Dŵr Cymru
Welsh Water

Enhanced Investment Case: WSH54-CW02 – Improving Acceptability of Tap Water - Networks

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Executive Summary

This investment will improve the acceptability of water to our customers, focusing primarily on reducing discolouration of water within our distribution network but also addressing taste and odour concerns. The programme of work will be delivered alongside our business-as-usual base activities including mains cleaning and ice pigging and our other operational interventions which improve both discolouration and the taste and odour of our water supply.

The main focus of our investment within this Enhancement Case is the improvement of discolouration (brown, black and orange) within the distribution network. A wider programme of improvements is also being undertaken across Welsh Water including the water treatment improvements to manganese treatment and our catchments programme which will aim to reduce further deterioration of our raw water supplies.

Across our distribution network we will invest £118M to support the reduction of contacts per thousand population (C/1k/p) associated with total Acceptability of Water to a rate of 1.0 C/1k/p and for discolouration only to 0.7 C/1k/p. A summary of the proposed programme and associated costs and benefits can be seen in Table 1 below.

Summary of the Proposed Programme Spend and Forecast AOW Reduction Benefits

Intervention Type	£M	Benefits AOW C/1k/p
Data Improvements	1	0.04
Operational network interventions new additional equipment, valves, new technologies and fittings	5	0.05
Care Plans (training, monitoring, ancillaries etc)	21	0.10
Trunk mains automation for conditioning etc actuators and monitors purchase and installation	20	0.10
Mains Cleaning & Ice Pigging (the improvement element for additional network ancillaries to facilitate this work)*	3	0.13*
Mains replacement and abandonment	64	0.03
Implementation of Emerging Solutions Studies	4	Required to assess and trial emerging solutions**
Total Programme	**118**	**0.45**

*An additional spend of £34M for this intervention will be funded from Base Maintenance which will contribute the AOW benefit show here for mains cleaning and ice pigging. This will also be supported by a further £1.5M of base network modelling and investigations.
**The Emerging Solutions Studies will enable emerging technologies to be fully tested and if successful will result in further benefits to our AOW performance.

We will implement a programme of care plans to undertake mains conditioning (supported by automation of trunk mains flow controls) to maintain clean pipes, mains cleaning, pipeline replacement and abandonment. We will also investigate emerging technologies and methods and deliver emerging techniques using the most cost beneficial interventions to within our delivery programme to meet our challenging AOW improvement target of 1.0 C/1k/p.

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 investment (5 sections),
- best option for customers (4 sections),
- cost efficiency (2 sections),
- customer protection

Need: Acceptability of water is measured by the number of customer contacts per 1000 population (C/1k/p). These contacts are broadly categorised as discoloration (brown, black & orange contacts),

other appearance or taste & odour, each of which has a target level of performance. The root cause of acceptability of water complaints can mainly be addressed at either our treatment facilities and/or within our distribution system.

The water that we produce for our customers can contain material that can form depositions in our mains, if there is a step change in flow these depositions become agitated and disturbed from the wall of the pipe. Furthermore, over 40% of our conveyance mains are unlined ferrous pipes, the progressive degradation of these pipes increases the amount of depositions within our system.

The focus of this Enhancement Case is managing our distribution network to improve taste, colour and odour at the tap. Investment at our water treatment works is covered in the CW03 Improved water quality by reducing risks on water treatment works investment case.

Our internal and DWI service performance targets are summarised in Table 2 below.

DWI and Welsh Water AOW Performance Targets End AMP7 and End AMP8

Category	Start AMP8 C/1k/p	End AMP8 C/1k/p
DWI Target AOW Discolouration	1.4	0.7
DWI Target Total AOW	1.75	-
Welsh Water Total AOW Target	1.58	1.0

Options: We have assessed multiple scenarios, informed by cost benefit analysis, to consider how best to scale and target our response. We have worked with independent specialists to analyse the impact of our unlined ferrous mains within our networks. We have a well-developed understanding of the statistics and science behind the observed trends and have been able to use this insight to develop and optimal intervention programme.

Our chosen option for the intervention programme for discolouration focuses on ferrous mains and is a combination of implementation of care plans and trunk mains automation to maintain network water quality, and installation of additional ancillaries to enable additional operational improvement activities. This is supported by targeted replacements of higher risk mains. This replacement is required to enable the network to be improved and to avoid the need to cyclically repeat cleaning activities within the Base Maintenance programme every five years. The other key part of our programme will be the implementation of industry emerging techniques associated with cleansing and extending the operational life of ferrous mains. This work will be in addition to improvement activities across our water treatment works.

What We Will Deliver: This Enhancement Case will deliver mains cleaning, automations, optimisations, or replacement across 862km of our mains. These actions will cover interventions downstream of our WTW including actions at service reservoir sites, trunk and distribution mains. Each main will be evaluated independently but also as part of its system to identify the preferred action, or combinations of actions.

Efficient Costing: We will invest £118M (post efficiency, 22/23 price base) on ferrous mains actions and enhanced network modelling. This work will be in addition to that delivered in our Base Maintenance programme (£36M, post efficiency, 2022/23 price base)

In developing schemes, we have modelled costs from previous pipe replacements to improve acceptability of water, and the implementation of previously piloted flushing techniques. We have built on insights gained through our zonal studies programme and in the development of investment models to generate efficient and cost beneficial schemes.

Customer Protection: Benefits will be monitored both through compliance with DWI expectations and through the performance commitment for customer contacts about water quality.

Benefits: This investment will improve the acceptability of water to our customers and will be a progressive step in our journey to reduce our AOW total contacts to 0.5 C/1k/p by 2050, as part of our Long Term Delivery Strategy (LTDS).

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

1. Introduction

The driver of this Enhancement Case is to improve the acceptability of water to customers, it will create a step change in performance in line with DWI expectations outlined within their Notice Reference No: DWI DWR-2022-000004 issued in March 2023.

Acceptability of water (AOW) is measured by the number of customer contacts relating to aesthetic water quality. There are two main parts to AOW, namely discolouration and taste and odour. The primary focus of this investment case is discolouration (brown, black and orange) within the water supply network.

Within the networks there will be minor projects to reduce taste and odour (chlorine monitoring within network), however taste and odour is primarily addressed within our treatment facilities which are part of a separate Enhancement Case (WSH55-CW03 - Improved water quality by reducing risks on water treatment works). CW03 also covers the reduction of manganese within the conveyed water (which contributes to discolouration).

Discolouration of water at the customer tap is attributed to depositions within the pipeline that are disturbed and conveyed to the customer by agitation within the pipeline. The two key sources are depositions within the treated water from a water treatment works (WTW) most commonly manganese, but also organic material, and the degradation and deposition of solids, mainly iron, from unlined ferrous water mains.

40% (11,000km) of our water mains are unlined ferrous materials (primarily cast iron), which was the preferred pipe material in the early part of the twentieth century. Three quarters of these cast iron mains are now over 70 years old, and a quarter are older than 110 years. While we have continued to replace cast iron mains c500km were replaced over AMPs 5, 6 and 7. Traditionally flushing and other forms of mains cleansing were viewed to be a more cost effective solution to tackling discolouration in the short term. However, in conjunction with this it is necessary to undertake mains replacement to provide a long term sustainable solution. This approach is more cost effective when considered over 25 years but significant up-front investment is required.

This investment case focuses on reducing customer contacts by addressing the degrading ferrous water mains within our network and managing deposits of decolouration material in our pipelines. The management of discolouration will also include implementation of industry emerging techniques associated with cleansing and extending the operational life of ferrous mains, where these are approved for use and proven within our system in small scale trials.

The value of this Enhancement Case is £118M (post efficiency, 2022/23 price base).

The DWI has issued a notice and letter of support which are based on our proposed AOW enhancement intervention programme. A summary of these can be seen in Table 1 below.

