for treatment at Bontgoch, the unprecedented deterioration we have seen since 2010 will take this process beyond the treatment capability of the installed process.

The risk will deteriorate through the effects of climate change, the impacts of which are already being felt, with more frequent heavy rainfall and extended hot and dry periods, being experienced more frequently since 2010. We are planning to invest to further enhance the capability of the existing asset in AMP8 to allow it to continue to perform in response to raw water deterioration until at least AMP9 or later where more significant investment may be required in response to forecast further raw water deterioration.

6.1.5 Alignment with the Long Term Delivery Strategy

> ***Is the need clearly identified in the context of a robust long term delivery strategy within a defined core adaptive pathway?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1e*

Welsh Water have a long term output targeting a CRI score of 0, while this will be practically very difficult, minimising the score each year is of great importance both internally and to our external stakeholders. The quality of final water at our treatment works is a key contributor to achieving this long term ambition.

Welsh Water's core pathway has identified a range of interventions that are required to achieve this ambition.

The schemes identified in this Enhancement Case are a key contributor to this. Welsh Water have identified alternative pathways focused on changing legislation, primarily associated with Welsh Government adopting EU drinking water legislation along with forecasts of raw water deterioration and their impact on our asset's treatment capabilities.

Further details can be seen in WSH01 Long Term Delivery Strategy.

6.1.6 Evidence of Customer Support

Our approach to customer engagement is set out in Stepping up to the Challenge: Business Plan 2025-30 (Section 2.2).

Customers are generally supportive of investment to improve water quality.

6.1.7 Management Control of Costs

Is the investment driven by factors outside of management control? Is it clear that steps been taken to control costs and have potential cost savings been accounted for?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.1g

The factors that are driving these Enhancement Cases that are outside of management control are raw water deterioration (additional solids loadings) linked to climate change and were not addressed in previous AMPs.

Optimisation has been undertaken at the existing site over recent years but the limitations of the existing installed processes do not allow and further improvements and the risk remains. We have forecasted raw water deterioration to continue in the future and will need to invest in an enhancement scheme in order to secure the long term delivery of water treatment at this location.

6.2 Best Option for Customers

Our overarching approach is described in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

The three sub sections below correspond to the eight criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.2.

6.2.1 Identification of Solution Options

Has the company considered an appropriate number of options over a range of intervention types to meet the identified need?
Is there evidence that the proposed solution represents best value for customers, communities, and the environment over the long term?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.2a and A1.1.2b

A longlist of possible interventions that could reduce the impact of raw water deterioration was developed. These possibilities were reviewed by an experienced panel during a 'longlist workshop' to eliminate the options that:

- will not give sufficient improvement,
- have been tried previously and have not been successful,
- experience elsewhere has shown to be poor, providing little benefit.

The options developed for each of the investment schemes in this section are as follows:

We have considered a number of options to reduce the risk at Bontgoch which are summarised in the following table -

Table 31: Long list of options considered for Bontgoch

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
1	**Eliminating, reducing or delaying the need for change:** Manage demand	**Not viable.** 'Demand' management alone will not address this issue. The customer metering and leakage strategies will address the need to minimise customer demand.	✗

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
2	**Eliminating, reducing or delaying the need for change:** Maintain the existing asset or service	**Not viable.** The existing assets have already been optimised and an enhancement is now required.	✗
3	**Eliminating, reducing or delaying the need for change:** Replace the existing asset like-for-like	**Not viable.** The existing assets have already been optimised and an enhancement is now required.	✗
4	**Eliminating, reducing or delaying the need for change:** Mothball/dispose of the existing asset or service	**Not viable.** Providing this service is a statutory requirement and the site cannot be removed from service.	✗
5	***Manage operation or use of the existing asset or service*** Catchment Solution	**Not Viable** – This solution will not resolve deteriorating levels of turbidity and colour within the raw water and although part of an overall approach to raw water quality management does not provide the long term solution for this issue.	✗
6a	***Enhance/upgrade the existing asset or service*** New Dissolved Air Flotation Plant	To replace existing primary filters with new DAF units with associated pumps and pipework in order to cope with potential increases in solids loading. New pumps for feeding existing 2nd stage filters are also included in the scope as the new DAF will break the existing pressurised supply to the 2nd stage filters. Decommissioning the existing 3rd stage filters because they would not provide process benefit to the works but would create extra maintenance costs and unnecessarily take extra dirty backwash water holding/treatment capacity.	✓
6b	***Enhance/upgrade the existing asset or service*** New Lamella Clarifier	**Not viable -** To replace existing primary filters with new Lamella Clarifiers. High cost and no immediate need for of additional benefit from this solution.	✗
6c	***Enhance/upgrade the existing asset or service*** New Ceramic Membrane Plant	**Not viable -** To replace existing primary filters with new ceramic membrane filters provided by PWNT. High cost and unfamiliar process technology for WELSH WATER.	✗

