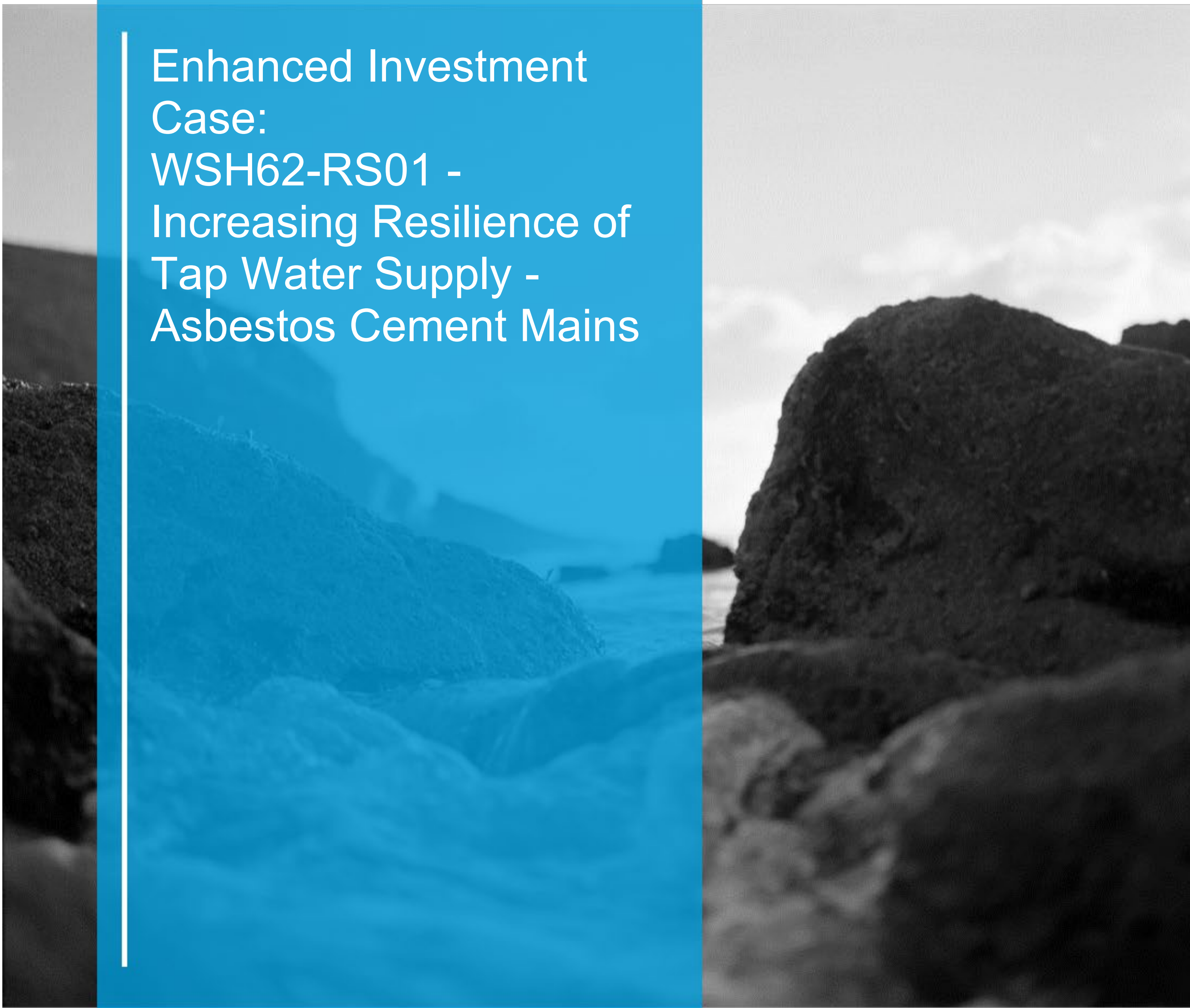
Dŵr Cymru
Welsh Water

Enhanced Investment Case:
WSH62-RS01 - Increasing Resilience of Tap Water Supply - Asbestos Cement Mains



Contents

Executive Summary

This investment will improve the resilience of our distribution mains network. It will counteract geology-based, accelerated deterioration in asbestos cement (AC) water mains performance that is particular to our operating area and allow us to deliver additional benefits for our customers and communities.

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 groupings:

1. Need for enhancement investment (5 sections)
2. Best option for customers (3 sections)
3. Cost efficiency (2 sections)
4. Customer protection

Need: The unique combination of water and soil chemistry in our operating area means that AC mains are degrading at a rate much faster than the UK average. This has an adverse effect on several areas, particularly mains repairs and interruptions performance.

If we do not step up the level of investment in our AC mains in AMP8, we can expect to see:
- Increases in mains repairs, worsening interruptions to supply, and worse service (particularly repeat failures for certain customers and communities).
- Significant increases in reactive costs, an extra £30m/year by the end of AMP9.

We have worked with independent specialists to analyse the drivers behind the condition of our AC mains and understand the subsequent impact on performance. 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 assessed over 40 scenarios using cost benefit analysis within our investment modelling software to consider how best to scale and target our response. Our chosen option is to invest to hold mains repair and supply interruptions steady (despite a step change in deterioration), and thereby provide a basis from which improvements in services can be delivered. We will need to invest in AC mains replacement at a level significantly higher than in previous periods.

What We Will Deliver: We will deliver 174km of AC mains replacement. This work will mainly focus on small-diameter pipes. We will also deliver 26km of AC replacement in base maintenance.

Efficient Costing: We will invest £66m (post efficiency, 22/23 price base, overlap removed) to replace 174km of AC water mains.

In developing schemes, we have modelled the costs for a basket of intervention types (open cut, directional drill etc.), by surface (grassland to urban) and diameter. 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: This work will be in addition to that delivered in our base maintenance programme and will be ringfenced through a price control deliverable (PCD) linked specifically to km of water main installed.

If the agreed length is not delivered, funding will be returned to customers on a proportional basis.

Benefits: The investment will maintain compliance with the performance commitment for mains repairs and interruptions to supply. Delivering a resilient asset base will allow us to build in additional, stretching performance improvements in mains repairs (reduce by 130 pa) and interruptions (reduce by 30 seconds). The work will reduce repeat failures and strengthen the resilience of rural water supplies which are disproportionally fed by AC mains.

Our approach has been independently assessed by Jacobs (Engineering and Costs), Economic Insight (CBA) and Cardiff University School of Mathematics (Statistics).

1. Introduction

The enhancement assessment criteria are divided into four groupings:

1. Need for enhancement investment (5 sections)

This section will set out the drivers behind the enhancement case and describe the context within which it has been developed.

2. Best option for customers (3 sections)

In this section, we will describe how we have developed options for addressing the need identified above. Our approach is facilitated by our investment modelling software, AIM, which allows us to consider multiple future scenarios. We can assess costs and benefits (including private and societal costs) through time, including performance impacts.

3. Cost efficiency (2 sections)

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. Customer protection

In this section, we set out the template for the proposed price control deliverable (PCD). This is designed to provide strong controls in terms of work delivered against funding allowed – if the proposed length of mains for replacement is not delivered, funding will be returned to customers on a proportional basis.

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 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 will set out the drivers behind the enhancement case and describe the context within which it has arisen.

We describe the deterioration observed in AC mains, the environmental factors (outside of management control) which are driving this and the implications for 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 Evidence that Enhancement is Needed

Is there evidence that the proposed enhancement investment is required?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.1a

Through AMP7, we have seen a material increase in the number of repairs required on AC water mains. In 2022/3 AC mains, which form 13% of our water distribution network, generated around 40% of mains repairs - this has increased from around 15% in 2009/10. This concentration of failures on a small proportion of the network means that certain customers and communities are receiving a disproportionately poor service. We have analysed this data to quantify the current situation, forecast our performance, and understand the underlying causes. Our analysis is set out in the sections below.

Current and historic performance

Across Welsh Water, AC mains now have the highest mains repair rate of any pipeline material, over double that observed on cast iron mains (the next highest), (Figure 1). This rate of failure is also increasing rapidly against a stable background for other materials.

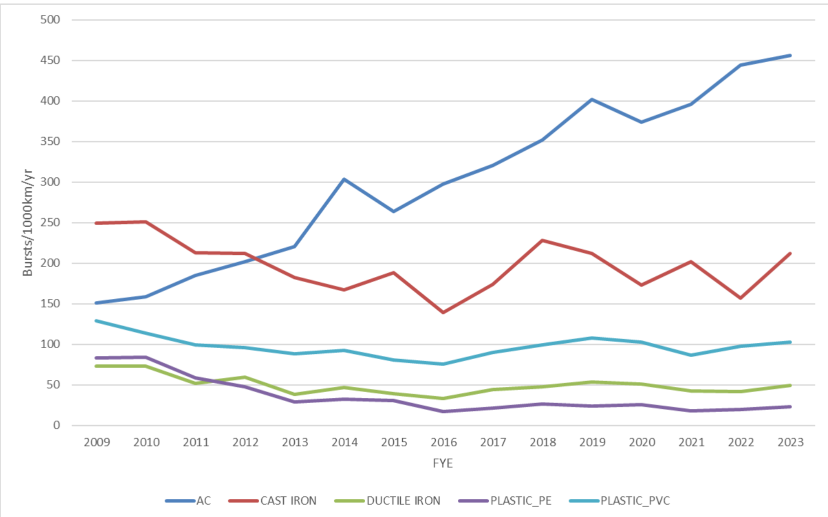


Figure 1 - Comparison of mains repair rates for top five pipeline materials by length since 2009

Through time, we have been able to meet expectations against the mains repair performance commitment and deliver improvements in interruptions to supply (which are strongly correlated with mains repairs).

This has been achieved by an efficient combination of targeted investment to manage mains repair rates; secondary benefits from our acceptability of water programme (AOW), through additional iron mains replacement to improve water quality performance; and our continued focus on implementing good operational practices, such as improved pressure management.

In addition, to manage interruptions to supply, driven by mains repairs, we have evolved our operational responses: for example, making more effective use of temporary supplies (such as overland riders), using our distribution teams more efficiently and improving use of network insights.