Table 1: DWI Notice and Letter of Support

DWI Scheme Reference:	Project Description	Legal Instrument Required	Timescale	Supporting Documentation
DWR6: supporting the delivery of this scheme to cover regulation 28(4) notice DWR-2022-000004).	**Mitigation of discolouration and associated impact on consumer acceptability**	**Regulation 28(4) notice**	**In place**	**PR24 submission, regulation 28(1) risk assessments.**

1.1 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	Addressed
A1.1.1 Need for enhancement investment	a	Is there evidence that the proposed investment is required?	Section 2.1
	b	Is the scale and timing of the investment fully justified?	Section 2.1
	c	Does the proposed investment overlap with Base Maintenance activities?	Section 2.2
	d	Does the need and/or proposed investment overlap/duplicate with previously funded activities or service levels?	Section 2.3
	e	Does the need clearly align to a robust long term delivery strategy within a defined core adaptive pathway?	Section 2.4
	f	Do customers support the need for investment?	Section 2.1
	g	Have steps been taken to control costs, including potential cost savings?	Section 2.5
A1.1.2 Best option for customers	a	Have a variety of options with a range of intervention types been explored?	Section 3.1
	b	Has a robust cost-benefit appraisal been undertaken to select the proposed option?	Section 3.1
	c	Has the carbon impact, natural capital and other benefits that the options can deliver been assessed?	Section 3.2
	d	Has the impact of the proposed option on the identified need been quantified?	Section 3.2
	e	Have the uncertainties relating to costs and benefit delivery been explored and mitigated?	Section 3.3
	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)
	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 4.1
	b	Is there evidence that the cost estimates are efficient?	Section 4.2
	c	Does the company provide third party assurance for the robustness of the cost estimates?	Section 4.1
A1.1.4 Customer protection	a	Are customers protected if the investment is cancelled, delayed or reduced in scope?	Section 5.1
	b	Does the protection cover all the benefits proposed to be delivered and funded?	Section 5.1
	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

2. Need for Enhancement Investment

This section sets out the drivers behind the AOW Enhancement Case. The work set out in this investment case is driven by customer contacts related to the acceptability of water mainly related to discolouration and the associated targets set by the DWI within their Notice Reference No: DWI DWR-2022-000004 to improve discolouration performance.

The proposed investment aligns with our long term delivery strategy by responding to the need for long term stewardship of our network assets and targeted improvements in service.

2.1 Evidence that Enhancement is Needed

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

We are required by DWI to make improvements to our acceptability of water performance which is measured through customer contacts. This requirement is set out in a legal Notice Ref DWR-2022-00004 issued by the DWI 8th March 2023, relating to the discolouration element of Acceptability only, which states:

1. *The Drinking Water Inspectorate ('the Inspectorate') has received a regulation 28(1) report of the Water Supply (Water Quality) Regulations 2018 ('the Regulations') from the Company dated 21 October 2021, which states that there is or has been a significant risk of supplying water from all water supply zones (WSZ) (and associated assets as applicable) that could constitute a potential danger to human health or could be unwholesome.*
2. *Consequently, this Notice is served on the Company by the Inspectorate on behalf of the Welsh Ministers, under regulation 28(4) for the assets listed above, for risks associated with:*

Table 2: Table of the hazards, hazardous events, and/or parameters covered by this notice, including the Hazard ID numbers and the description of risks.

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

The notice sets out the following targets:

- Target maximum customer contacts for discolouration by the end of AMP7 (1.4/1000 population).
- Target maximum customer contacts for discolouration by the end of AMP8 (0.7/1000 population).
- Target maximum customer contacts for discolouration by the end of AMP9 (0.4/1000 population).

The number of customer contacts make it clear that an improvement in performance is required and the timescales within which this improvement must be delivered.

This Notice also sets a target for individual water quality zones (at a rate of 1.07). If this target is exceeded, then that Zone is listed in an Annex to the Notice and has to have a full root cause and action plan developed. This Annex is updated annually.

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

This is focused on AOW for this case and providing improved water quality through network and other source to tap interventions to improve customer service at the customer through a reduced frequency of discolouration or taste and odour failures. This is linked to the number of customer contacts which provide the metric for this measure and there is a clear link with customer sentiment about this issue.

We are also required by the DWI to improve AOW Discolouration performance through their Notice Reference No: DWI DWR-2022-000004.

2.1.1 Scale and Timing of Investment

We have delivered continuous improvement in the acceptability of water performance over recent AMPs. A summary of the end of AMP7 position and our targets set by the DWI can be seen in Table 3 below. This will require a significant investment during AMP8 to achieve. Further commentary on our AMP7 to AMP8 transition is given in our data table commentaries.

Table 3 – AOW Discolouration Targets for AMP7 and AMP8

Category	Start AMP8 C/1k/p	End AMP8 C/1k/p
DWI Target AOW Discolouration only (not inc T&O)	1.4	0.7
Welsh Water Total AOW Target	1.58	1.0

In the Notice, the DWI have set a detailed timeline for the implementation of activities and performance improvements throughout AMP8 and beyond, which is summarised within Table 4 below.

Table 4: AMP 8 programme to achieve 0.7 customer discolouration contacts/1000 population

Target date	Deliverable	Works to achieve deliverables
End of AMP 7	Discolouration customer contacts at 1.4 C/1k/p	Implement bespoke solution: a. Treatment works optimisation b. Service reservoir risk assessment and cleaning c. Work on Trunk mains and pumping stations d. Water quality zones and DMAs Prioritising zones to an agreed programme with highest risks for discolouration, and consumer acceptability.
End of April 2025 - 2030	Present annual review of discolouration data from all sources and complete risk assessments for all zones. Update regulation 28 reports where necessary.	
End of June 2025 - 2030	Present annual review of new high and medium risk zones.	
End of September 2025 - 2030	Present action plan to mitigate risks in new high and medium risk zones	
End of AMP 8	Achieve target of 0.7 C/1k/p	

This case focuses on deliverable c. (trunk mains only) and d. to deliver water network related improvements. The wider enhancement and Base Maintenance intervention programmes addresses the other items.

2.2 Overlap with Activities to be Delivered through Base Maintenance

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

Our approach to separating base and enhancement is set out in WSH50-IP00 Our Approach to Investment Planning (Section 3.4.2).

While both Base Maintenance and Enhancement activities will be implemented on mains within our networks, we have clearly separated the scope and budget allocations which are outlined in the bullets below.

Base Maintenance interventions: Focussing primarily on mains constructed of preferred materials (non-ferrous) conventional cleaning, flushing and ice-pigging and maintenance of our WTW and SRVs assets. These are not included within in Enhancement Case but will be required to maintain the AMP7 level of performance. This base performance can offset the "natural rate of rise" of discolouration i.e., the gradual deterioration that would occur without us intervening. This can also deliver some improvements in performance to both discolouration and taste and odour as we become more efficient and effective at targeting these activities. The refresh of our Distribution Operational Maintenance Strategy (DOMS) will help us achieve this, along with optimisation of water treatment processes and chemical dosing, particularly chlorine.

In addition to the network related schemes mentioned above, our activities funded through Base Maintenance are forecast to maintain the end of AMP7 position for Total AOW of 1.58 C/1k/p, including discolouration and taste and odour improvements during AMP8. Further details of the planned interventions from source to tap to deliver this improvement and the type of AOW benefit that will result can be seen in Appendix 2. We will also undertake other interventions through our Water Quality and Catchments enhancement programmes which will deliver a further 0.13 C/1k/p reduction in total AOW.

These interventions, in conjunction with our forecast enhancement improvement of 0.45 C/1k/p, will move from our starting position in AMP8 of total AOW 1.58 C/1k/p to an end of AMP8 position of 1.0 C/1k/p.

Enhancement activities: Follow a two-pronged approach which first assesses the suitability to cleanse and or extend the of unlined ferrous mains

- Continuation of investigation and trialling industry emerging cleansing techniques on unlined ferrous mains, details outlined in section below.
- If the above methods are not technically viable, or the risk of not replacing the pipe is too high, the desired solution is replacement of unlined ferrous mains.

2.3 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 investment need is a continuation of our discolouration focussed intervention programmes delivered during AMP6 and 7. Throughout the last 10 years we have invested to make a considerable

improvement in our discolouration (Brown, black, orange) performance. The contact numbers in Figure 1 below indicate the impact on discolouration performance within the water quality zones where the targeted interventions have been undertaken.

The performance between 2016 and 2022 for these water quality zones has moved discolouration AOW values from 2.89 C/1k/p to 1.58 C/1k/p.

At a company level these interventions have supported an improvement in AOW discolouration performance from 2.35 C/1k/p in 2016 to 1.67 C/1k/p in 2022 which is the equivalent a reduction of over 2,010 customer contacts for discolouration, see Figure 2 below. The slight rise in 2022 can be attributed to a single event at Cefn Dryscoed WTW that is included within the Water Quality enhancement Investment Case. Without this event there would have been another small decline in contacts.