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
6d	***Enhance/upgrade the existing asset or service*** Expand and refurbish existing primary filters	To install internal dirty washwater exit launder and top-up sand media for each of the primary filters. Add another five primary filters (with associated pumps and pipework) for the future increase in total solids loading. Jar testing of coagulants and potential acid dosing system, as well as decommissioning of the existing 3rd stage filters are included in the scope. This option would present an opportunity for phased implementation/expenditure across multiple AMPs.	✓
7	***Create/acquire a new asset or service***	**Not Viable.** Included within Options 2 and 5 above.	✗

6.2.2 Assessment and Selection of Solution Options

Our approach to cost benefit appraisal and its role in decision making is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

The table below has been completed using data from our cost benefit spreadsheets to illustrate the value generated by the proposed investment (All monetary values are expressed in 2022/23 prices and are prior to portfolio adjustments for corporate overheads and efficiency challenge. Welsh Water ref: SMF version 5).

Table 32: Value generated by the proposed investment options

Solution Option	Option Name	CapEx	Present Value Whole Life Costs (WLC)	Present Value Whole Life Benefits (WLB)	Benefit/ Cost Ratio	Net Present Value (=WLB - WLC)
Option S1	Enhancement of Primary Filters	£0.466M	£1.897M	£4.296M	2.264	£2.399M
Option S2	Expansion and Enhancement of Primary Filters.	£4.608M	£10.310M	£1.942M	0.188	-£8.368M
Option S3	New DAF plant located within existing WTW works boundary	£4.404M	£7.731M	£2.866M	0.371	-£4.866M

Based on our CBA analysis Option S1 was recommended for implementation. S1 was selected as it addresses the risk of mitigating the increase in raw water deterioration while using a phased approach to reduce the risk where further investment may be required in the future. The alternative options, although may be required in the future were not cost beneficial or affordable due to the significant CapEx cost compared with the risk reduction of Option 1.

6.2.3 Quantification of Benefits

Has the company fully considered the carbon impact, natural capital and other benefits that the options can deliver?
Has the impact (incremental improvement) of the proposed option on the identified need been quantified, including the impact on performance commitments where applicable?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.2c and A1.1.2d

The benefits of a scheme have been calculated by our asset planning and engineering teams based on the best available information and have been used to forecast the impact a scheme will have on service measures in comparison to the pre investment position/do nothing position.

Benefits are quantified against our service measure framework (SMF) meaning they are well understood and trackable through regular business activity. For more detail on this approach see WSH50-IP00 Our Approach to Investment Planning (Section 5.4). We have included an excerpt from the SMF in section 1.2.3 showing the categories of benefit that roll up to the Ofwat drivers identified as part of the overall case. The table below shows how we have apportioned the benefits, with improved drinking water quality carrying the largest weight.

6.2.4 Quantifying the Impact on Need and Performance Commitments

The identified schemes will resolve the issues raised by the DWI. The proposed work has been discussed with the quality regulator and they are supportive of the activities proposed.

The schemes will impact on the resilience of performances against the CRI. They will reduce the likelihood of performances deterioration, but not in a way which is visible to the measure.

From our analysis the proposed option will make the following impacts:

We have assessed the impact of enhancement on CRI, ERI and Acceptability of Water performance commitments

- Reduces the risk of an impact on CRI following the inability to treat water sufficiently.

6.2.5 Uncertainties relating to cost and benefit delivery

Have the uncertainties relating to costs and benefit delivery been explored and mitigated? Have flexible, lower risk and modular solutions been assessed – including where forecast option utilisation will be low?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.2e

Our methodology is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3). This includes commentary on our approach to optioneering, costing and cost benefit analysis.