The planned combination of these activities has offset past changes in AC: i.e., we have been able to maintain stable performance of the network overall but allowing AC mains to fail more often (Figure 2).

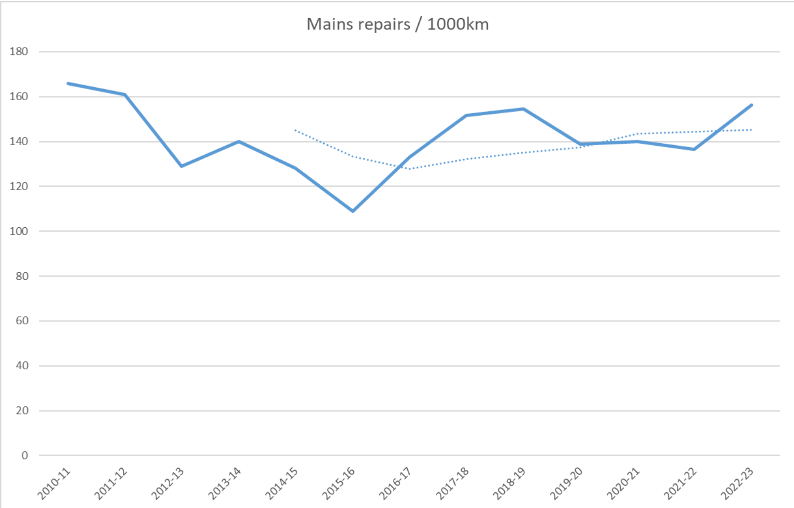


Figure 2 - Mains repairs since 2010/11, with 5yr moving average.

We have, however, reached a point where the rate of observed deterioration within our AC estate is so significant that we cannot continue to address it by mechanisms which have been successful in the past (see the options development section for more details) and the increase in mains repair numbers for AC are now preventing us from maintaining our desired level of service to our customers. In addition, we are also seeing a concentration of service failures in certain communities, which is creating an unfair distribution of risk across our operating area.

When we examined the asset health of our water mains using the PR24 Table CW20 Mains Condition matrix, we found that we have 314km of pipe in the worst asset health banding, Condition Grade 5 ('Very Poor'), of which approximately 75% (237km) are AC mains.

Figure 3 below builds on the cohort analysis work for Table CW20 by analysing mains repair data from three different five-year periods. This highlights the concerning pace of deterioration of our AC mains: the total length share of Grade 5 AC mains increases markedly from 1% (5 years from April 2008) to 6% (5 years from April 2018). When analysing this for Grade 4 and 5, an even more marked increase can be observed, from 5% (5 years from April 2008) to 21% (5 years from April 2018). This demonstrates that the issue has a scale and pace that will require immediate action and also a long-term commitment across several investment cycles. It is therefore outlined in this case and in our long-term delivery strategy.

When the other material cohorts are reviewed in a similar way, they exhibit typical lifecycle behaviour and, therefore, our previous investments in these areas have maintained or improved the assets' health over the last 15 years.

Figure 3 – Excerpt from PR24 table CW20 “Distribution mains condition” 2018-2023 with comparative analysis for previous periods

Figure Notes:
Although these show three different five-year periods, the analysis is all based on a single GIS-extract of water mains conducted in 2021. It shows how our current asset base was performing in prior periods. The table below sets out the condition grade definitions developed by Ofwat.

Condition grade	General meaning
1	Excellent Bursts average up to 125/1000km/annum over five years, (equivalent to 1600 metres or more between bursts over the five year period).
2	Good Bursts average greater than 125 up to 250 burst/1000 km/annum over five years, (equivalent to less than 1600 metres down to 800 metres between bursts over the five year period).
3	Adequate Bursts average greater than 250 up to 500 bursts/1000km/annum over five years (equivalent to less than 800 metres down to 400 metres between bursts over the five year period).
4	Poor Bursts average greater than 500 up to 1000/1000 km/annum over five years (equivalent to less than 400 metres down to 200 metres between bursts over the five year period).
5	Very Poor Bursts average greater than 1000/1000 km/annum over five years (equivalent to less than 200 metres between bursts over the five year period).

Forecast performance

We have worked with specialist consultants to examine the deterioration rate of our AC network and establish a future forecast of performance. Figure 4 shows the forecast increase in AC mains repairs with no investment being made. The increase, if left unchecked, would add significant opex costs and compromise our ability to manage both repairs and interruptions to supply.

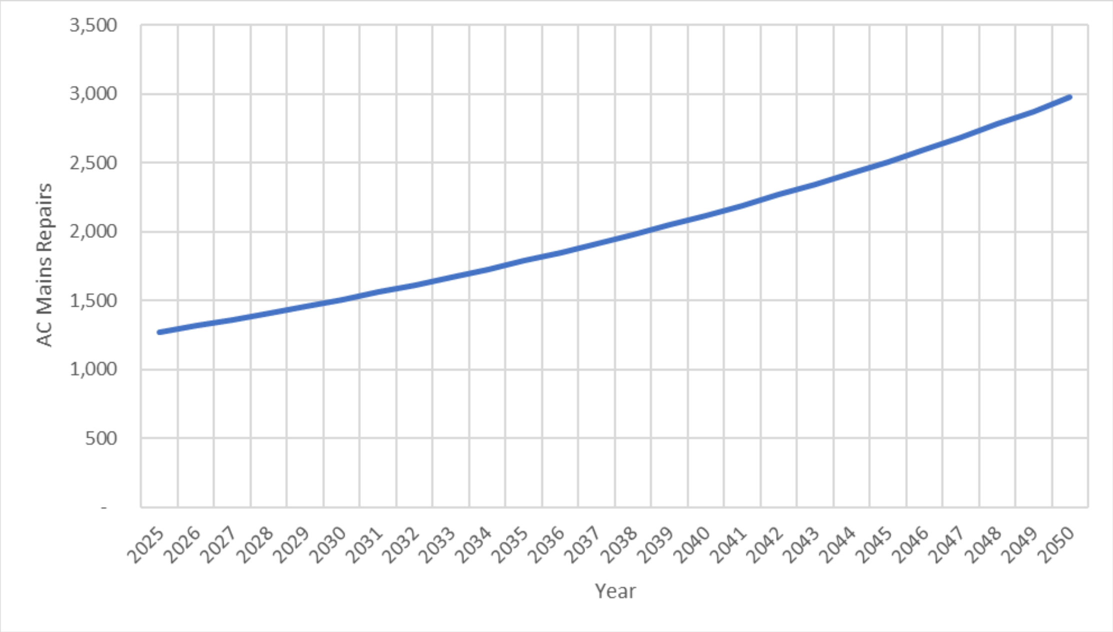


Figure 4 – Forecast deterioration in AC mains repairs without investment.

Our deterioration analysis has been built into our investment modelling tool, AIM, to allow future scenarios and interventions to be considered.

This work has been independently peer reviewed by Cardiff University School of Mathematics to further assure our approach to deterioration modelling.

Without intervention, the number of AC mains repairs is projected to increase from 1,272 in 2025 to 2,976 by 2050. Although AC makes up a relatively small portion of the network, this annual rate of increase (3.4%) is much steeper than that observed on Iron (0.7%). The service impact in the areas that AC mains are concentrated (e.g., South-West Wales) are heavily dependent on tourism and see a disproportionate impact on service.

Increased bursts lead to other negative outcomes for customers and communities.

- We will see increases in interruptions to supply, increased leakage and increased costs for repair.
- We will also see deterioration in other aspects: more traffic disruption, more carbon expended on repairs and more risk of customer flooding from clean water main failures. These impacts are monetised using our service measure framework (SMF), (Figure 5).
- These factors would collectively contribute to around £14m of additional private and societal costs each year by 2030.

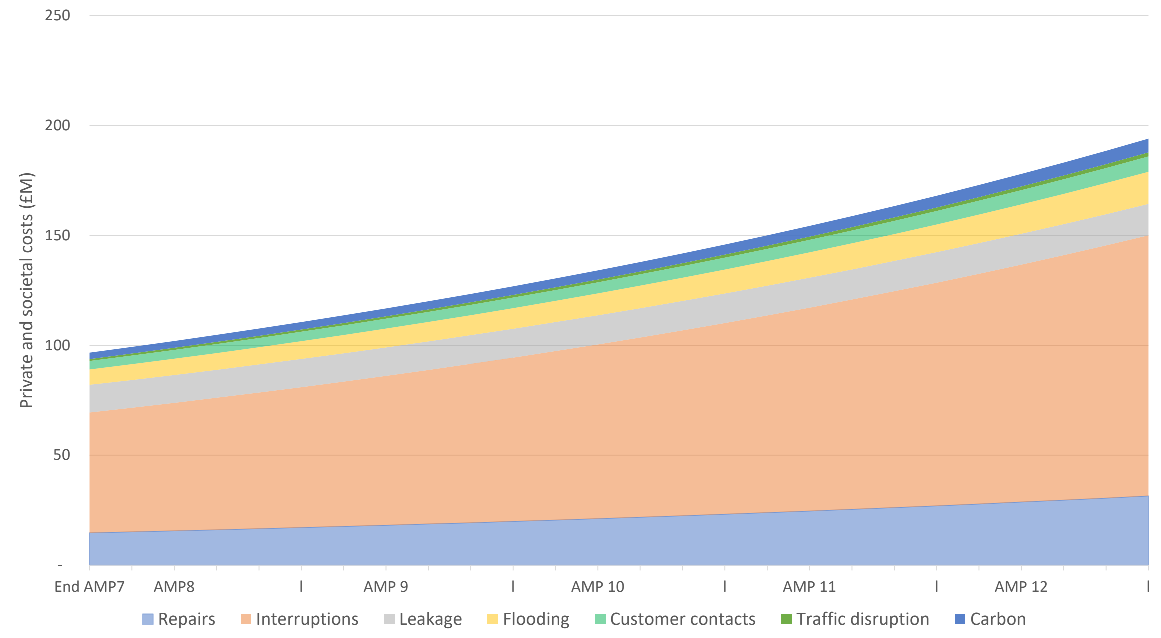


Figure 5 - Increase in mains burst impacts with no proactive investment

No Investment	2025	2030	2050
Total mains repairs (of which AC)	3,600 (1,272 – 35%)	4,200 (1,507 – 36%)	7,801 (2,976 – 38%)
Customer Minutes Lost	5 mins	6 mins 8 seconds	9 mins 22 seconds
Monetised disbenefit from deterioration all materials	n/a	£14m	£97m

It is also important to note, building on the condition Grade 5 analysis above, that many of these failures are concentrated on certain pipelines and in certain communities. AC is not uniformly distributed but is prevalent in areas where it was a favoured material. The hydro-chemical factors impacting deterioration are also not uniform in their distribution: rural areas of NW and SW Wales are particularly impacted. Disbenefits are therefore impacting disproportionately on certain communities (including those heavily reliant on tourism, where a poor water supply may impact the attractiveness of the area, in a competitive market), and customers – clearly, this is not acceptable.