The targets set out in Table 3 for the end of AMPs 7 and 8 will mean that the reduction in customer contacts for discolouration will continue to follow the downward trends in Figures 2 and 3.

The improvements to the end of AMP7 have been separately funded (we received £86M for enhancement investments at PR19) and the improvements made will be maintained through Base Maintenance investment in AMP8 and beyond. Our Base Maintenance programme will also maintain Total AOW performance to the levels achieved at the end of AMP7.

The proposed funding through this Enhancement Case will make a further step change in performance. This investment case seeks funding for service levels beyond those previously set to support moving from a total AOW performance of 1.58 C/1k/p at the start of AMP8 to 1.0 C/1k/p at the end of AMP8, as such there is no overlap or duplication.

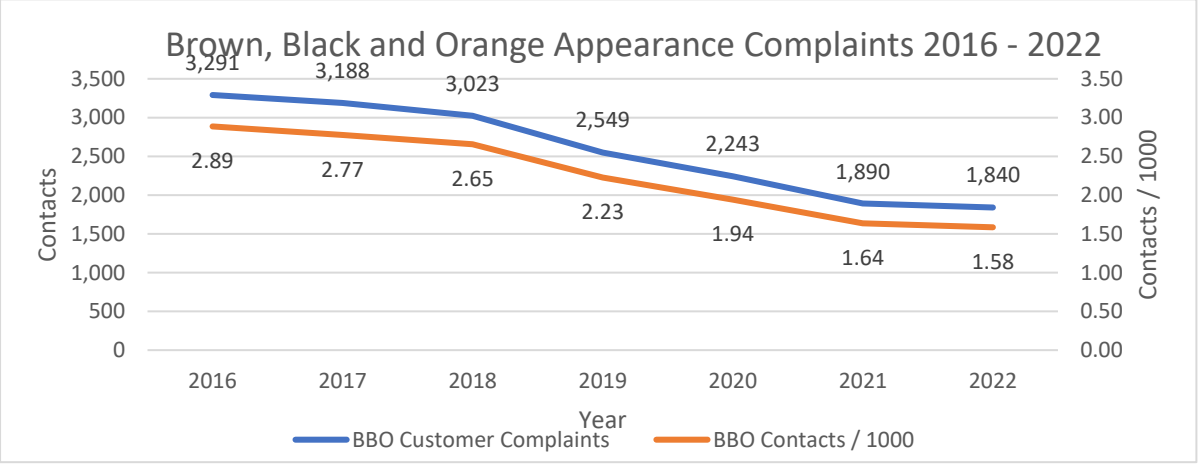

Figure 1: AOW Discolouration Customer Contacts from water quality zones which have received an intervention between 2016 and 2022

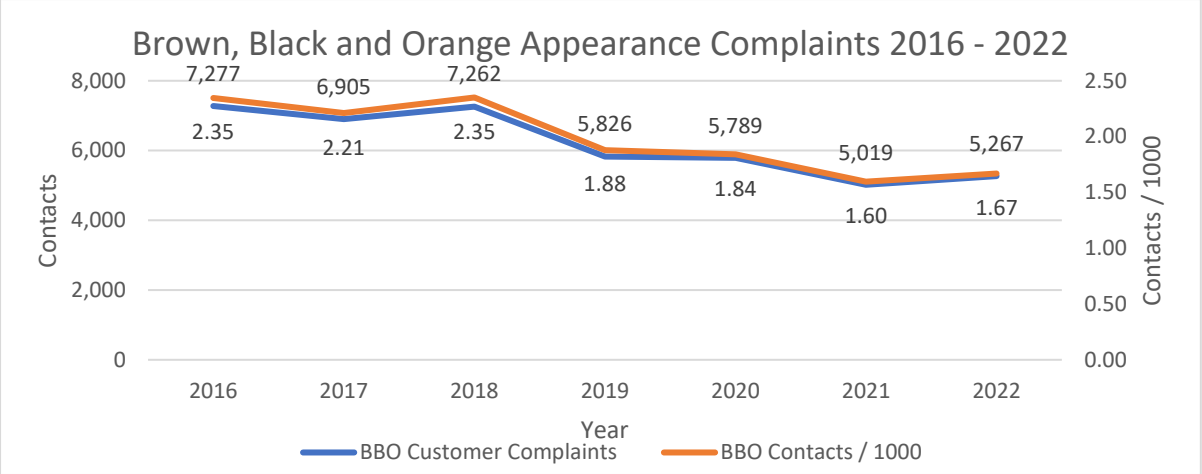

Figure 2: Company Level Reductions in AOW Discolouration Customer Contacts 2016 to 2022

2.4 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

Customer contacts related to acceptability of water is part of our Long Term Delivery Strategy outputs.

Our 2050 ambition is to achieve an average customer contact rate for Total AoW of less than 0.5 C/1k/p across taste, colour and odour, compared to an end of AMP7 target of 1.75 C/1k/p Total AOW and 1.4 C/1k/p for discolouration only.

Our core pathway comprises several interventions covering a source to tap approach with projects within the water quality and catchments Enhancement Cases contributing secondary benefits to the AOW long term delivery ambition. The network intervention schemes outlined in the Enhancement Case form a central part of our core pathway. Replacement of unlined cast iron mains remains critical to our Long Term Delivery Strategy to reduce Acceptability of Water contacts. Further details can be seen in WSH01 Long Term Delivery Strategy.

2.5 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

Discolouration of the water at our customers' tap is caused by three main factors.

1. Dissolved and particulate metals not removed from the raw water at our treatment facilities, pass into our distribution system and settle.
2. Legacy mains materials such as unlined cast iron mains provide surfaces for these metals to concentrate, while also contributing further through corrosion products from the pipe walls.
3. Operational incidents which result in flow changes can mobilise these particles leading to a discoloured tint to the water.

This Enhancement Case focuses on the second and third factors, where our legacy unlined non-ferrous mains are negatively impacting performance, through the resuspension of particles during an incident.

There are additional factors which impact our water network, we have naturally soft water that expedites the corrosion of these unlined mains. We undertake every effort to extend the life of our legacy unlined ferrous mains through careful operational management. We will build on this through our assessment of emerging solutions and will further support this with the installation of additional ancillaries to facilitate conditioning and limit the rate of valve movements.

While we continue to review current mains relining techniques, we are yet to be persuaded of the long term effectiveness of these techniques. Figure 2 below shows examples of failed lining within our system, these have been found at part of our investigations into discolouration hotspots. These failed linings mean that our preferred cleaning technique, ice pigging, is not technically viable or the risk is too high in further damaging the lining leading to performance deteriorating further. This leaves replacement as the only option. Our approach during AMP8, where cleaning is not possible, will remain as the replacement of mains with preferred materials of construction. This balanced programme of interventions will deliver best value to deliver the improved performance targets for our customers over the long term.

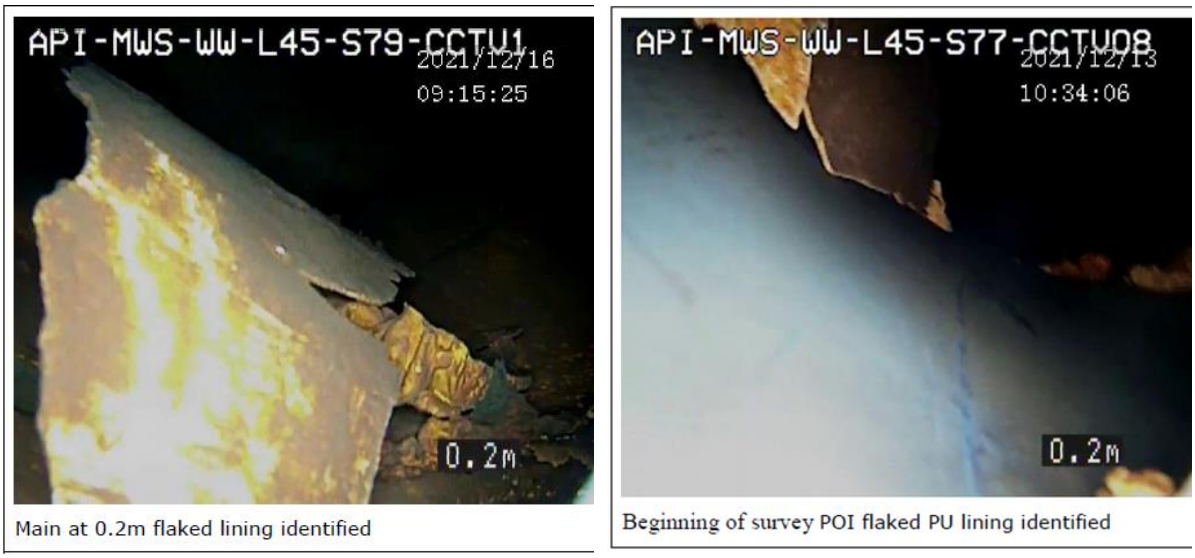

Figure 3 – Example Water Main Lining Failures

3. Best Option for Customer

In this section we will describe how we have developed options for addressing the need identified above.