For this Enhancement Case we have evaluated a wide range of options in line with our TotEx hierarchy approach. We have aimed to balance most efficient solution with risk and innovation in all instances.

Option 6d –

This option involves:

1. Open each of the primary filters to install a dirty backwash water exit launder and top up filter media
2. Decommission the existing 3rd stage filters
3. Jar testing of coagulants and potential acid dosing system to be added

Table 33: Advantages and disadvantages of Option 6d

Advantages	Disadvantages
Lower cost Best use of existing assets Enhanced resilience against climate change by provision of additional filter capacity Phased implementation to allow a refined decision on future investment	Interrupted operation during refurbishment Risk this solution does not completely resolve the risk based on forecasts of raw water deterioration

Chosen Option

The chosen option for this scheme is Option 6d for inclusion in the PR24 business plan, the reasons behind this chosen option are as follows -

1. Highest benefit to cost ratio
2. Lowest CapEx, repeat CapEx and OpEx
3. Partially resolves risk from raw water deterioration and ineffectiveness of existing treatment process
4. Allows a phased approach should further investment be required in the future if raw water deterioration continues on forecasted trajectory.

6.3 Cost efficiency

In this section we give specific details on our approach to costing and benchmarking. Our overarching approach to developing efficient costs is set out in WSH50-IP00 Our Approach to Investment Planning (Sections 4.10 and 7).

The two sub sections below correspond to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.3.

6.3.1 Developing a cost for WTW Interventions

> ***Is it clear how the company has arrived at its option costs? Is there supporting evidence on the calculations and key assumptions used and why these are appropriate? Does the company provide third party assurance for the robustness of the cost estimates?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.3a and A1.1.3c*

We have costed the schemes using our UCD C&CET as described in WSH50-IP00 Our Approach to Investment Planning (Section 4.10). This approach utilises like-for-like (top down) costing of process assets and construction related costs to forecast and estimate future project and programme costs.

An individual specific scope was developed for each of the schemes, as part of the optioning process which identified the assets for construction, modification and upgrade along with any site specifics, which formed the basis of our estimates.

Much of the scope is for items of work which has been constructed throughout previous AMPs, and therefore we have a rich source of historical cost data. For these items of work we have developed cost models based on the most important cost drivers, e.g., the most influential driver to cost for a tank is volume. This costing approach forms the direct works and site-specific costs. We apply construction indirect costs and project oncosts based on the work stream, in this instance this is

Water Non-Infrastructure, which applies modelled percentages to the cost of the direct works and site specifics.

The scope is aligned to our Work breakdown Structure (WBS), which was developed to support our data capture process of historical project cost against delivered assets, into a scope input sheet. Within this, sizing of the assets based on the relevant yardstick, which is dictated by the WBS, is provided following calculation in the previous engineering stages. Our costs models are developed in line with our WBS and this allows us to input this information into the C&CET and generate a project estimate. WBS details the inclusions and exclusions of works under each cost model and the limitations of the model, so we can ensure all project costs are captured and there is also no over costing.

The costing was carried out by Welsh Water Costing Team. The Governance procedures, as outlined in Section 5 Costing Methodology were adhered to with the appropriate use of cost models being confirmed and all manual allowances verified prior to providing sign offs throughout the different iterations of the costings.

Along with our overall costing strategy being reviewed and assured by Jacobs, we have also employed third party consultants to review single Enhancement Cases to provide confidence that the estimates within them are robust, efficient and deliverable. Please refer to WSH50-IP00 Our Approach to Investment Planning (Section 6) for more information regarding the review and assurance undertaken.

6.3.2 Benchmarking our approach

Is there evidence that the cost estimates are efficient (for example using similar scheme outturn data, industry and/or external cost benchmarking)?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.3b

The cost estimates for schemes have been based on Welsh Water's unit cost database and its associated Cost and Carbon tool to generate cost estimates for schemes. The costs generated are based on internal outturn costs collected by Welsh Water as described in WSH50-IP00 Our Approach to Investment Planning (Section 4.10).

6.4 Customer Protection

In this section we set out how oversight will be provided by the DWI on the proposed works.