‘Our property is plagued with poor water supply . . . not being able to flush the toilet, not being able to shower, dishwashing and washing machine issues, etc. This is now affecting our wellbeing and mental health, and something has to be done about this situation’.

Extract from customer correspondence, July 2023

We have also undertaken research to understand the future impacts of climate change on water mains bursts. It suggests that there will likely be a decrease in bursts for cast iron pipes due to anticipated warmer winters, reducing freeze-thaw events. However, this decrease is outweighed by an expected increase in bursts for AC mains. This increase is attributed to wetter winters, which will increase the level of degradation of our AC pipes externally due to the higher soil moisture content in autumn, winter, and spring, and warmer, extended summers causing greater stress on these pipes due to increased ground contraction.

This reinforces the need to accelerate the rate of replacement for our AC pipes ahead of the climate change impact. The predicted burst rates presented in this enhancement case exclude this additional deterioration. We are continuing to enhance our modelling in this area taking account of different climate scenarios to determine whether the pace of investment needs to increase even further in future AMPs. The early indications show that the impact in AMP8 would not be significant but would start to take effect in AMP9 and onwards.

Underlying causes

Welsh Water commissioned Ovarro DA Limited ("Ovarro") to conduct an analysis of failure rates on AC mains. Ovarro were selected as they have held a prominent role in the water industry in the analysis of asset risk for over 25 years, leading on many technical projects for UK Water Industry Research (UKWIR). Ovarro were also best placed as this analysis was an evolution of their AC Water Mains Deterioration & Failure Prediction Model UKWIR project of 2020, which included an industry data share on AC water mains failure rates.

The national data, as used in the recent UKWIR Project 20/WM/03/24 "Asbestos Cement Water Mains Deterioration and Failure Prediction Models", was compared against AC mains owned by Welsh Water to understand any difference in failure rates between our assets and the national asset stock. The findings are set out more fully in Section 2.7 below. Relevant sections of the Ovarro report (*W028503_GD004_03 AC Mains Failure Rate Analysis - Report*) is embedded in Appendix B, C and D.

AC is a brittle material, and like iron and PVC, it is vulnerable to fracture due to ground movement or loading. Unlike iron, it will not rust or corrode but is vulnerable to breakdown as the cement (lime) portion of the pipe matrix is dissolved into the water both inside and outside the pipe. The leaching of cement weakens the structure of the pipeline leaving it 'soft' and vulnerable to failure. The softening of the pipeline also makes it difficult to repair or replace sections as its integrity no longer allows jointing or clamping – meaning that longer sections of pipe often need to be removed, increasing the cost of repair and the impact on customers.

The major drivers of AC mains deterioration are water chemistry and water movement within and around the pipe. The soft water in Wales dissolves cement more rapidly than the water in some other parts of the UK does. More significantly, the soil pH, and the changing pattern of wetting and drying, changes through the year, leaching away the external layer of cement as well as creating ground movements that further weaken the pipes.

Our analysis (see Section 2.7) clearly shows that the environmental conditions in Wales are different to those in other parts of the UK and, as such, our AC mains are deteriorating more rapidly than in other areas.

> *'There is strong evidence that features of the Welsh Water asset base and particularly the environment are likely to be causing AC main burst rates to be several tens of percent higher than they would otherwise be'*
>
> Ovarro, August 2023

Conclusion

We have quantified the challenge posed by AC mains in our supply area:

- poor health as shown by increased mains failures (figure 1) and the emerging high proportion of Grade 5 mains (figure 3).
- forecast deterioration (figure 4) and the impact on future performance.

We are clear on the root cause behind this issue, and that these challenges are particular to our operating area.

We must act above and beyond investment in our base maintenance plans to prevent a service deterioration and allow a stable foundation from which to deliver improvements in mains repair and interruptions performance in AMP8 and beyond.

2.1.1 Evidence of Customer Support

Where appropriate, is there evidence that customers support the need for investment?

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

We do not believe that seeking customer support for this kind of investment would be appropriate or proportionate. This is in line with Ofwat's guidelines as set out in PR24 and Beyond: Reflecting customer preferences in future price reviews, and PR24 and beyond: Customer engagement policy – a position paper.
We defined an approach and framework for PR24 in discussion with our Independent Challenge Group which took a more focused approach than at PR19, focusing on the key questions with relevance for the price review.

The reasons for not pursuing research to assess the level of customer support for this kind of investment include:

- Materiality: The bill impact of this investment we estimate would be around £2.60 per year on the average customer bill, or around 0.5%. This is not material enough to be the basis for a meaningful conversation with customers about costs and benefits. Conducting customer research on this investment would therefore not be proportionate.
- Complexity: To reach an informed view on this investment, customers would have to be expected to consider technical issues around asset management, materials science, and modelling. Customers accept that they are not in a strong position provide advice on these matters and believe that it is the company's job to make the necessary decisions on how to invest in its assets. Conducting customer research on this investment would therefore not be proportionate.
- Relevant and useful: In view of the inevitable weaknesses in the strength and robustness of any customer views that would arise, the results would not be very meaningful, and it is not clear how the research would have practical relevance. Given the nature of the need for this investment, the decision on whether to progress with it or not would not be dependent on achieving a positive response from customers.

We do know from current communication with customers in affected areas, the impact this issue has on the service they receive and from previous research that customers do not expect to see any decline in performance levels. This investment is primarily intended to address the accelerating risk of mains repairs which will be impossible to contain without impacting customer service over the long run.

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

2.1.2 Scale and Timing of Investment

Is the scale and timing of the investment justified?

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

Through AMP7 we have seen a marked deterioration in our AC mains asset base. We can demonstrate that this deterioration will continue to accelerate as we enter AMP8 and beyond. Previously we have been able to mitigate the impacts of this deterioration through small scale, targeted base maintenance (and ongoing improvements to operational practices). However, the scale of the forecast increase and the diminishing returns from optimising base maintenance investment require a step change in activity. The rate of increase and our modelling results also show that putting this intervention off into future AMPs does not provide value or the service our customers expect.

Figure 6 below shows the age of our AC asset base, with most pipelines being over 40 years old and the majority being over 60 years old. Whilst age is not in itself a driver for replacement, the factors set out in Section 2.7 – soil pH, etc. - have been acting on these pipes for a considerable time and the resultant increase in service failures is visible in our mains repair data observed for each age cohort of pipelines.

Our analysis has helped us to pinpoint pipelines installed just after 1960 as of particular concern. Post-1960, AC is problematic due to changes in the manufacturing process; this cohort was largely manufactured using autoclave curing and contains less free lime which can affect long-term deterioration rates. Analysis of mains repair rate vs age for different installation date cohorts' points to this, and pipes installed just after 1960 are the oldest (and hence most deteriorated) of this problematic cohort. This engineering and statistical insight is captured in our deterioration models.

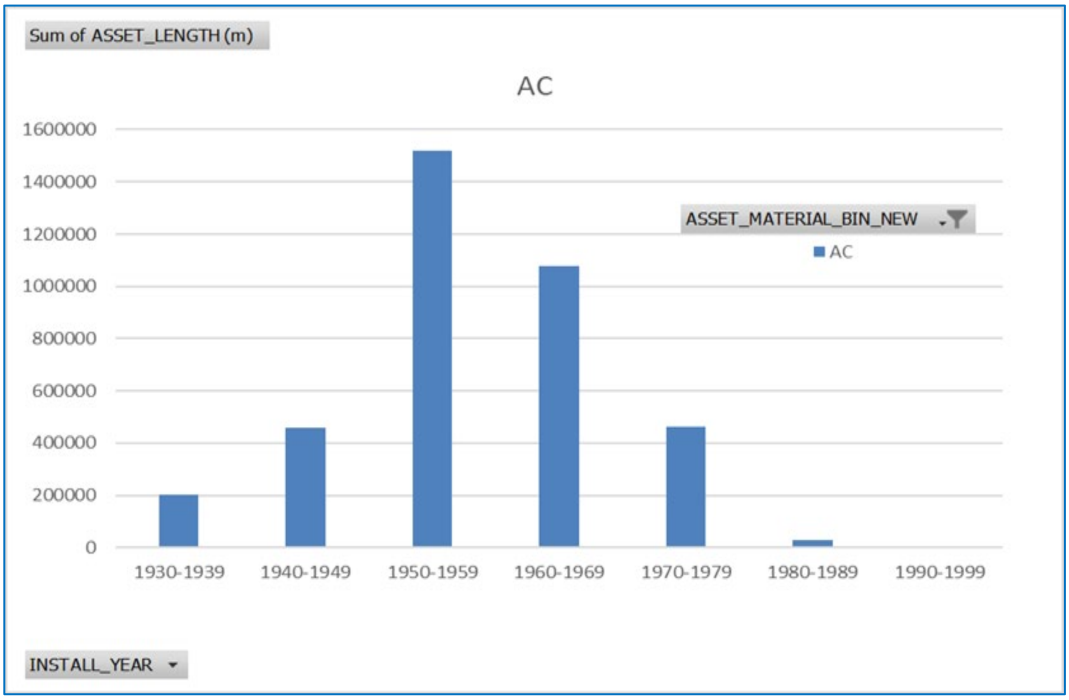


Figure 6 – Age of AC mains

Section 2.1 shows that the risks associated with this deterioration have already become visible and will continue to worsen through time. Other companies will not yet have observed the same levels of AC deterioration given the relatively benign hydro-chemical environment within which their AC mains operate.