The targets included within the DWI Regulatory Notice are challenging and cannot be achieved by operational changes and Base Maintenance alone. The chosen option builds on our previous approach of identifying the main contributory factors in an area and selecting a basket of activities to create the required step change – some of these activities will be assigned to Base Maintenance.

3.1 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*

The longlist of options was assessed, see the full list in Appendix 1 below, and Option 9 was selected. This option consisted of a range of interventions from Operational, Asset renewal, Asset abandonment, Asset enhancement and the installation of new assets. As a result, the short list options developed consist of a range of options including mains replacement, mains cleansing and automation, and mains cleaning using both traditional and emerging techniques.

These intervention solutions have been developed to provide a programme of work where each of the interventions are interdependent on each other. To inform our decision making on the appropriate size of programme we considered investment at a variety of scales. These were notionally named as £33M, £66M, £100M and £152M scenarios reflecting the pre-efficiency cost levels. For each of these scenarios we calculated the impact of customer contacts and the wider benefits within our SMF. The shortlist interventions can be seen in Table 5 below.

The six different solution options developed have been produced as a programme of interventions S1 to S3. These are different sized programmes following the more traditional solution approach only, utilising mains cleaning, mains replacement and abandonment, a similar approach to that undertaken during AMPs 6 and 7.

Option S4 is a combination of the traditional interventions supported by additional interventions to improve data analysis and management; improved modelling and implementation of Care Plans; Installation of trunk mains valves and controls to automate Care Plans and the associated mains cleansing; and installation of additional network ancillaries to facilitate operational improvements through our Base Maintenance interventions. This combination of interventions provides a step change in AOW discolouration improvements beyond the 0.16 C/1k/p from traditional methods and adding a further 0.29 C/1k/p to enable 0.45 C/1k/p to be achieved.

Solution options S6 and S7 include the assumption that we will be able to implement the benefits from the emerging solutions that we are assessing through previously piloted studies, see Table 5 below. There is a high risk that some of these solutions will not be possible for implementation. Using "No Des" mains cleaning as an example, this solution is reliant on the achievement of Regulation 31 approval from the DWI for use within a clean water network. Consequently, we have not stated associated benefits because of the high risk of these not be available for implementation in AMP8.

We developed an integrated approach to identifying the investments we need to maintain existing performance improvements and stretch forward to achieving the targets set by the DWI. It should be noted that as part of our assessment we have identified the need to undertake a range of interventions including the need to continue to replace mains alongside a combination of emerging techniques and our Base Maintenance activities. Without the installation of new mains there will be a continued need to increase mains cleansing every AMP to maintain the ever tighter performance targets. This is not a sustainable solution in the long term.

We have a range of improvement options available to us and summary and the Pros and Cons of each are shown in Table 5 below. To select the priority options, we have used a two-step hierarchical assessment which is described in the bullets below.

1. Identifying options which could be deployed, these included ice pigging, mains replacement, mains conditioning.
2. Considering varying combinations of this activity to produce the desired benefits. We have assessed options in terms of their viability, scalability, costs and benefits – specifically their ability to improve compliance with the customer contacts about water quality measure.

Table 5: Available Enhancement options for mains improvement to reduce discolouration customer contacts.

Scheme	Description	Advantages/Disadvantages/Viable?
Eliminate, reduce or delay the need for change. Data Improvements	Integration of new equipment and systems (see Emerging Techniques D-F) with existing systems to enable continuous monitoring of discolouration risk from source to tap.	**Advantages –** this will allow for more proactive, automated understanding of risk before contacts arise which will drive more preventative measures. **Disadvantages –** the technological success of emerging initiatives is not guaranteed. The integration requirements with existing systems cannot be fully defined until after the trial activities.
Eliminate, reduce or delay the need for change. Operational network interventions new additional equipment, valves and fittings	Installation of new additional valves, washouts, meters and other fittings to facilitate investigative and maintenance activities.	**Advantages –** these installations will enable effective investigative and maintenance activities to be undertaken. **Disadvantages –** without these installations effective investigative and maintenance activities cannot be undertaken.
Eliminate, reduce or delay the need for change. Care Plans (training, monitoring, ancillaries etc)	Develop care plans which define the assets and the flow rate change requirements to condition the mains to remove colour from the network in a managed way. This will include the development and training of a dedicated in house team to produce Care Plans, purchasing of monitoring equipment and conducting the pre-automation activities and installation of ancillary assets including valves, washouts and monitors or quadrinas to allow portable monitor installation.	**Advantages –** reduces the risk of discolouration events and reduces the reliance on contracted resource through in house dedicated resource and enables a faster response to changing conditions. **Disadvantages –** manually intensive resource requirement and availability of staff. Short lived benefit and required regular repetition &/or automation.

Scheme	Description	Advantages/Disadvantages/Viable?
Enhance existing resources or add new resources. Trunk mains automation for conditioning etc actuators and monitors **purchase and installation**	Conditioning gradually raises flows in trunk mains to remove layers of biofilm and mains particles reducing the impact of discolouration resulting from flow changes and the associated complaints. A targeted installation programme of new equipment to facilitate automated mains conditioning for c125 trunk mains, particularly mains that supply service reservoirs (SRV). Equipment will include the installation of automated control valves and water quality monitors, upgrading and reprogramming of existing equipment.	**Advantages –** removal of biofilms to manage discolouration risk. This is a relatively low-cost solution. Automating this activity will mitigate the manual time taken to undertake this activity after the target flow has been achieved. **Disadvantages –** conditioning activities are iterative and are required to be repeated regularly. If automation is not implemented, then there will be a high resource requirement to regularly repeat the conditioning activity.
Maintain the effective risk controls already in place. Mains Cleaning & Ice Pigging (Part Base/ Part Enhancement)	Targeted mains cleaning, through ice pigging, to remove sediment and biofilms that lead to discolouration complaints during flow changes. Enhancements to network ancillaries including isolation valves and washouts are required to facilitate this work. These solutions are used in co-ordination with mains replacements and abandonments.	**Advantages –** removal of sediment and biofilms to manage discolouration risk. This is a relatively low-cost solution. **Disadvantages –** cleaning activities are iterative and are required to be repeated regularly.
Enhance existing resources or add new resources. Mains relining – Discounted as an option	Relining of mains to install a barrier between the pipe material and the water to prevent further corrosion and deposition.	**Advantages –** a non-ferrous surface to prevent further iron corrosion. **Disadvantages –** poor track record in the industry due to premature failure and early replacement being required.

Scheme	Description	Advantages/Disadvantages/Viable?
Maintain the effective risk controls already in place. Mains replacement and abandonment	Targeted mains replacement and abandonment to remove the iron mains that are the source of discolouration complaints. These solutions are used in co-ordination with mains cleaning.	**Advantages –** ensures long term sustainable performance improvements for reducing discolouration risk and complaints. There are further benefits for leakage reductions and reduced maintenance requirements. **Disadvantages –** replacement is the highest cost solution. The benefits appear lower as these solutions commonly target trunk mains, where contacts are 'indirect' meaning that the complaint from the main occurs some distance downstream. These downstream areas are also proposed for cleaning and replacement, where the contact benefit will be represented.
Implementation of Emerging Techniques Programme		
Enhance existing resources or add new resources. Emerging technique A Battery Powered Automated Control Valves	Testing of alternative forms of automated control valves to support automated / remotely controlled conditioning activities. Technology Readiness Level – 6 The technology is developed but will be delivered considering it is an emerging initiative.	**Advantages –** less disruptive installation requirements and lower cost than conventional automated control valves. **Disadvantages –** could require higher maintenance costs for battery changes depending on the frequency of use. The flow tolerances are likely to have higher ranges than conventional automated control valves.
Enhance existing resources or add new resources. Emerging technique B NO-DES Network Cleaning	Testing of NO-DES water mains cleaning to potentially enable the cleaning of all mains materials 200mm and under, including unlined ferrous mains. Technology Readiness Level – 6 The technology is operational in North America and Australasia but has no UK or European regulatory approvals. The technology is developed but will be delivered considering it is an emerging initiative.	**Advantages –** it is used in North America and Australasia to clean all mains materials, including unlined ferrous mains, without leading to iron failures. The technology wastes virtually no water. Costs are lower than other effective cleaning methods, like ice pigging which cannot be used on unlined ferrous mains, and could reduce the requirement to replace unlined ferrous mains. **Disadvantages –** it does not have DWI Reg-31 approval. The technology has not been tested in the UK operating environment. As such it cannot be considered until the approval is granted.