The sub section below corresponds to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.4. There is no third-party funding for this Enhancement Case.

6.4.1 Providing Customer Protection

Are customers protected (via a price control deliverable or performance commitment) if the investment is cancelled, delayed or reduced in scope?
Does the protection cover all the benefits proposed to be delivered and funded (e.g. primary and wider benefits)?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.4a and A1.1.4b

Customers will be protected via two mechanisms:

1. The regulatory oversight from the DWI. The delivery of performance improvement is inherent to the DWI Notices. The legal mechanism within which the DWI will hold the company to account will be in place in accordance with timescales outline by DWI. Failure to meet these targets could result in prosecution, and

2. The existing performances commitment for customer contacts about water quality (and CRI) agreed with and regulated by Ofwat.

Section 6.1 above sets out clear reporting requirements which the DWI have put in place to monitor progress both in terms of programme development and performance improvement.

For the performance commitment Welsh Water will report progress each year through the Annual Performances Report (APR). The common performance commitments include 'Customer contacts about water quality' which will report on the number of consumer contacts per 1,000 population and the Compliance Risk Index (CRI).

The work will deliver resilience and prevent deterioration in the Performances Commitment for CRI

7. Investment Package 7: Raw Water Deterioration at Pendine

7.1 Need for Enhancement Investment

This section will set out the drivers behind the Enhancement Case and describe the context within which it has arisen.

We describe the deterioration of raw water quality, the environmental factors (outside of management control) which are driving this and the implication to performance. The need to invest in AMP8 is quantified by presenting the increase in costs and reduction in service which would emerge without action. We set out overlaps with our Base Maintenance programme, which we have examined and removed from the Enhancement Case and give confidence that past allowances have been effectively invested.

The proposed investment aligns with our Long Term Delivery Strategy – responding to the need for long term stewardship and improvement in service. The five sub sections below correspond to the seven criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.1.

7.1.1 Evidence that Enhancement is Needed

> ***Is there evidence that the proposed enhancement investment is required?***
> ***Is the scale and timing of the investment justified?***
> ***Where appropriate, is there evidence that customers support the need for investment?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1a, A1.1.1b and A1.1.1f*

This investment package is driven by compliance with water quality regulations enforced by the DWI. Raw water deterioration, the existing assets treatment capability and to a related extent, coastal erosion are the key drivers for this Enhancement Case.

The overall risks is related to deterioration of raw water quality for coagulated water solids loading beyond our the treatment capability of the existing asset.

The analysis shows that there is raw water deterioration in Morfa Bychan borehole (Turbidity and E-Coli). The severity and frequency of poor raw water quality is increasing. The Morfa Bychan catchment is in a carboniferous limestone area, with a large number of sink holes and streams. The root cause of the raw water deterioration is due to run-off from the surrounding farmland and forestry following rainfall events washing into the various sink holes which then impacts on the quality of the water in the aquifer.

The borehole pumps water into a raw water reservoir (approximately twice a day). This, in turn, feeds Pendine WTW. When the turbidity of the water reaches a certain level, the borehole pumps stop. Pendine ultimately has to shut down if the turbidity level is above this level for more than a few hours. While there are various network mitigations to sustain the network for short-duration outages at Pendine, as peaks in turbidity become more frequent and sustained, there is a risk that Pendine WTWs will have longer, more frequent outages, with an impact on customer supply. Based on the trends noted over the last 10 years, between 5 and 20 potential events could occur which might require customers in Pendine to have a tankered water-supply.

7.1.2 Scale and Timing of Investment

The scale of investment and activity has been selected to balance the reduction of the appropriate level of risk, affordability and deliverability in AMP8.

7.1.3 Overlap with Activities to be Delivered through Base

Does the proposed enhancement investment overlap with activities to be delivered through base?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.1c

We have a standard approach for assessing base/enhancements splits set out in a fair regulatory treatment within WSH50-IP00 Our Approach to Investment Planning (Section 3.4.2).

The options that were put forward to shortlisting, and the option that was ultimately recommended all require new infrastructure and are not part of base in response to raw water deterioration.