Scale

We have choices around how we respond to the disproportionate impacts of AC deterioration, and these are explored in Section 3.1 below.

We can set out the scale of the opportunity.

Under a no proactive investment (i.e. Reactive only) scenario we would see annual costs to Welsh Water and our customers (disbenefits), driven by AC deterioration alone, increase sharply in AMP8. The table shows that in 2029/30 annual repair costs and associated disbenefits from AC would have increased by nearly £6m.

Period	Increase in annual Private Costs (£) – AC repairs and response	Increase in annual Customer and Community Costs (£)	Total annual value of disbenefit (£)
To end of AMP8	£2.21m	£3.47m	£5.68m
To 2050	£15.38m	£25.18m	£40.56m

The costs and impacts are concentrated in certain communities with a high proportion of (grade 5) AC pipe. Our models do not escalate costs for repeat failures, and as such it is likely that we are underestimating the value of the economic burden (especially those with high tourism levels) on these communities.

Acting now to deliver future promises

As part of our strategic plan to 2050, Welsh Water has identified a complementary suite of objectives and performance targets to best protect service resilience and prevent deterioration of service to customers. Reducing the number of 'water main mains repairs' is one such 'Critical to Quality' characteristic. 'Water main repairs' affect leakage performance, account for around 20% of customer complaints/contacts and 80% of Water Supply Interruptions. Without establishing a firm foundation of asset health we will not be able to deliver against these promises.

2.2 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

For all enhancement cases we have undertaken an exercise to ensure that base and enhancement spend is clearly segregated. This is covered in our investment narrative under 'fair regulatory treatment'.

For this specific case there is a clear overlap in activity which we have disaggregated.

- We will be investing (separately) through our base maintenance programme to replace pipes in our water distribution network. This work will include activity on all pipe materials and will continue to deliver at its historic levels (which has previously maintained performance – figure 2).
- The work in this enhancement case will be delivered in addition to the base expenditure and has been scaled back to account for the benefits which base maintenance will deliver.

The mains repair rate of our AC mains is now so high (the highest in the industry – Figure 7), that a step change in investment beyond base is required to offset the decline in asset health.

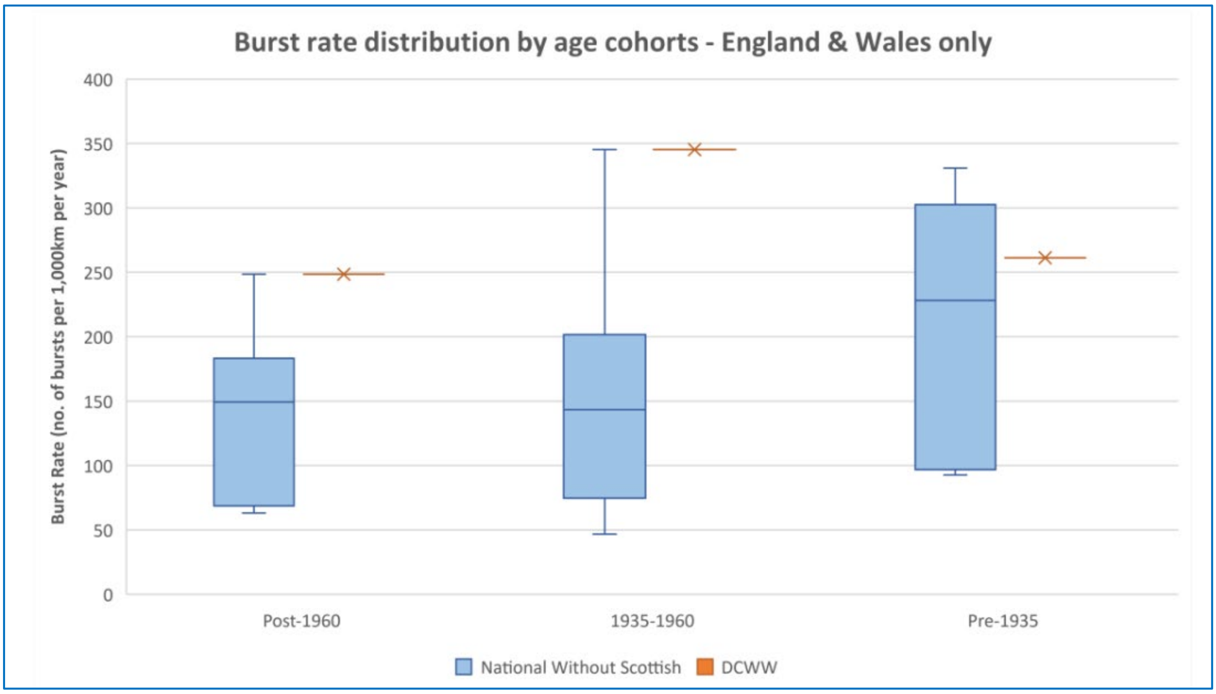


Figure 7 - Box-and-whisker plot comparing Welsh Water average burst rates with England & Wales companies

Figure notes:

- *The 'box' ranges show the 25th and 75th percentiles of company average burst rates i.e. the burst rates that are higher than for 25% of other companies, and for 75% of other companies.*
- *The horizontal line within each box shows the median burst rate i.e. the burst rate of the company that is in the 'middle' of the range.*
- *The vertical lines (the 'whiskers') show the maximum and minimum burst rates of the included companies.*
- *Comparison lines (the Welsh Water mean burst rate for each cohort) are included.*

Enhancement investment also allows us to create a step change in the benefits secured for customers and communities through targeting of pipe replacement. These benefits are not limited to the number of burst mains repairs but also allow improvements in other factors, such as the cost and level of service in this area.

The split is set out in the table below, using the enhancement case figures selected through our option development process.

	Base Maintenance AMP8	Enhancement AMP8	Total investment
Pipes targeted	26km of AC mains, 4km of other materials	174km of AC pipe	204km
Proportion AC	>80% of investment will be in AC	100%	>95%

Understanding base

Our base maintenance programme for structural rehabilitation is focused on delivering compliance with the mains repairs per 1,000km performance commitment. We can use our models, combined with our Zonal Studies approach, to effectively target which pipes should be replaced, to deliver this commitment, at lowest cost.

We have reviewed our historic activity to establish a base level of investment, prior to the emergence of the AC challenge, this will give us 26km of AC replacement.

We can target this investment effectively using our investment models, but it will not allow us to maintain the targets within the performance commitment going forward. Our models predict that with the current rate of AC deterioration our burst rate will rise by 448 bursts by 2030 under base conditions.

	Mains repairs 2025	AMP8 Base replacement	Mains repairs 2030
Base maintenance	3,600	30km	4,048

Removing the overlap

The figures presented below, in options development, include the activity funded through base – we are using an integrated model to promote efficient decision making within the option development process.

The 26km of AC replacement identified as base investment has then been removed from the investment proposed as enhancement post modelling.

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

We have been funded in previous price controls to hold mains repair levels stable, or in AMP7 to produce a small reduction in mains repairs through ongoing evolution of good practice. This funding has been based on a steady state network in which deterioration can be offset with base funding. Figure 2 above shows that previous levels of funding have been sufficient to hold mains repairs flat.

Over the longer term, mains repair rates have been managed through a combination of mains renewal and improved operational management (calmer, lower pressure networks). However, it is now clear that mains repair rates are rising again, driven by the strongly increasing mains repair rate of our AC mains (Figure 1). The opportunities for base to buy further amelioration of the increased deterioration of AC are limited.

We have not previously applied for any enhancement funding to address the exceptionally high mains repair rate of AC mains. Instead, we have used effectively targeted base investment to manage this emerging trend.

Our approach to this investment has been two-fold. Service impact modelling is used to set the long-term direction of travel and select between options at a companywide level. This sets the optimum spend value within each AMP investment period and how performance will be impacted.

Delivery within the AMP period is informed and refined through alignment with our approach to reducing Acceptability of Water contacts, while the reasons for investment are distinct the solution delivery can be combined. This approach targets areas that have the worst performance or in this case worst condition asset base, then undertakes a comprehensive investment report based on a full hydraulic model and data analysis. The schemes that are proposed out of this analysis, are individually assigned a cost benefit that is used to draw a best value line determining which investments go ahead. We have used this approach in AMP6 and AMP7 and delivered significant improvements in performance for discoloured water contacts, whilst holding mains repair performances stable.

Welsh Water have also invested in keeping this hydraulic model coverage up to date following the completion of works or major network changes. These refreshed models allow Welsh Water to continue with root cause analysis, capital investment and maintenance activities. Since 2017 Welsh Water have refreshed models covering 36% of the clean water network (10,080 km). This focus on use of hydraulic models has also driven operational benefits in how we respond to mains repairs, in allowing us to understand how rezoning can be achieved to mitigate supply interruptions and to plan maintenance work to mitigate any customer impact. This will continue to mitigate the impacts of these mains failures.

The delivery of these programmes will be through our Water Network Alliance. This set up allows us to delivery cost efficiently through blending work planning with the delivery of our reactive maintenance and leakage workload. Delivering in discrete areas also allows the efficiencies expected rather than from a disparate programme across a wide area.