Scheme	Description	Advantages/Disadvantages/Viable?
Enhance existing resources or add new resources. Emerging technique C NMR Pipetector	Expanded testing and research for the NMR Pipetector for the reversal of iron corrosion in water mains. Technology Readiness Level – 3 The Brithdir trial has demonstrated the potential of the invention however, further research is required.	**Advantages –** pilot testing at Brithdir has demonstrated the potential of the technology to reverse iron corrosion. If successful and fully operational then costs could be significantly lower than replacement costs. **Disadvatanges –** trial results may take an extended period of time due to the nature of the process. The factors that drive success are not sufficiently defined, which will be resolved through the research.
Enhance existing resources or add new resources. Emerging technique D Enhanced Network Monitoring	Developing new equipment and systems to enable continuous monitoring of discolouration risk from source to tap. Technology Readiness Level – 4 Some technology has been developed by various companies but will be delivered considering it is an emerging initiative..	**Advantages –** the data will lead to better lead risk information to act before contacts arise. **Disadvantages –** the measurement accuracy of equipment is not known. It is possible that further product developments may be required to suit the operating environment.
Enhance existing resources or add new resources. Emerging technique E Optimatics Software	Testing and potential implementation of Optimatics – a genetic algorithm tool to optimise the water systems. Technology Readiness Level – 6 The technology is developed but will be delivered considering it is an emerging initiative.	**Advantages –** the software is capable of running 100,000s multi-criteria simulations to improve analysis efficiency and accuracy. The software can also be used to balance outcome requirements. **Disadvantages –** The software requires trained individuals to create assessment criteria.
Enhance existing resources or add new resources. Emerging technique F Chlorine Decay Modelling	Testing an alternative method to assess chlorine decay, network maintenance requirements and causes of taste and odour complaints. Technology Readiness Level – 6 The technology is developed but will be delivered considering it is an emerging initiative.	**Advantages –** this method has been trialled with UU through Atkins and used in system design. This may lead to more effective targeted maintenance. **Advantages –** initial outlay costs are higher than conventional modelling activities.

It should be noted that for all combinations of options assessed, the need to undertake a range of interventions, including replacing cast iron mains, must continue alongside a combination of network cleansing and stabilisation, emerging techniques and our Base Maintenance activities. It should be

noted that all the interventions within Table 6 below are not mutually exclusive and are interdependent with each other.

Without the renewal of mains there will be a continued need to increase mains cleansing every AMP to maintain the evertighter performance targets. This will significantly increase costs. For example, in AMP9 mains cleaning will need to be increased by £34m to repeat the work undertaken during AMP8. Mains replacement (of our worst performing pipes) in combination with the other interventions provides the long term sustainable solution to deliver our Long Term Delivery Strategy AOW targets.

To inform our decision making on the appropriate size of programme we considered investment at a variety of scales. These were notionally named as £33M, £66M, £100M and £152M scenarios reflecting the pre-efficiency cost levels. For each of these scenarios we calculated the impact of customer contacts and the wider benefits within our SMF.

Table 6 – Preferred AMP8 AOW Programme Option Costs and Benefits

Intervention Type	£m	Benefits	Cumulative spend £m	Cumulative Benefits	Cost per benefit £M/benefit
Eliminate, reduce or delay the need for change. Data Improvements	1	0.04	1	0.04	0.0500
Enhance existing resources or add new resources. Operational network interventions new additional equipment, valves, new technologies and fittings	5	0.05	6	0.09	0.0100
Eliminate, reduce or delay the need for change. Care Plans and enhanced modelling (training, monitoring, ancillaries etc)	21	0.10	27	0.19	0.0049
Enhance existing resources or add new resources. Trunk mains automation for conditioning etc actuators and monitors purchase and installation	20	0.10	47	0.29	0.0050
Maintain the effective risk controls already in place. Mains Cleaning & Ice Pigging (the improvement element for additional network ancillaries to facilitate this work)*	3.4	0.13*	50.4	0.42	0.0036**
Maintain the effective risk controls already in place. Mains replacement and abandonment	63.7	0.03	114.1	0.45	0.0005

Intervention Type	£m	Benefits	Cumulative spend £m	Cumulative Benefits	Cost per benefit £M/benefit
Enhance existing resources or add new resources. Emerging Solutions Studies	4.3	Required to assess and trial emerging solutions	118.4	0.45	N/A

*An additional spend of £34.25M for this intervention will be funded from Base Maintenance which will contribute the AOW benefit shown here for mains cleaning and ice pigging. This will also be supported by a further £1.5M of base network modelling and investigations.
**Cost per benefit has been calculated using the total programme value not just the enhancement element.

3.1.1 Building a programme of work

The analysis set out in Table 6 above indicates that we have a range of options available with different relative costs and benefits. Emerging techniques options present new opportunities to improve service but come with low confidence, particularly where regulatory approval is required before they can be implemented.

No single option can deliver all the required AOW improvement because there would be diminishing returns and operational constraints. The basket of activities has been developed to deliver the required benefits through a diverse programme. The mix of activities in our preferred investment case can be seen in Table 6 above. We have also tested lower and higher levels of investment to optimise the balance of service and affordability. Options based entirely on emerging techniques (which whilst impractical to deliver at present) set out the scale of the opportunity if implementation barriers can be overcome and benefits materialise.

The core of our approach remains a source to tap assessment of the root cause of discolouration within the zone. This starts within the Catchment and at Treatment works – where we have separate investment cases - to deliver the benefits of reduced manganese entering the distribution system. Within this investment case, the prioritisation begins at trunk mains level with cleansing where this is possible. Where this is not feasible due to material type and pipe size, the options to replace will be carefully considered.

A minimum option would be to undertake conditioning of the main to reduce the impact of significant flow variations. Within the distribution system we will again review the options for cleansing and replacement dependent on pipe material and condition. All these options are reviewed through full hydraulic model and data analysis to ensure the most cost beneficial schemes are progressed. This approach has served us well in AMP6 and AMP7 and we will continue to develop and refine our processes into AMP8. The tables below highlight the levels of spend proposed to reduce Acceptability of water contacts and the use of emerging solutions.

Table 7: Mains intervention Enhancement Case shortlist options.

Solution Number	Improvement in contact rates for discoloured water	Combination of activities base and enhancement
Option S1	0.08	Mains interventions (Cleansing and mains replacements. Use of new technologies where beneficial) £33M budget
Option S2	0.13	Mains interventions (Cleansing and mains replacements. Use of new technologies where beneficial) £66M budget

Solution Number	Improvement in contact rates for discoloured water	Combination of activities base and enhancement
Option S3	0.16	Mains interventions (Cleansing and mains replacements. Use of new technologies where beneficial) £100M budget
Option S4	0.45	Mains interventions + wider programme to deliver beyond requirement. £152M budget
Option S6	0.39	Emerging Solution (100% emerging techniques solutions) £100M budget
Option S7	0.68	Emerging Solution (100% emerging techniques to deliver requirement.£152M budget

3.1.2 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).

Table 8 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).

Options **S1**, **S2, S3** and **S5** will not meet the performance targets required in our Regulatory Notice from the DWI, potentially leading to prosecution, and are discounted. Options **S6** and **S7** were discounted as they would rely 100% on unproven technologies and would present an unacceptable l risk of not meeting the requirements of the DWI notice. However, we will continue to investigate new technologies, at appropriate scales, and progressively, and responsibly, integrate them into our holistic approach.

Option **S4** was selected as it will meet the DWI requirements in conjunction with our Base Maintenance interventions, has the appropriate blend of approach strategies to meet to minimise risk and deliver the required performance requirements. It is cost beneficial and achieves the required total AOW customer contact target. The NPV is the highest of the technically viable options.