7.1.4 Overlap with Funding from Previous Price Reviews

Does the need and/or proposed enhancement investment overlap with activities or service levels already funded at previous price reviews?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.1d

The investments proposed in this case are the result of raw water quality deterioration reaching a critical inflection point. Investment outlined here has been identified during the PR24 process and has not been funded previously. The unprecedented raw water deterioration we have seen since 2010 will take this process beyond the treatment capability of the installed process. The risk will deteriorate through the effects of climate change, the impacts of which are already being felt, with more frequent heavy rainfall and extended hot and dry periods, being experienced more frequently since 2010. We are planning to invest to further enhance the capability of the existing asset in AMP8 to allow it to continue to perform in response to raw water deterioration until at least AMP9 or later where more significant investment may be required in response to forecast further raw water deterioration.

7.1.5 Alignment with the Long Term Delivery Strategy

Is the need clearly identified in the context of a robust long term delivery strategy within a defined core adaptive pathway?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.1e

Welsh Water have a long term output targeting a CRI score of 0, while this will be practically very difficult, minimising the score each year is of great importance both internally and to our external stakeholders. The quality of final water at our treatment works is a key contributor to achieving this long term ambition.

Welsh Water's core pathway has identified a range of interventions that are required to achieve this ambition. The schemes identified in this Enhancement Case are a key contributor to this. Welsh Water have identified alternative pathways focused on changing legislation, primarily associated with Welsh Government adopting EU drinking water legislation along with forecasts of raw water deterioration and their impact on our asset's treatment capabilities.

Further details can be seen in WSH01 Long Term Delivery Strategy.

7.1.6 Evidence of Customer Support

Our approach to customer engagement is set out in Stepping up to the Challenge: Business Plan 2025-30 (Section 2.2).
Customers are generally supportive of investment to improve water quality.

7.1.7 Management Control of Costs

Is the investment driven by factors outside of management control? Is it clear that steps been taken to control costs and have potential cost savings been accounted for?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.1g

The factors that are driving these Enhancement Cases that are outside of management control are raw water deterioration (additional solids loadings) linked to climate change.

Deterioration of the raw water quality through climate change impacting the local geology is not within management control and an investment is required to mitigate this risk. Raw water quality has significantly deteriorated over the last 10 years particularly following periods of heavy rainfall. Raw water quality parameters is starting to test the design capabilities of the treatment works and should we not invest in the next AMP, will start to see more of an impact on water quality and supply.

7.2 Best Option for Customers

Our overarching approach is described in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

The three sub sections below correspond to the eight criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.2.

7.2.1 Identification of Solution Options

Has the company considered an appropriate number of options over a range of intervention types to meet the identified need?
Is there evidence that the proposed solution represents best value for customers, communities, and the environment over the long term?

– Ofwat's final methodology for PR24, Appendix 9, A1.1.2a and A1.1.2b

A longlist of possible interventions that could reduce the impact of raw water deterioration was developed. These possibilities were reviewed by an experienced panel during a 'longlist workshop' to eliminate the options that:

- will not give sufficient improvement,
- have been tried previously and have not been successful,
- experience elsewhere has shown to be poor, providing little benefit.

We have considered a number of options to reduce the risk at Pendine WTW which are summarised in the following table –

Table 34: Long list of options considered for Pendine WTW

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e., progress to shortlisting?
1	***Enhance/upgrade the existing asset or service*** Additional Raw Water Storage	Not viable due to high CapEx investment. Additional raw water storage provides resilience during maintenance/cleaning. The variable speed drive (VSD) units provide the flexibility to run the abstraction pumps at slightly higher turbidity (i.e. 35NTU instead of 25NTU) due to more water being available for dilution. This option will have low OpEx costs but still require relatively high CapEx investment.	✗
2	***Manage Demand*** Catchment Protection	Not viable due to difficulties in quantifying the improvement based on catchment benefits alone. The number of sink holes in the catchment limits the chances of catchment solutions being effective; therefore, there is no single catchment option and it would need to be in conjunction with other solutions. A catchment option would add value in the long term by providing resilience and safeguarding for the water resource. Existing catchment activities include farming, boundary options, stream diversions and grid installation.	✗
3a	***Enhance/upgrade the existing asset or service*** Use of cartridge filters	Viable: a Cartridge filter should be able to improve the water quality from the borehole. However, the performance of the filters is difficult to predict without a trial on site. recent experience has shown the expected life is short and OpEx costs would be high	✓
3b	***Enhance/upgrade the existing asset or service*** Floc Blanket Clarification and Sludge Treatment Facilities	Not viable due to higher CapEx investment and bigger footprint in comparison to the high-rate clarifier option even though a floc blanket clarifier is a robust process for solids removal that is likely to cope with the very high turbidity water from the borehole following rainfall events and maintain continuous supply of water to customers without tankering.	✗
3c	***Enhance/upgrade the existing asset or service*** High-Rate Clarifier	Viable. A new clarifier with sludge treatment facilities should be able to sufficiently treat the high turbidity water.	✓