2.4 Alignment with the Long-Term Delivery Strategy

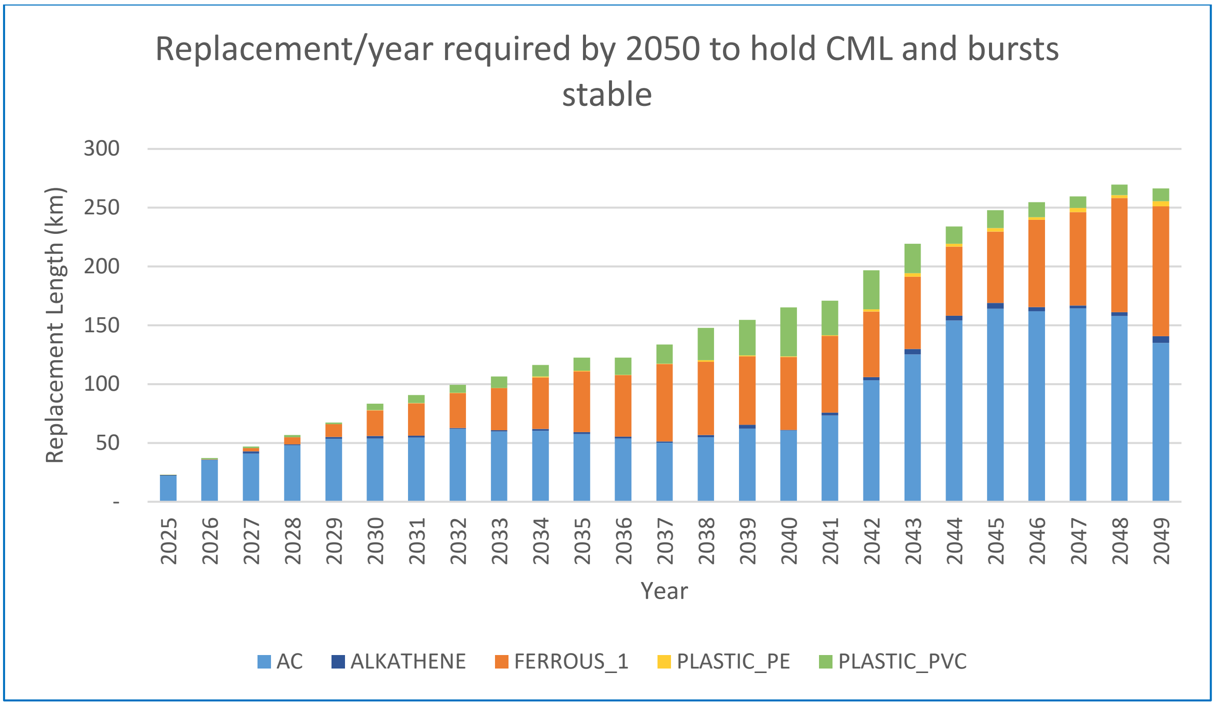
> ***Is the need clearly identified in the context of a robust long-term delivery strategy within a defined core adaptive pathway?***
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.1e*

Our investment modelling has allowed us to examine a broad range of future scenarios and consider the impacts of intervention on a full range of benefit outcomes. This includes, but is not limited to, mains repairs, interruptions, carbon, leakage and disruption to customers and communities. We have considered our investment needs over the next 25 years and the benefits which will accrue to customers over this period. Our approach to option development is set out in 3.1 below.

Welsh Water have a specific long-term output focused on customer supply interruptions. A key element of Welsh Water's core pathway is to address the impact that AC mains contribute to mains repairs within the network and associated interruptions of supply for customers. Welsh Water's 2050 target is to achieve an average supply interruption rate of 2 minutes per property from the end of AMP7 position of 5 minutes. The works outlined in this enhancement case are a central element in achieving this long-term ambition.

To outline the long-term scale of investment required to deal with our AC issue, running our preferred investment scenario forward to 2050, the investment in AMP8 is the start of a long-term plan to improve the health and resilience of our supply system.

Shown in the graph below, our modelling has identified the need to replace 2069km of the 3752km of our current AC mains by 2050 to support the delivery of our 2050 target for interruptions to supply and to counteract the steepening rate of deterioration that we are experiencing with our AC mains estate. We will continue to monitor our asset base using our service impact models to review the pace of replacement and whether we need to trigger an alternative investment profile as part of our adaptive plan.



The level of investment in AMP8 reflects what our current modelling suggests is most appropriate rate of mains replacement to be low regret to a range of future scenarios and hence forms our core adaptive pathway. Further details to how we have defined our core adaptive pathway can be found 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*

We have strong evidence of accelerated AC mains deterioration in Wales.

The UKWIR Project 20/WM/03/24 "Asbestos Cement Water Mains Deterioration and Failure Prediction Models" showed that certain environmental factors cause AC mains repair rates to increase.

Welsh Water commissioned Ovarro DA Ltd. to build on this work. To provide objective analysis of our AC mains repairs to identify and quantify the environmental factors, outside of management control, driving failure - *W028503_GD004_03 AC Mains Failure Rate Analysis – Report*. Relevent sections from this report is embedded in Appendix B, C and D of this document.

Ovarro examined the following factors and identified their impact on Welsh Water compared to the national average:

Table 3: Estimated effects of different features of the DCWW asset base – summary	
Feature / attribute of DCWW	**Estimated uplift caused to DCWW burst rates**
Smaller average pipe diameter	+4%
Lower average soil pH	+28%
Higher average soil moisture	+21%
Higher average monthly rainfall	+8%
Lower average water hardness	+3%
Difference in distribution of pipe installation dates	+1.5%

Source: Ovarro analysis conclusions (contained within in the sub-sections of section 7.1 of this document)

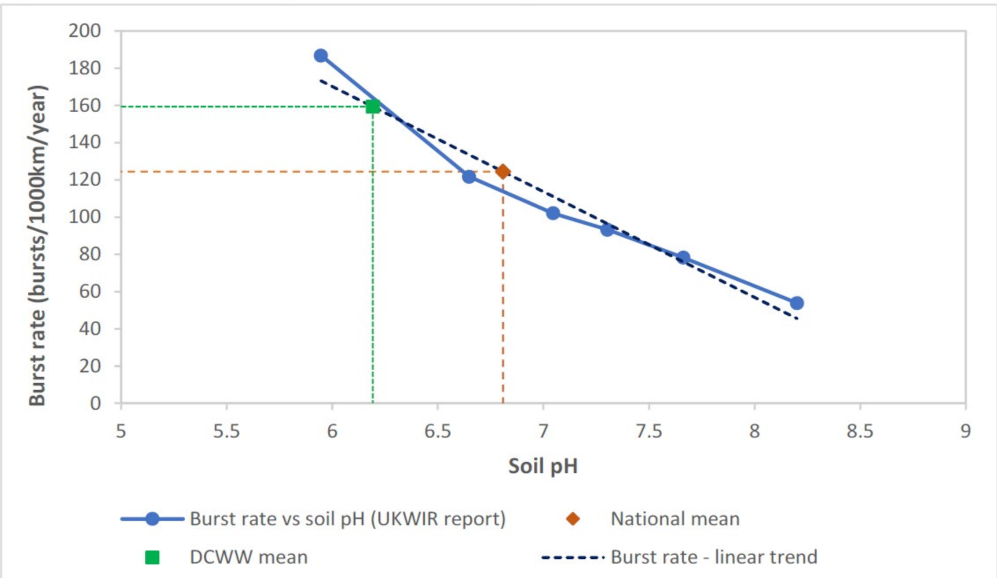
Ovarro compared our distribution of each of these factors with the England & Wales average. This provided a simple method to show how much higher our mains repair rates are than they would be under average environmental conditions. Ovarro concluded that:

'There is strong evidence that features of the Welsh Water asset base and particularly the environment are likely to be causing AC main burst rates to be several tens of percent higher than they would otherwise be'

Ovarro, August 2023

Analysis clearly shows that lower (more acidic) **soil pH** is associated with higher mains repair rates on AC mains, and soil pH in the Welsh Water area is particularly low compared to England & Wales. This is estimated to be making Welsh Water mains repair rates around 28% higher than they would otherwise be.

Figure 8, extract from Ovarro report, shows the national relationship between soil pH and AC mains bursts rate. [Note that this is the soil pH specifically where the AC mains are located.] Moving from the national average soil pH of 6.8 to the Welsh Water average soil pH of 6.2 (X-axis) shows that burst rate (Y-axis) would be expected to increase by a factor of 160/125 = 1.28, i.e., an increase of 28%. This difference would compound with other variables to create the failure rate observed on our asset base.



Source: Ovarro working

Figure 8 – The relationship between soil pH and AC failure rate nationally

Higher average **soil moisture** is also associated with higher mains repair rates on AC mains (the wetter soil is leaching away cement more quickly than in a dryer soil), and typical soil moisture in the Welsh Water area is higher than in most parts of England (although not Scotland). This is estimated to be causing Welsh Water mains repair rates to be around 21% higher than they would otherwise be.

There is also a relationship between **hardness** of water conveyed in AC mains and mains repair rate, with higher mains repair rates being seen on the pipes with the lowest water hardness levels. Water hardness in Welsh Water is typically significantly lower than the England & Wales average (although not Scotland). Based on national trends, the lower average hardness of water at Welsh Water is estimated to be making Welsh Water mains repair rates around 3% higher than they would otherwise be.

In addition, **smaller pipe diameter** mains are associated with higher mains repair rates, and a higher proportion of AC pipes are in the smaller diameter bands (<100mm) at Welsh Water than is the case in the national data. This is estimated to be causing Welsh Water mains repair rates to be 4% higher than they would be if Welsh Water had the same distribution of pipe diameters as is seen nationally.

The UKWIR report and the subsequent follow-on work by Ovarro are based on good science and good statistics. We have also worked with Cardiff University School of Mathematics to provide a further academic peer review of the work delivered.

These hydro-chemical factors are clearly outside the management control of Welsh Water.

<u>Controlling costs - delivering more from base</u>

Through AMP7 we have invested to maintain the performances of our network. This has included targeted replacement of failing pipes but has also involved ongoing improvements in how we are managing the network. Delivering calmer lower pressure networks through both training our operators in network interventions, installation of new pressure management systems and optimisation of existing pressure controls. We have also invested in improved modelling and analysis to be able to better understand and target investment. This work has been delivered through base investment.

Beyond AMP7 there remain limited opportunities for further pressure management interventions or other alterations to network control to prolong the life of our distribution mains assets.

<u>Controlling costs - delivering more for our money</u>

We undertake every effort to extend the life of our legacy asbestos cement 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 maintaining supplies to our customers.

While we continue to review current mains relining techniques, we are yet to be persuaded of the long-term effectiveness of these techniques. Figure 9 shows examples of failed lining within our system. These failed linings mean that our preferred approach during AMP8 will remain the replacement of mains with preferred materials of construction. This balanced programme of interventions in conjunction with our base interventions will deliver best value in delivering the improved interruptions to supply performance for our customers over the long term.