Table 8: Cost Benefit Analysis For the AOW Programme 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)
Conventional Solution	End of AMP7 Position	£0.000M	£0.000M	£0.070M	0.000	£0.070M
Option S1	0.08 C/1k/p AOW intervention Programme	£35.895M	£35.396M	£49.679M	1.404	£14.283M
Option S2	0.13 C/1k/p AOW interventions Programme	£71.791M	£70.792M	£124.066M	1.753	£53.274M

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 S3	0.16 C/1k/p AOW interventions Programme	£108.774M	£107.260M	£169.631M	1.581	£62.371M
Option S4 Preferred Plan	0.45 C/1k/p AOW interventions Traditional Mains and Networks Interventions programme	£165.337M	£163.035M	£233.319M	1.431	£70.284M
Option S5	Do Nothing - Deteriorate through AMP8	£0.000M	£0.000M	-£206.564M	0.000	-£206.564M
Option S6	0.39 C/1k/p AOW interventions Emerging Solutions Intervention Programme	£108.774M	£107.260M	£239.851M	2.236	£132.591M
Option S7	0.68 C/1k/p AOW interventions Emerging Solutions Intervention Programme	£165.337M	£163.035M	£284.925M	1.748	£121.890M

3.1.3 Detailed selection of zones for investment

The DWI Notice, Ref DWR-2022-00004, requires that all zones with a Contact rate greater than 1.08 are included within the Annex to the Notice and require an action plan. These action plans will cover WTW, SRV's Trunk mains and Distribution Mains. This Annex will be revised annually, based on the previous year's performance. For the purposes of putting together this plan we have selected a suite of zones where we will invest to reduce contacts in line with the overall Company level target, but some flexibility will be required to meet the terms of the Notice.

Table 9 below shows these zones that make up the current investment plan and from which the costs have been based.

Table 9 – Water Quality Zones Included with the AOW Investment Plan

Water Quality Zone Name	Mains Length Cleaned or Replaced (m)
Holywell Mold	70,166
Caerau / Ystradfellte	57,354
Conwy	155,991

Water Quality Zone Name	Mains Length Cleaned or Replaced (m)
Skewen / Llandarcy	66,421
Cardiff (Ely / Radyr / Llandaff)	28,968
Bolton Hill	85,650
Malpas / Caerleon / Cwmbran	55,331
Swansea / Morriston	22,663
North Anglesey	84,870
Hereford Central / North	74,279
Preseli	117,590
Denbigh	63,794

Other zones included within the Annex of the DWI Notice will have plans developed that reduce contacts, through Base Maintenance activities. This approach allows both the certainty of planning and delivering a known investment programme but also responding to the requirements of a DWI Notice that can change annually. Planning in this way will mean we deliver a company level benefit that hits the targets set out in this document.

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).

3.2 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

In order to demonstrate that we have considered the carbon impact, natural capital and other benefits we have included an excerpt from our Service Measures Framework which quantifies the benefits of different options, in this case the preferred scheme(s) associated with this Enhancement Case.

Table 10 – Profile of Benefits from our Preferred Option

Scenario	Benefits from AMP8 Spend relative to baseline		
	Legal Compliance	Customer Contacts	Total
Option S4	35.2%	64.8%	100%

The preferred option provides benefits split across improved legal compliance and a reduction in customer contacts with reduced customer contacts accounting for 64.8% of the overall benefits. These benefits feed into the Ofwat driver Improvements to taste, odour and colour. This benefit is low relative to the investment as it reflects the low impact of this measure to anything other than customer perception. This work is driven through Regulator pressure in comparing our performance against other companies.

3.2.1 Quantifying the Impact on Need and Performance CommitmentsThe foundation of our approach to reducing contacts from customers about water quality is our ability to map contact against network risk factors (pipe materials, hydraulic performance, source water characteristics etc.) and predict the way in which the network will respond to different types of corrective intervention (flushing, mains replacement etc.).

Our approach, developed over the last 10 years in collaboration with leading thinkers in the industry, begins with targeting the worst performing area, we do this at a Water Quality Zone (WQZ) level - as it is an appropriate size and how we are monitored by the DWI. Each WQZ has its own reporting line and target. This approach is carried over into the new DWI Notice where we have an Annex (updated Annually) which includes all zones above the Zonal target. Each zone then must have an action plan developed, from source to tap.

The new Notice requires that we undertake root cause analysis in four areas, namely Water Treatment Works, Service Reservoirs, Trunk Mains and Distribution main. The first two items are covered in other Investment Cases but the second two are picked up in this Enhancement Case.

Root cause analysis at a Water Quality Zone level begins with the production (or update) of an all-mains hydraulic model. Operational data, alongside the model, including water quality sample, customer contact data, and operational interventions, are collated to establish trends and identify risks. A longitudinal analysis allows for the quantification of risk and impact over time. As a result, this analysis identifies the number of customer complaints linked to each risk.

Each trunk main and DMA risk is then assessed to define the most appropriate network intervention mix based on the specific root cause requirements. The benefits are calculated for each solution and these account for any residual risk, for example cleaning solutions retain 20% of the original complaint risk due to future external factors like natural biofilm growth.

The most cost beneficial schemes for that zone are collated and the value of work selected within the zone is fitted into the overall programme level view of risk, performance and budget availability.

In AMP6, this programme delivered reduction in customer contacts at the rate of 1 contact reduction per £99k invested.

This was achieved because of our comprehensive source to tap strategy (targeting water treatment plants and trunk mains before local areas), the performance gap in the targeted areas and a lower cost capital environment. It was anticipated that the cost per complaint reduced would increase each AMP due to inflation, and a lower performance gap to the new target. As a result, the original AMP7 forecast was £144k per complaint reduced from construction spend. Due to the impacts of inflation, we now anticipate achieving a £151k cost per complaint reduced from construction spend. This is achieved through the system wide water quality benefits of targeting trunk mains.

In AMP8, we have forecast a cost per contact reduced at £157k, reflecting the lessons learned, new practises already implemented, and the expansion of enhancement solutions reflected in this case.

Throughout this approach, we have worked with external consultants to verify our strategy, work with us on hydraulic modelling and data analysis and validate our cost benefit assessment in each zone. This gives confidence in the schemes selected, with the track record to date exceeding performance improvements in each zone targeted.

A case study of a mains cleaning scheme selection, and its benefit analysis is detailed below.

3.2.2 Case study - calculation for mains cleaning scheme performance commitment benefits

To illustrate our approach in action, quantifying the impact of an intervention on the need, we have prepared a short case study related to mains cleaning.

The first image shows an extract from our analysis report highlighting the risks, benefits and estimated cost. The image also shows past contacts and water quality PCV failures in the area, as

well as linkages between this zone and others. The second image shows the data for past contacts, PCV failures, burst history, areas impacted, properties directly supplied, and assets targeted. Note the zone shows high numbers of contacts but is not showing any structural failures (mains repairs).

This is a good example of where cleaning is then recommended as the solution (i.e., no structural integrity issues). However, on further site investigation, cleansing may not be possible due to pipes being unlined Cast iron. This would lead to replacement being selected as an option and the cost benefit being rerun to establish if it is still viable.

The calculation for benefits per intervention is: (number of complaints) / (company population served) x 1000.

We assume that an intervention will remove 80% of the risk and complaints downstream of intervention over the long term. This is because potable water is not sterile and will naturally contain minerals which will accumulate over long periods of time and biofilms will naturally grow in drinking water systems as residual risks. Our proposals also include current and emerging technologies to enable more effective and efficient management of these residual risks.