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e., progress to shortlisting?
3d	***Enhance/upgrade the existing asset or service*** Ceramic Membrane Filtration	Not viable due to the cost and intrusive nature of the solution at this site. Advanced technology which would treat water to higher standards, might make some existing treatment processes redundant. Compared with other polymer-type membrane technologies, ceramic membranes have a longer working life, low maintenance/replacement, and are therefore a long lasting, low-carbon solution. However, this solution costs £11m compared with the high-rate clarifier option of £5m, based on high level longlisting costing. It is likely to have higher OpEx costs as well since it uses various chemicals in its ICP process.	✗
4	***Manage operation or use of the existing asset or service*** Network Solution	Not viable. This option would not be a feasible due to the limited water resource available in the area and unlikely to be delivered in AMP8. However, a network solution might be a long term strategy option since the current borehole will not be able to sustainably produce the water after another 10 years, and a new borehole is likely to suffer from similar water quality issues as it will be in the same aquifer/geology.	✗
5	***Create/acquire a new asset or service*** New Borehole	Viable. This option is likely to be incorporated as part of a phased solution (i.e., carry out improvements at the works now to deal with the existing borehole water and implement a new borehole in the next 10 years, when the existing borehole starts to become unviable).	✓

7.2.2 Assessment and Selection of Solution Options

Our approach to cost benefit appraisal and its role in decision making is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

The table below has been completed using data from our cost benefit spreadsheets to illustrate the value generated by the proposed investment (note these figures are in 2022/23 price base, prior to application of capital salaries, overheads and internal efficiencies).

Table 35: Value generated by the proposed investment options

Solution Option	Option Name	CapEx	Present Value Whole Life Costs (WLC)	Present Value Whole Life Benefits (WLB)	Benefit/ Cost Ratio	Net Present Value (=WLB - WLC)
Option S1	Process Optimisation: Amazon Filter	£3.361M	£5.229M	£12.131M	2.320	£6.901M
Option S2	WTW Enhancement: High-rate Clarifier	£7.011M	£8.669M	£20.939M	2.415	£12.270M
Option S3	New Borehole	£4.498M	£4.711M	£13.781M	2.925	£9.071M

From our CBA analysis, Option 3 is the most cost beneficial although not necessarily the cheapest of the short list options. Option 1 does not necessarily reduce the risk sufficiently considering the comparable cost to Option 3 and although Option 2 replicates full risk reduction through the installation of a comprehensive treatment process, the cost benefit score is lower due to the significantly higher cost. Therefore we propose Option 3 for inclusion in the business plan with a suitable balance of cost and risk reduction illustrated in the highest cost, benefit ratio.

7.2.3 Quantification of Benefits

> ***Has the company fully considered the carbon impact, natural capital and other benefits that the options can deliver?***
> ***Has the impact (incremental improvement) of the proposed option on the identified need been quantified, including the impact on performance commitments where applicable?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2c and A1.1.2d*

The benefits of a scheme have been calculated by our asset planning and engineering teams based on the best available information and have been used to forecast the impact a scheme will have on service measures in comparison to the pre investment position/do nothing position.

Benefits are quantified against our service measure framework (SMF) meaning they are well understood and trackable through regular business activity. For more detail on this approach see WSH50-IP00 Our Approach to Investment Planning (Section 5.4). We have included an excerpt from the SMF in section 1.2.3 showing the categories of benefit that roll up to the Ofwat drivers identified as part of the overall case. The table below shows how we have apportioned the benefits, with improved drinking water quality carrying the largest weight.