Main at 0.2m flaked lining identified

Beginning of survey POI flaked PU lining identified

Figure 9 – 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. Our approach is facilitated by our investment modelling software, AIM, which allows us to consider multiple future scenarios. By turning business problems into mathematical models, AIM can try out trillions of possibilities to find the optimal solution. We can assess costs and benefits (including private and societal costs) through time including performances impacts. The modelling approach in AIM is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

We identify investment to offset increased deterioration and hold burst and interruption levels stable at a company level as a foundation for delivering stretching improvements in interruptions to supply and mains repair performance. The chosen option will deliver NPV benefits of over £250m, with a NPV spend ratio of 3.4. There remains higher cost, higher benefit options which we have ruled out at this stage.

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.

3.1 Identification of Solution Options

> ***Has the company considered an appropriate number of options over a range of intervention types to meet the identified need?***
>
> *– Ofwat's final methodology for PR24, Appendix 9, A1.1.2a*

Our overarching approach to optioneering is set out in our investment narrative.
In answering this question two levels of optioneering have been undertaken.

Firstly, we have looked at different solutions that could be deployed to manage the risk of increased deterioration.

Option	Description	Assessment
Enhance existing resources or add new resources. **Chemical dosing at Water Treatment Works** **Non-traditional**	Dosing at treatment works to increase water hardness slowing deterioration of mains	▪ Unproven/limited benefits ▪ Will not correct damage already done. ▪ Will not mitigate hydro-chemical challenges outside of the pipe ▪ Creates additional water quality risks to disinfection of water. ▪ REJECT
Eliminate, reduce or delay the need for change. **Pressure management**	Reduce pressure in the network to reduce mains repair frequency	▪ Extensive pressure management has already been successfully implemented during the last 20 years, extending asset life. ▪ Opportunities for additional interventions are very limited. ▪ REJECT
Maintain the effective risk controls already in place. **Semi structural lining** **Non-traditional**	Restore structural integrity of pipes, prevent further internal corrosion	▪ Technology not routinely used. ▪ Pipes would still be vulnerable to external corrosion. ▪ Technical challenge of applying to deteriorated pipes ▪ Restricts water flow ▪ Not suitable for small-diameter pipes ▪ REJECT

Option	Description	Assessment
Maintain the effective risk controls already in place. Remediation: Slip Lining	Pulling or pushing a new pipe of smaller diameter into an existing pipe	▪ Significantly restricts water flow, ▪ Not suitable for small-diameter pipes ▪ VIABLE FOR SOME PIPES
Maintain the effective risk controls already in place. Remediation: Directional Drill	A trenchless method of installation using horizontal boring machines which drill a pilot hole which is then enlarged to allow insertion of new pipe.	▪ Poor soil conditions limit speed of remediation and increase cost. ▪ With good conditions faster than traditional excavation methods ▪ VIABLE FOR SOME PIPES
Enhance existing resources or add new resources Replacement: Pipe bursting	Pulling a new pipe of similar diameter through the existing pipeline, destroying the existing main in the process	▪ Faster than traditional excavation methods ▪ Can be more expensive than traditional methods in certain situations ▪ May not be suitable where soil movement is an issue ▪ VIABLE FOR SOME PIPES
Enhance existing resources or add new resources Replacement: Open Cut	Replace pipe with modern equivalent through excavation along the full pipe length	▪ Well established approach removes risk ▪ Expensive intervention ▪ Most predictable intervention ▪ Additional above ground disruption ▪ VIABLE FOR ALL PIPES
Enhance existing resources or add new resources Replacement with/without associated communication pipes	When replacing the main we have a choice around whether to re connect the existing communication pipe or replace it	▪ Both options are technically viable, replacement of communication pipes increases costs but is a very efficient way to deliver additional benefits – reducing leakage and improving water quality (particularly removal of lead pipes) ▪ WE WILL REPLACE COMMUNICATION PIPES WITH STRUCTURAL REHAB WHERE EFFICIENT

Note: Our work with HSE on AC replacement has concluded that pipe-bursting, and slip-lining are acceptable methods even though AC will remain in the ground.

Having identified structural replacement (using a variety of methods) as being the only viable option for addressing AC mains deterioration we have used our investment planning software to appraise multiple programme options. The key scenarios are set out in the tables below.
The cost benefit assessment (CBA) tool within our investment model is a powerful support to decision making, building a clear view of different options through time. We have examined the output from the modelling in two ways:

- We can use the common CBA metrics – NPV and the ratio of NPV to spend – and the absolute figures for performances (mains repairs and interruptions to supply).
- We can look at the individual benefits, both direct costs to Welsh Water (mains repair costs) and wider societal and environmental benefits captured by our Service Measure Framework (SMF). This analysis helps us to understand where benefits are accruing within the CBA (see Section 3.3).

We can also repeat this analysis to take account of overlaps with other programmes, specifically our base maintenance and the iron mains replacement programme, which is driven by our acceptability of water (AOW) programme.

Modeled options

We have assessed over 40 options in preparation of our plan, examining targeting particular pipe groups (e.g., pipes in condition grade 5), phasing work are different rates through time and exploring different levels of service. In the section and table below, we present six core scenarios:

1. **Do nothing:** We have begun by assessing a reactive, no investment approach. This shows the deterioration in the network with regards to mains repairs, customer minutes lost and other factors within the SMF. Over AMP 8 we see a deterioration of 17% in mains repair rate.

2. **Base maintenance only**: Investing to replace 26km of AC mains from base funding to reduce the number of mains repairs in AMP8. This option, alongside the arguments in the sections above, demonstrates that historic investment levels will no longer sustain stable performance.

3. **Hold Mains repair numbers flat at minimum cost**: we have assessed an option designed to hold mains repairs stable at lowest private cost – this sets the model to identify the pipes which will give the most cost-effective means of maintaining mains repair numbers with no consideration of wider benefits. This scenario, in which the model chooses to invest 80% of its interventions in AC replacement, can be achieved for £63M.

4. **Hold mains repairs and interruptions flat at minimal cost:** This option changes the mix of pipes being selected to pick pipes which are failing and having an impact on water supply interruptions. To counteract deterioration on the network and the corresponding increase in interruptions, we would need to invest more than we would simply to hold mains repairs flat (we would also need to invest a total of 85% of the funding in AC). This scenario can be achieved for £66M.

   THIS OPTION – TO INVEST AN ADDITIONAL £66M IN AC - HAS BEEN PUT FORWARD AS PREFERRED

5. **Maximise whole life benefits**. This run allows the model to seek out the most beneficial set of interventions over a 30-year horizon. The model picks a larger volume of pipes to make a significant investment in AMP8, which increases payback time but produces the greatest overall NPV (nearly double that of option 3). The investment does not pay back within the 30-year horizon but would continue to accrue benefits beyond this time to become NPV positive. This option brings the greatest benefits to customers but would be difficult to deliver within a 5-year timeframe and would create short term affordability challenges. As such it is not recommended for AMP8.

6. **Lowest whole life costs (WLC)** – this model seeks to minimise private (company) costs through time. It looks purely at balancing the costs of structural rehabilitation against repair and response costs over a 30-year period. This is the most efficient solution in terms of 'real £' costs – the balance of repair/response costs against replacement costs. This is a strong option with a higher NPV than option 4 and reductions in mains failures and interruptions to supply through asset replacement. This option also selects some larger diameter iron pipelines which are expensive to repair (and replace) and as such the % of AC investment is reduced, but still at nearly 70%. The NPV for private costs at 30 years can be compared in the table below.

Scenario	NPV of private costs (at 30 years)
3. Hold mains repairs Flat	£102.5M
4. Hold Mains repairs and Interruptions Flat	£104.5M
5. Maximise whole life net benefit	-£45.2M
6. Lowest whole life cost	£107.0M

Scenario	AMP8 spend above base allowance (2022/3 price)	AC length replaced (km)	End of AMP8 Position		NPV (30 years)	Ratio of present value of costs to present value of benefits at 30 years	Payback year
			Mains repair rate	Customer Minutes Lost			
1. Reactive Only Base Allowance (no mains replacement)	£0	0	4,200	6m 8s			
2. Base Maintenance investment only	£0	26km	4,048	5m 46s	£63M	7.3	2030
3. Hold mains repairs Flat	£63M	186km	3,600	5mins 17s	£234M	4.2	2034
4. **Hold Mains repairs and Interruptions Flat**	**£66M**	**200km**	**3,600**	**5mins**	**£270M**	**4.5**	**2033**
5. Maximise whole life net benefit	£447M	570km	2,926	3mins 17s	£431M	1.9	2041
6. Lowest whole life cost	£144M	289km	3,382	4mins 42s	£366M	3.4	2036

Notes:
AC makes up 13% of our current network.
Scenario 3 to 6 include the length of pipelines replaced through base maintenance, for example in Option 4, 26km of the 200km is base maintenance.
Scenario 1, reactive only, is our baseline position the 'zero' from which the benefits in other scenarios are measured.

<u>Discussion of modelling results</u>

Our modelling analysis is a helpful tool in quantifying options and provides insights for consideration. Focusing only on asset health, and simply the number of mains repairs recorded, we would promote Option 3, hold mains repairs flat. However, this option would lead to an increase in interruptions to supply, which would not be acceptable.

As such Option 4 is the minimum viable option. In this option (which includes 26km of AC replacement under base maintenance) 85% of the total investment is used to replace AC mains –

highlighting the challenge posed by this material. It has a better ratio of NPV to AMP8 spend than Option 3 – tuning the investment to manage interruptions gives greater customer benefits than focusing on mains repairs alone.

Option 4 does not however maximise benefits to customers or deliver lowest costs, and more ambitious programmes of work could still be promoted:

1) Whilst investment can hold the overall mains repair/interruption numbers flat we will continue to accrue the negative impacts of mains repair failures – repair costs, interruptions to supply, carbon etc. Increasing targeted replacement of mains beyond that chosen in Option 4 will reduce whole life costs and increase whole life benefits to customers. These benefits are visible in Option 5 which seeks to maximise all benefits to customers and Option 6 which seeks to minimise whole life costs. Option 6 is worthy of further consideration.
2) Prevalence of condition grade 5 pipes, particularly in AC. The model runs targeting flat mains repairs will pick up pipes with high numbers of mains repairs, but it will not eliminate all category 5 pipes. These pipes have a disproportionate impact on customers (an asymmetrical risk for some bill payers) with repeat disruption and interruption. The model does not assign additional benefits for addressing repeat failures. We will seek to take account of pipe failures with higher customer impacts through further optimisation in period, but again a case could be made for increased investment in condition grade 5 materials.