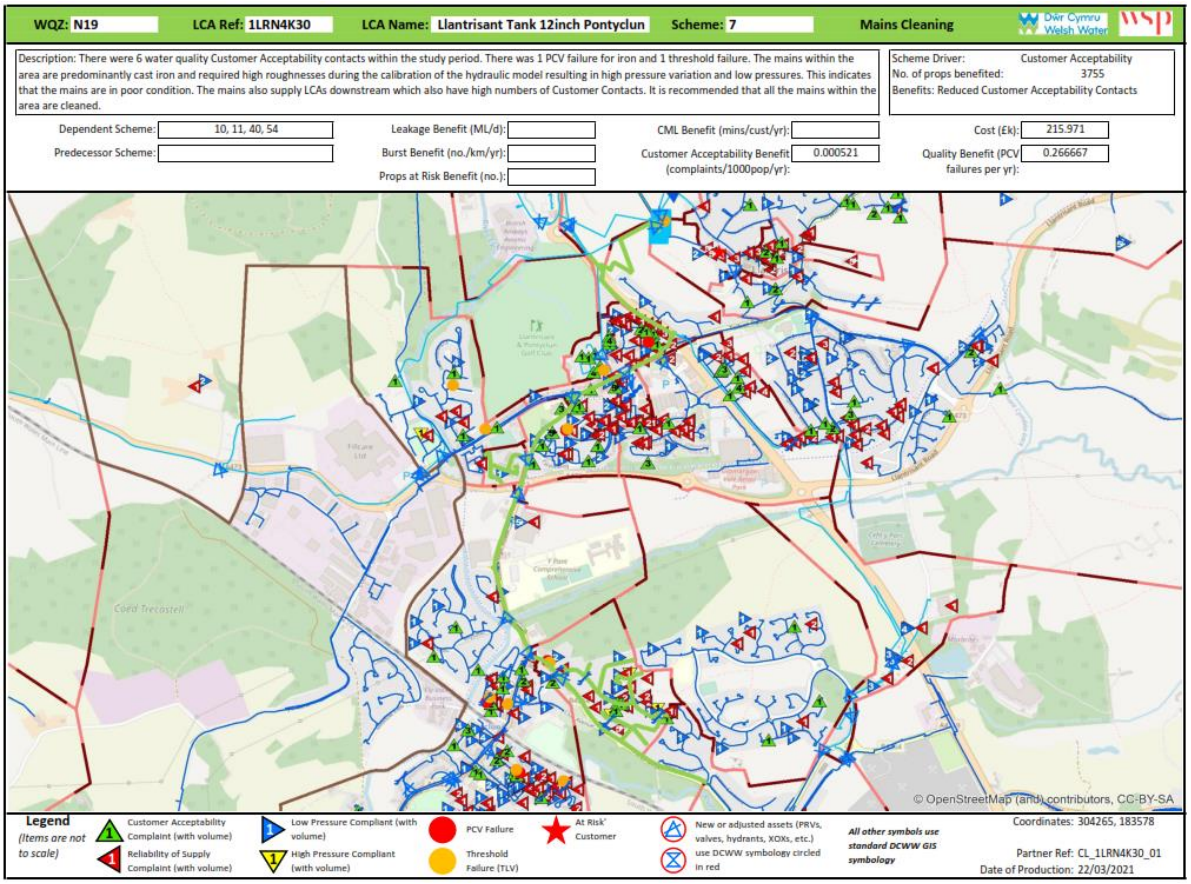

Figure 4 – Overview of historical contacts

WQZ: N19 | LCA Ref: 1LRN4K30 | LCA Name: Llantrisant Tank 12inch Pontyclun | Scheme: 7 | Mains Cleaning

Properties on the Main: 390 | Total Scheme Length (m): 6171

Proposed Mains in Scope

Material	Lining Type	Diameter	Length (m)
CI	None	3	146
CI	None	4	1520
CI	None	6	989
CI	None	10	1635
CI	None	12	428
		CI Total	4718
DI	None	100	19
DI	None	150	60
DI	None	250	89
		DI Total	168
DI	CL	80	10
DI	CL	100	26
DI	CL	150	34
DI	CL	250	529
DI	CL	300	64
		DICL Total	662
DI	EL	80	3
DI	EL	300	117
		DIEL Total	119
HPPE	None	90	259
HPPE	None	110	225
		HPPE Total	484
MDPE	None	180	12
		MDPE Total	12
uPVC	None	6	7
		uPVC Total	7
		Scheme Total Length	6171

Total Properties Benefiting

LCA Ref	LCA Name	LCA No. of Properties
1LWN4K34	New Park Llantrisant	425
1LWN4K35	Talbot Green	538
1LWN4K33	Forest Hills	398
1LWN4K37	Pontyclun District	2004
1LRN4K30	Llantrisant Tank 12inch Pontyclun	390
	Total Number of Properties Benefiting:	3755

Burst History

Job Number	Burst Date	Cause Code	Mains IPID

Attributable Water Quality and Customer Contact History

	Study Period (3 yrs)	Historic (3-5yrs)
Linked Acceptability Contact	6	3
Linked No Water Contact		
Linked WQ PCV Failure	1	

Figure 5 – Extract from Analysis Report

3.3 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. 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, these are set out above.

We are familiar with conventional maintenance methods such as mains replacement, ice pigging and flushing, and their costs and benefits are well understood. We will always default to the most efficient, "no-dig" techniques for mains replacement, only deviating where this is either not possible or the costs become comparable with open cut.

Drivers that can influence this choice are;

- Ability to reduce the size of the main, allowing slip lining to be a viable option.
- Need to provide a temporary supply in an urban environment connection each property can push costs as high as laying a new main. These methods are required to manage the CML

impact of our mains replacement programme. Allowing planned shut-offs for a duration of >3 hours but < 8 hours would reduce costs significantly.

- Ground conditions and proximity of other services will dictate construction method.

This detail emerges during the detailed design phase but we have developed check points and tracking tools in our AMP6 and AMP7 programmes for how to manage these costs.

During AMP7 we have been investigating alternative techniques to meet our Acceptability of Water Challenge. While there is no silver bullet, and mains replacement is the gold standard, we have investigated alternatives to allow pipe to remain in the ground. These alternatives include a magnetic device called the NMR – Pipetector (NMR stands for Nuclear Magnetic Resonance) that can reverse the corrosion in downstream mains (proven in small scale, closed loop systems – now being trialled at a larger scale within our network) and alternative cleansing techniques that may be able to allow cleansing of unlined cast iron mains without the risk of subsequent iron leaching. This latter technique is used in North America and Australasia but is not currently approved for use in the UK or Europe. We will continue to work with the industry but cannot build unapproved processes into our plans.

Case Study – NMR Pipetector Trial in Brithdir

The NMR Pipetector is a proprietary technology, NMR stands for Nuclear Magnetic Resonance. It is a magnetic device that offers the potential to reverse corrosion in unlined ferrous mains by converting rust, an orange soluble form of iron, into magnetite, a non-soluble form of iron that is 5-10x denser than rust. The conversion process occurs in-situ bound to the walls of the main. This technology has been proven in use in recirculated industrial heating systems. We have trialled the impact in a potable distribution network, the initial results are positive and we now need to widen that trial.

The trial in Brithdir was conducted on a 76mm cast iron main with an internal diameter corroded to 43.75mm (32% of the original water carrying capacity). The trial was measured using improvements in pressure loss brought on by the conversion of rust corrosion to the denser magnetite. Over an 18-month period the internal diameter of the main had increased to 49mm (43% of the original water carrying capacity) a 30% increase in flow carrying capacity. We now need to demonstrate that the expected reductions in customer contacts related to discolouration can also be achieved.

The graph below shows the original lower pressure conditions in green and the current higher pressure conditions in red. The lower pressure is apparent in the higher demand period of 8am to 10pm, when flows are at their greatest.

Figure 6 – Graph of original and current pressure levels

The uncertainties inherent in this investment case relate to mains condition, impacting the choice between cleansing and replacing, and once replacement is selected the site conditions that will impact the method of construction.

As outlined above, the preference will always be for cheaper, no-dig techniques, but reverting to an open cut method may be the only feasible or cost beneficial method. We have priced our programme on a blend of pipe sizes and ground conditions/ construction techniques to reflect a companywide programme.

Approximately 70% of the programme is expected to focus on mains above 200mm in diameter, which is consistent with AMP6 and 7, and we have assumed a 64% proportion of no-dig techniques, based on average practises to date. We are therefore confident our proposals adequately balance the requirement for efficiency with the need to innovate at the same time as managing risk.

4. Costing 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 (Section 4.10).

4.1 Developing a cost for the Acceptability of Water Programme

> ***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 undertaken large intervention programme within our network during AMP6 and AMP7 to improve acceptability of water performance and therefore have historical cost data to inform our AMP8 expenditure.

We have followed our standard approach to obtaining cost data in our which is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.10).

To incorporate the latest information we have used a bottom up approach using cost data from AMP7 projects, supported by the generation of interventions and our Unit Cost Database and the Cost and Carbon Tool. We were able to generate a range of costs for inclusion within each intervention type. This has allowed us to robustly cost the extent of the AMP8 intervention programme.