7.2.4 Quantifying the Impact on Need and Performance Commitments

The identified schemes will resolve the issues raised by the DWI. The proposed work has been discussed with the quality regulator and they are supportive of the activities proposed.

The schemes will impact on the resilience of performances against the CRI. They will reduce the likelihood of performances deterioration, but not in a way which is visible to the measure.

From our analysis the proposed option will make the following impacts:

We have assessed the impact of enhancement on CRI, ERI and Acceptability of Water performance commitments. This reduces the risk of an impact on CRI following the inability to treat water sufficiently

7.2.5 Uncertainties relating to cost and benefit delivery

> ***Have the uncertainties relating to costs and benefit delivery been explored and mitigated? Have flexible, lower risk and modular solutions been assessed – including where forecast option utilisation will be low?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2e*

Our methodology is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3). This includes commentary on our approach to optioneering, costing and cost benefit analysis.

For this Enhancement Case we have evaluated a wide range of options in line with our TotEx hierarchy approach. We have aimed to balance most efficient solution with risk and innovation in all instances.

Option 5 -

This option involves:

- Survey to identify the location of new borehole
- Borehole construction
- New raw water pipework from borehole to Pendine WTW.

Table 36: Advantages and disadvantages of Option 5

Advantages	Disadvantages
The solution should resolve the risk of raw water deterioration. The solution should resolve the loss of production risk considering any future potential of coastal erosion should the borehole become unavailable	There is a risk that the chosen solution does not completely resolve the existing water quality issues as the new borehole is likely to abstract water from the same or adjoining aquifer and therefore be subject to the same constraints

Chosen Option

The chosen option for this scheme is Option 5 for inclusion in the PR24 business plan, the reasons behind this chosen option are as follows -

1. Highest benefit to cost ratio
2. Lowest CapEx, repeat CapEx and OpEx
3. Resolves risk created from coastal erosion as a result of climate change
4. Should resolve water quality risk from raw water deterioration but some risk residual may remain

7.3 Cost efficiency

In this section we give specific details on our approach to costing and benchmarking. Our overarching approach to developing efficient costs is set out in WSH50-IP00 Our Approach to Investment Planning (Sections 4.10 and 7).

The two sub sections below correspond to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.3.

7.3.1 Developing a cost for WTW Interventions

> ***Is it clear how the company has arrived at its option costs? Is there supporting evidence on the calculations and key assumptions used and why these are appropriate? Does the company provide third party assurance for the robustness of the cost estimates?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.3a and A1.1.3c*

We have costed the schemes using our UCD C&CET as described in WSH50-IP00 Our Approach to Investment Planning (Section 4.10). This approach utilises like-for-like (top down) costing of process assets and construction related costs to forecast and estimate future project and programme costs.

An individual specific scope was developed for each of the schemes, as part of the optioning process which identified the assets for construction, modification and upgrade along with any site specifics, which formed the basis of our estimates.

Much of the scope is for items of work which has been constructed throughout previous AMPs, and therefore we have a rich source of historical cost data. For these items of work we have developed cost models based on the most important cost drivers, e.g., the most influential driver to cost for a tank is volume. This costing approach forms the direct works and site-specific costs. We apply construction indirect costs and project oncosts based on the work stream, in this instance this is Water Non-Infrastructure, which applies modelled percentages to the cost of the direct works and site specifics.

The scope is aligned to our Work breakdown Structure (WBS), which was developed to support our data capture process of historical project cost against delivered assets, into a scope input sheet. Within this, sizing of the assets based on the relevant yardstick, which is dictated by the WBS, is provided following calculation in the previous engineering stages. Our costs models are developed in line with our WBS and this allows us to input this information into the C&CET and generate a project estimate. WBS details the inclusions and exclusions of works under each cost model and the limitations of the model, so we can ensure all project costs are captured and there is also no over costing.

The costing was carried out by Welsh Water Costing Team. The Governance procedures, as outlined in Section 5 Costing Methodology were adhered to with the appropriate use of cost models being confirmed and all manual allowances verified prior to providing sign offs throughout the different iterations of the costings.

Along with our overall costing strategy being reviewed and assured by Jacobs, we have also employed third party consultants to review single Enhancement Cases to provide confidence that the estimates within them are robust, efficient and deliverable. Please refer to WSH50-IP00 Our Approach to Investment Planning (Section 6) for more information regarding the review and assurance undertaken.