Whilst Option 6 is economically more efficient, and Option 5 produces greater benefits than the chosen option these scenarios have larger bill impacts and slower paybacks than the chosen option.

Removing Overlaps

We have set out an overlap with base investment in 2.3 above. The figures in the table above (Options 3 to 6) include 26km of AC replacement from base funding which has been removed from the enhancement case in the data tables.
In addition to the work planned to deliver improvements to our mains network for asset health we will also be:

- Investing in iron main replacement to support our Acceptability of Water (AOW) programmes (see enhancement case WSH54-CW02 Improving Acceptability of Tap Water). This is driven by our performance vs the rest of the industry and is supported by the DWI, and
- Investing in mains replacement to manage leakage. This investment is in AMP10 and beyond, and to simplify presentation we have not included this as part of the enhancement case – there is no overlap in AMP8.

We can re-run the options above forcing the model to pick the AOW pipes for replacement before seeking the goal (option) set out above. We can capture the changes in the asset base and associated benefits from the AOW and assess whether this reduces the scale of the required investment for AC.

The results of the refreshed analysis are below, showing the addition of the forward works programmes for our chosen option – to hold bursts and interruptions flat – is negligible.

1. **Do nothing:** As above we have begun by assessing a reactive, no investment approach. This shows the deterioration in the network with regards to mains repairs, customer minutes lost and wider factor. Over AMP 8 we see a deterioration of 17% in mains repair rate.
2. **Forward Works Programme (AOW mains replacement):** Here we see the impacts of the FWP. None of this work is on AC mains. The iron mains selected for replacement are chosen using water quality criteria rather than structural performance. Mains repairs are 40 lower, and interruptions are 3 seconds lower, i.e., lower than they would be without the AoW mains replacement. This impact is not material – as shown below.

Scenario	AMP8 spend	End of AMP8 Position	
		Mains repairs	Customer Minutes Lost
Reactive Only	£0	4,200	6m 8s
AoW (Iron) Programme only	£63.7M	4,160	6m 5s
Difference		**40 (<1%)**	**3s (<1%)**

As the AOW programme is driven by water quality needs, focused on iron mains replacement, the overlaps with maintaining burst and interruption performances are non-material. We have, therefore made no adjustment to this enhancement case to reflect AOW activity.

3.1.1 Assessment and Selection of Solution Options

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, A1.1.2b

Our approach to cost benefit assessment is set out in WSH50-IP00 Our Approach to Investment Planning (Section 4.3). For this enhancement case our cost benefit assessment has been delivered within our AIM optimiser model. The approach is mathematically the same as that used elsewhere in the plan but is calculated in a different environment (within the AIM software and not within an MS Excel worksheet).

The results from our economic analysis are included in our scenario results above to ensure a clear articulation of results in the context of options considered.

We have assessed private costs (the costs of replacement and repair) and societal costs/benefits (carbon, valuations for interruptions and disruption etc.).

The option put forward has a positive NPV and a strong return on investment. Our approach is prudent but is does not deliver the lowest whole life cost or maximise benefits – by investing more we could improve returns to customers.

The approach has been independently assured by Economic Insight and details are provided in WSH50-IP00 Our Approach to Investment Planning (Sections 4.10 and 6).

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

Our approach to cost benefit assessment and valuation of benefits via our Service Measure Framework (SMF) is outlined in WSH50-IP00 Our Approach to Investment Planning (Section 5.4). The SMF benefits are included in our model, and we can clearly track these benefits for each of the options considered.
The table below shows the breakdown of the benefits accrued under the preferred option. It breaks down the 30-year NPV presented in the table in 3.1 above by driver.

Scenario	AMP8 Spend above base (22/23 price)	Benefits from AMP8 Spend relative to baseline (£M, discounted to 2022/3 prices)					
		Opex for mains repair	Carbon reduction	Customer Complaints	Interruptions	Other	Total NPV (30 years)
Preferred – 4. Hold Mains repairs and Interruptions Flat	(£66M)	£140M	£6M	£9M	£186M	£5M	£270M

Notes: 'Other' includes traffic disruption and risks of customer flooding.

The analysis above clearly shows how the economic benefits of investing in our mains network have been quantified.

We see significant benefits from reducing interruptions to supply (this is the major driver within Option 5 which seeks to maximise whole life benefits), whilst carbon reductions are a smaller part of the benefits calculation, they remain material in moving us towards our net zero target. The carbon figure here is the cost of carbon associated with the impact of bursts and repairing them.

Within our cost benefit process the impacts of each option on the need have been quantified. Our methodology is set out in the document WSH50-IP00 Our Approach to Investment Planning (Section 4.3).

This approach has been assured by Jacobs and has been used to ensure that we pick the best option for customers using CBA principles.

For this enhancement case we have examined the impacts of options on 3 performances commitments: leakage, interruptions and mains repairs and used our models to quantify impacts.

Option	Mains repairs	Interruptions	Leakage
Do nothing (No Investment)	+600 mains repairs	+1 minute 8 seconds	+ 2.86 Ml/d
Preferred – 4. Hold Mains repairs and Interruptions Flat	No change - stable	No change – stable	No change
Chosen Option Stretch target for the end of AMP8 ('typical year')	Reduce mains repairs by 130 per annum	Improve interruptions performance by 30 seconds	Improve 0.62 Ml/d

The chosen option – hold bursts and interruptions flat – against a background of the accelerated deterioration specific to our operating area, provides a firm foundation on which to build improved performance.

As such we are setting ourselves stretch targets for this enhancement case to deliver a further reduction in burst numbers and improvements in interruptions to supply beyond what out modelling suggests, this is set out in the table above.

For the purpose of completing the tables, the interruptions enhancement is attributed in the enhancement tables and the mains repair enhancement in the base tables – this is explained in our table commentary.

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 (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.

For the type of work involved within this case we are confident in the costs and benefits put forward as we have conducted similar work in the past and understand the risks and opportunities which are inherent in the activity.

Costs: The proposed intervention, pipe replacement, is a well-established and well understood approach. As such we have good historic data on which to develop our cost models. This is reflected in our estimating tolerance of +/-20% at this stage of costing which is well within the AACE benchmark of +/-30% for the same level of design maturity. This confidence has come from the work we have undertaken to understand cost pressures and where we were under, or over, estimating costs as well as our annual refresh of cost curves which is the predominant method of costing used within the business plan.

We are continuing to benchmark our approach and consider how changes in procurement and changes in market rates will impact on the work programmes which we are developing.

Benefits: Our SMF provides a robust basis for quantification of benefits. Mains replacement is a well-established activity and the benefits to service of new water mains compared to the aged mains they replace are well understood. We have worked with SMEs and undertaken detailed statistical analysis, which has been independently verified, to establish linkage between our assets and service performance. This is described in WSH50-IP00 Our Approach to Investment Planning (Section 5.4).

Our approach has been assured by independent consultants, Jacobs and Economic Insight.

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).

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.

4.1 Developing a cost for Structural Rehabilitation

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

Structural rehabilitation of water mains is a well-established process which is routinely delivered. Cost drivers include diameter of main being installed, the surface type under which the pipe will be laid (ranging from cheap grassland to expensive urban centres) and the technique which is utilised (open cut, directional drill etc.) Our modelling environment (AIM) allows us to analyse the proposed investment option at pipe level and so we understand the full makeup of the investment option. We have used this to build up viable schemes for delivery and utilise our corporate costing database (UCD) to cost specific types of work.

Efficient Schemes

Our analytical model (AIM) contains details of each pipe on our network, its length, and the surface type above it. We have established rule sets for which renewal technique is applicable in each circumstance, e.g., pipes under rivers will be directionally drilled, short lengths will be open cut.

The cost of intervening on every pipe in our network is understood (the benefits of the intervention are also quantified as set out above).

The model also provides the opportunity to group similar (and spatially adjacent) pipes into combined schemes – 'superstrings'. The model automatically examines different ways of combining separate pipes with similar performances characteristics and in the same neighbourhood into integrated schemes.

The superstring approach is both advanced and innovative; it brings some of the efficiencies that would previously be identified at the detailed design stage (or which might be missed altogether) forward to the beginning of the pipeline selection processes. This produces better schemes and reduces costs for customers. It also addresses feedback we have had from customers about dealing with issues on a single visit rather than leaving sections of pipe to be picked up later (where it is cost beneficial to do so).

Corporate Costing Approach

We have used data from our Unit Cost Database Cost & Carbon Estimating Tool (UCD C&CET) tool to build up costs in our investment model.

The UCD C&CET holds our cost modelling data, which has been developed from historical project actual costs. This provides us with the best data to forecast spend based on the costs we experience in our own network. This approach along with our governance process is identified in our 'Overview: How we have developed our investment plan'.

To adhere to our costing methodology of using like-for-like (top down) to cost our business plan, we have taken the UCD models version 18, with an uplift for ancillaries and associated work, and incorporated these into the AIM system. The AIM model understands the costs of replacing each pipe individually or in combination with its neighbours as part of a 'superstrings'.

This approach has provided an optimised and costed programme for this investment.

We are continuing to review our approach to costing considering changing market conditions and the changes in activity identified for AMP8.

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.

<u>Approach to establish costs for the PCD</u>

In developing the PCD we looked to use a banded approach with one of the factors that influences the costs. We recognise that there a number of factors which influence the cost of replacing pipework, such as diameter, length, surface type, installation method and pipe material. To avoid a large complex rate matrix including all these factors, we selected bands based on the diameter, which provides a rate that can be applied to the length. We excluded pipe material and method, as we deemed that we would select the most cost effective and beneficial to the customers, method and material where possible, realising in some cases we do not have a choice.

One factor that does tend to influence costs significantly is surface type, where we are installing the pipe, e.g. grassland, footpath, roads etc. We would expect with the smaller diameter pipes, we would be closer to the properties and there would be more roads, footpaths etc within these pipe diameter bands.