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.

4.2 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*

To achieve the reduced customer contacts for total AOW to 1.0 C/1k/p, we costed the enhancement work in AMP8 as £118M supported by £36M of Base Maintenance investment. As the number of customer contacts reduce, it becomes harder to achieve a continued reduction in contacts and therefore it is difficult to benchmark this approach.

To ensure that we are cost efficient we have applied a efficiency challenge of £111M to our planned programme optioneering costing, reducing our AMP8 AOW programme expenditure from £263M to a total investment of £154M, of which £118M is enhancement.

When planning to achieve the levels of reduction required in this AMP period, a bottom-up estimate of £263M was calculated using conventional improvement methods. This targeted lower volume but high benefit investments, which have been both highly successful and necessary in AMP6 and 7. In order to meet AMP8 efficiency targets set internally, we still need to conduct lower volume higher benefit investment, such as specific trunk main replacement projects for oversized deteriorating systems but our programme will also include higher volume lower benefit investment, such as automated trunk main conditioning for 125 trunk mains. The mixture of low volume high benefit and high volume low benefit solutions has enabled an efficiency of £111M to be planned.

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.

5. Providing Customer Protection

In this section we set out the linkage to the DWI oversight which will be in place around this Enhancement Case and the performance commitments which will be in place with Ofwat.

The below corresponds to the three criteria set out in A.1.1.4 of Ofwat Final methodology Appendix 9 (Setting Expenditure Allowances). There is no third-party funding for this Enhancement Case.

5.1 Proposed Performance Commitments (PC)

> ***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 existing performance commitments for customer contacts about water quality agreed with and regulated by Ofwat, and
2. The regulatory oversight from the DWI. The delivery of performance improvement is inherent to the DWI Notice with both zonal level and company level performance targets. Failure to meet these targets could result in prosecution.

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 Performance 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.

5.1.1 Extent of Protection

The proposed approach gives strong protection to customers around improved performance on customer contacts about water quality.

The mains replacement work proposed within this investment case will not have a material impact on other performance commitments (mains repairs, leakage, interruptions to supply). These secondary benefits were assessed in Enhancement Case WSH62-RS01, the pipes proposed for replacement to improve discoloured water compliance were generally in good structural condition and the analysis showed no material overlap with schemes for improving mains condition. As such we are not proposing any leakage, burst or interruption improvements because of the work set out in this Enhancement Case.

6. Appendix 1 – Long List of Interventions Considered

Table 1111 – Long List of Interventions Considered

Option	Type of Option	Brief Description of Option and Comments	Potentially Viable, i.e. progress to shortlisting?
1	Manage demand	Not viable: Demand management will be one of a number of interventions which can be used for addressing issues with AOW. In isolation this will not be able to address all AOW issues.	✗
2	Manage operation or use of the existing asset or service	Partially viable: As far as is reasonably practicable AOW issues are minimised through optimisation of existing processes and assets and operational practice. Where this has not be able to achieve the necessary improvement in performance then wider options included here are being considered. New Assets will be required to support further improvement.	✓
3	Maintain the existing asset or service	Not viable: Maintenance of the existing assets will be one of a wider set of options that may be appropriate based on the needs of individual locations but will not be appropriate to address all AOW issues.	✗
4	Replace the existing asset like-for-like	Partially viable: Where there is an issue with a AOW replacement of the existing asset is the solution of last resort and only used after all the alternative operational, conditioning and cleaning options have been discounted.	✓
5	Enhance/upgrade the existing asset or service	Partially viable: It is likely that a large percentage of solutions will require the enhancement of existing assets. However it will be necessary to undertake the appropriate root cause analysis on a case by case basis and in isolation enhancement will not be appropriate to address WSC issues.	✓
6	Mothball/dispose of the existing asset or service	Partially viable: The targeted abandonment of mains that are no longer required can partially resolve discolouration AOW issues.	✓
7	Create/acquire a new asset or service	Partially viable: It is likely that it will be necessary to install new assets to address some of the root causes of worst served customer service. In isolation new asset instals will not be appropriate but will form part of a wider range of viable interventions which can be selected from.	✓
8	Implementation of emerging techniques	Partially Viable: The use of emerging solutions to address mains cleaning, mains cleansing and mains stabilisation can provide some AOW improvement.	✓
9	Other	Viable: To promote the most appropriate interventions it will be necessary to undertake interventions based on individual root cause requirements. A blend of options 2,4,5,6,7 & 8 discussed above will form part of the likely most appropriate mix of solutions to address issues related to AOW and deliver the required performance improvements.	✓

7. Appendix 2 – Summary of Base Interventions to Maintain Total AOW

Table 1212 – Summary of Base Interventions to Maintain Total AOW

Summary	Discolouration Benefit Y/N	Taste &Odour Benefit Y/N
Catchment		
ResMix/Impounding Reservoir Destratification actively used	Y	Y
Draw off valve operability and automation at key sites	Y	Y
Catchment management	Y	Y
Predicting future raw water quality deterioration	Y	Y
Raw Water Distribution		
Raw mains maintenance and conditioning	Y	
Ability run to waste/flush mains to prevent build-up of sediment etc in mains	Y	
Water Treatment		
Regular operator training to enable WTW optimisation	Y	Y
Mn Removal process optimised (coagulation, Primary Filtration, Chlorination, pH control and Secondary filtration)	Y	Y
Optimisation of existing WTW processes	Y	Y
Maintaining stable flows through WTWs	Y	Y
Regular tank maintenance	Y	Y
Optimisation of pH control for Mn removal	Y	Y
Chlorine level winter summer regimes (temperature impact of chlorine decay)	Y	Y
Filter backwash winter summer regimes	Y	
Optimise PAC and GAC dosing where available		Y
Optimisation of GAC replacement & regeneration.	Y	Y
Linkage between chlorophyll levels or equivalent to drive PAC dose and GAC optimisation		Y
Improving filter backwash return to service and regular media replacement		Y
Procurement of low level Mn coagulant and lime	Y	
Regular tank and clear water storage cleaning	Y	
Water Distribution		
Network Resilience (investigations, levels of storage and rezone plans)	Y	
Dead End Cleansing, removal of mains debris from the system.	Y	Y
Root cause analysis following events & failures	Y	
Regular Operational Training	Y	
Standpipe management for third parties	Y	Y
Air and PRV maintenance and replacement	Y	Y
Bulk meter maintenance and replacement	Y	

Summary	Discolouration Benefit Y/N	Taste &Odour Benefit Y/N
Regular update training for third parties in the use of hydrants for example the fire service.	Y	Y
Water Pumping Stations and Service Reservoirs		
SRV Cleaning, Inspection & Maintenance	Y	
Secondary Chlorination Stabilisation		Y
Customer		
Improved information for customers on domestic plumbing and its impact on T & O and other discolouration generated in the home.		Y
Reminder on the website about hardness and taste and odour from washing machines and dish washers prior to bank holiday weekends, sale periods when purchases can increase		Y
Website self-help pages for Discolouration and Taste & Odour	Y	Y
Greater awareness of discolouration and its impact on health	Y	
Event information on the website to raise awareness and provide customer updates and information	Y	Y
Customer supply filters and their maintenance	Y	
Standard advice to customers regarding Chlorine + earthy musty T&O		Y

8. Appendix 3 – AMP8 AOW Enhancement CapEx by Year

The table below shows the total CapEx enhancement cost in Amp 8 for AOW investment. For this Enhancement Case the values map to the following lines in table CW3b of the PR24 Ofwat tables:

- Improvements to taste, odour, and colour (grey solutions); enhancement CapEx. (CW3b.91)

Table 1313 – AMP8 Enhancement CapEx By Year for AOW

Driver Ref	CapEx in £M by Year in AMP8					
	1	2	3	4	5	Grand Total
CW3b.91 CapEx	£18.469M	£18.361M	£23.934M	£31.192M	£26.365M	£118.421M
CW3b.93 TotEx	**£18.469M**	**£18.461M**	**£23.934M**	**£31.192M**	**£26.365M**	**£118.421M**

What We Will Deliver: This Enhancement Case will deliver mains cleaning, automations, optimisations, or replacement across 862km of our mains. These actions will cover interventions downstream of our WTW including actions at service reservoir sites, trunk and distribution mains. Each main will be evaluated independently but also as part of its system to identify the preferred action, or combinations of actions.