7.3.2 Benchmarking our approach

Is there evidence that the cost estimates are efficient (for example using similar scheme outturn data, industry and/or external cost benchmarking)?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.3b

The cost estimates for schemes have been based on Welsh Water's unit cost database and its associated Cost and Carbon tool to generate cost estimates for schemes. The costs generated are based on internal outturn costs collected by Welsh Water as described in WSH50-IP00 Our Approach to Investment Planning (Section 7).

7.4 Customer Protection

In this section we set out how oversight will be provided by the DWI on the proposed works.

The sub section below corresponds to the three criteria set out in Ofwat's PR24 Final Methodology, Appendix 9 (Setting Expenditure Allowances), Section A.1.1.4. There is no third-party funding for this Enhancement Case.

7.4.1 Providing Customer Protection

Are customers protected (via a price control deliverable or performance commitment) if the investment is cancelled, delayed or reduced in scope?
Does the protection cover all the benefits proposed to be delivered and funded (e.g. primary and wider benefits)?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.4a and A1.1.4b

Customers will be protected via two mechanisms:

1. The regulatory oversight from the DWI. The delivery of performance improvement is inherent to the DWI Notices. The legal mechanism within which the DWI will hold the company to account will be in place in accordance with timescales outline by DWI. Failure to meet these targets could result in prosecution, and
2. The existing performances commitment for customer contacts about water quality (and CRI) agreed with and regulated by Ofwat.

For the performance commitment Welsh Water will report progress each year through the Annual Performances Report (APR). The common performance commitments include 'Customer contacts about water quality' which will report on the number of consumer contacts per 1,000 population and the Compliance Risk Index (CRI).

The work will deliver resilience and prevent deterioration in the Performances Commitment for CRI

8. Appendix A – Summary of Totex by year for AMP8

The table below shows the total CapEx, OpEx and TotEx enhancement cost in Amp 8, however for this Enhancement Case, the Ofwat drivers for this Enhancement Case maps to are:

- Addressing raw water quality deterioration (grey solutions); enhancement CapEx. (CW3b.97)
- Addressing raw water quality deterioration (grey solutions); enhancement OpEx (CW3b.98)
- Addressing raw water quality deterioration (grey solutions); enhancement TotEx (CW3b.99)

Table 37: Enhancement Case maps

Driver Ref	Year in AMP8					
	1	2	3	4	5	Grand Total
CW3b.97 - CapEx	£10.250M	£11.888M	£10.256M	£7.630M	£2.067M	££42.091M
CW3b.98 - OpEx	£0.220M	£0.220M	£0.461M	£1.362M	£1.558M	££3.821M
CW3b.99 - TotEx	**£10.470M**	**£12.108M**	**£10.717M**	**£8.992M**	**£3.625M**	**ff45.912M**

What We Will Deliver:

Raw Water Deterioration & Customer Acceptability - Cefn Dryscoed - This Enhancement Case will deliver a new counter current dissolved air flotation and filtration process, and a dedicated manganese removal process to treat the increasing concentrations of suspended solids and manganese within the raw water.

Customer Acceptability - Manganese at WTW - This enhancement will deliver a new dedicated manages removal process (cartridge filters) to 4 WTW, and process optimisations and improvements to 6 other WTW to remove treat the increasing concentrations manganese within the raw water.

Regulation 26 Disinfection Strategy - This Enhancement Case will deliver new ultra -violet disinfection to 4 WTWs to meet regulation 26 compliance along with minor investment to validate other WTW and reduce risks related to disinfection.

Raw Water Organics (Taste & Odour) – Mayhill WTW - This enhancement will deliver an increase in capacity to the existing organics removal process stream to treat the increasing concentrations of organics within the raw water ensuring that we achieve water quality standards.

Disinfection By-products – Capel Curig WTW - This enhancement will deliver a new process treatment unit (carbon filtration) to remove the disinfection by-product precursors (Tri-halo menthanes) and abandon an alternative raw water source.

Smaller schemes - Lastly this enhancement will deliver 2 smaller schemes (Bontgoch and Pendine raw water deterioration) and a feasibility study of disinfection by-products at Anglesey.