To cost this enhancement case, we have used UCDv18b rates which have been incorporated into the AIM system. The models created a rate based on diameter but distinguished between surface type and method of installation. To allow us to use a banded rate based on diameter, we needed a combined rate incorporating the different methods and surface types. To avoid issues with understanding different weightings on these, we created reflective rates based on our AMP8 plan. We captured the replacement lengths and costs across the programme, in each of the diameter bands and calculated the rates from these.

We have selected bands that increase by 50mm which is approximately the typical increments we see in diameters. We started with less than and equal to 100mm, as there is minimal difference in these rates.

As described above rates for smaller diameters appear high, as these have a heavier weighting of more difficult locations, but this is based on our optimised programme.

4.2 Benchmarking our approach

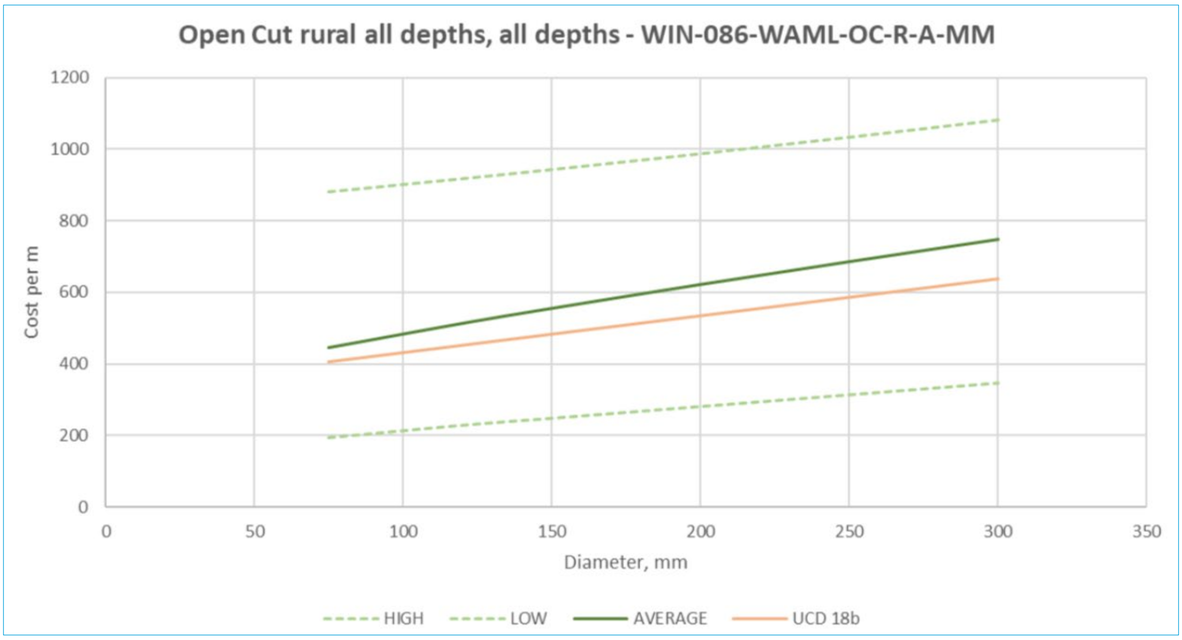
Is there evidence that the cost estimates are efficient (for example using similar scheme outturn data, industry and/or external cost benchmarking)?

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

To ensure the robustness of this costing approach, we have engaged independent consultants to undertake a benchmarking exercise of the programme and demonstrate efficiency. As our approach to this plan was to use the AIM system to provide an optimised programme for AMP8, we did not have specific developed projects for project level benchmarking. Therefore, the benchmarking took the form of benchmarking our UCD Cost Models used in the development of our AMP8 programme.

They carried out a benchmark of the key models used by AIM. The models benchmarked where v18b which incorporated the latest cost data available, to give us the best cost confidence.

Our consultants generated three individual data sets, using historical cost data collected across the UK water industry, to allow alternative models to provide three benchmark costs. Wherever possible the data used has been captured in the last three years (since 2020) to account for the recent high fluctuations in the costs of installations.



Example from Benchmark Report of v18b cost model for Open Cut Rural all depth

The outcome of the benchmarking suggests that we were within the benchmark range and better than average and improving further with the larger diameter pipes, which demonstrates that we are cost efficient.

Our costs 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 template for the proposed price control deliverable (PCD). This is designed to provide strong controls in terms of work delivered against funding allowed – if the proposed length of mains for replacement is not delivered, funding will be returned to customers on a proportional basis.

To assign costs to the PCD we have used the financial values produced through modelling, these calculate unit costs based on the cost drivers for the proposed work using our corporate costing database (UCD). The approach is described in Section 4.1 above. For the PCD we have 'bucketed' the costs produced by our modelling into five categories based on pipe diameter – whilst most of the work to be delivered is in smaller diameter pipe groups we will also be delivering some work in larger (more expensive) diameter bands. By splitting into five categories, we are making a clearer link between to the specific characteristics of the work to be delivered and the rates used for the PCD.

We believe strongly that mains replacement rates in AMP8 should be agreed as part of Final Determination.

The 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.

5.1 Proposed Price Control Deliverable (PCD)

Are customers protected (via a price control deliverable or performance commitment) if the investment is cancelled, delayed or reduced in scope?
– Ofwat's final methodology for PR24, Appendix 9, A1.1.4a

Price Control Deliverable Expectations / Scheme delivery expectations mains repair mains replacements AC	
Description	To maintain the reliability of its distribution mains network, the company will replace 174 km of Asbestos Cement (AC) distribution pipelines during AMP 8 at a cost of £66M (2022/3 price base, post efficiency, overlap removed). This investment is the first step in a 25-year programme to manage these ageing assets. The pipes to be replaced will be selected based on the lowest whole life cost required to maintain a stable mains repair and interruptions to supply performance; to offset the accelerated deterioration experienced by Welsh Water. The replacement works will be spread evenly across AMP 8 with the company committing to report on the length of AC pipe replaced in each year. This work will be in addition to that delivered by base investment. Where length has not been delivered (measured at the end of the AMP 8 period), funding will be returned to customers. The agreed unit costs will be used to establish the size of the investment to be returned as part of AMP 8 true up.

Price Control Deliverable Expectations / Scheme delivery expectations mains repair mains replacements AC

Measurement and Reporting

The PCD will measure the length of failing AC pipe replaced each year by diameter band. The company has identified five (5) diameter bandings in relation to the reporting criteria for this PCD.

The reporting criteria are therefore simple, clear and prescriptive, ensuring customer protection.

The following definitions are proposed to support the measurement of performances against this PCD.

Classification for eligibility

1. To enter the programme the main must be AC and have recorded multiple mains repairs (typically in Grade 4/5 condition).
2. Pipe Material: This work will cover AC pipe of any age, pipelines of other materials which are, for efficiency reasons, replaced as part of AC schemes will not be counted towards the reported length.

Classifications for cost reporting & recovery

3. Pipe replacement length (metres): The length of pipeline laid will be used for the calculation rather than abandoned length to ensure that the costs are reflective of the activity. Length will include only distribution mains; communication pipe and supply pipes replaced will not count towards the length.
4. Pipe Diameter: The programme will cover all diameters of AC. For reporting, pipes will be assigned to one of five diameter bands, these are set out below. The bands have been set to group pipes with similar unit costs for replacement. We will group pipes by the diameter of the pipe installed (laid).

Diameter (mm)	<100	>100 to 150	>150 to 200	>200 to 250	>250 to 300
Length (km)	127	26	19	1	1
Unit rate (£/m)	£370	£390	£420	£550	£600

Where length has not been delivered funding will be returned to customers.

Price Control Deliverable Expectations / Scheme delivery expectations mains repair mains replacements AC

The company will report separately on the Performance Commitments for Mains Repairs and Interruptions to Supply.

Conditions on scheme

No additional conditions identified.

Assurance

The company will agree appropriate assurances with Ofwat as part of Final Determination.

Price control deliverable payment rate

Diameter (mm)	<100	>100 to 150	>150 to 200	>200 to 250	>250 to 300
Length (km)	127	26	19	1	1
Unit rate (£/m)	£370	£390	£420	£550	£600

Where length has not been delivered the funding will be returned to customers on a proportional basis.

The agreed unit costs will be used to establish the size of the investment to be returned. The shortfall length in each diameter band will be multiplied by the unit rate for that band to calculate the value to be returned.

Impact performance in relation to performance commitments

This work is designed to maintain the level of performance against the Mains repair and interruptions to supply performance commitments.

This investment, when combined with base spend on structural rehabilitation will provide a stable level of service from which further improvements in performance can be delivered:

- Mains repair will decrease by 130
- Water supply interruptions will decrease by 30s

These improvements will be delivered through in period improvement in operation and targeting (see discussion in Section 3.4).

5.1.1 Extent of Protection

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, A1.1.4b

The PCD will cover the length of mains replaced.

The outcome benefits of mains repairs and interruptions to supply will be covered by their respective performance commitments.

6. Appendices

Appendix A – TotEx Costs By Year For AMP8

The table below shows the total CapEx enhancement costs in Amp 8 for this enhancement case. The Ofwat drivers this enhancement case maps to are:

- Resilience; enhancement water CapEx, OpEx and Totex. (CW3b.118, CW3b119 and CW3b120)

There are other enhancement cases which contribute to these drivers.

Total CapEx in AMP8 Plan in 2022/23 prices

Contribution to Driver Ref	Year in AMP8					
	1	2	3	4	5	Grand Total
CW3b.118 - CapEx	£8.073M	£8.458M	£13.548M	£20.469M	£15.715M	£66.263M
CW3b.119 -OpEx	£0.000M	£0.000M	£0.000M	£0.000M	£0.000M	£0.000M
CW3b.120 - TotEx	£8.175M	£8.559M	£13.649M	£20.571M	£15.818M	£66.774M

What We Will Deliver: We will deliver 174km of AC mains replacement, this work will mainly focus on small diameter pipes. In addition, we will deliver 26km of AC mains replacement in base.

Appendix B – Executive Summary - Ovarro Report

15 August 2023

AC Mains Failure Rate Analysis

Report

Dŵr Cymru Welsh Water

W028503\GD004\04
Version: 4

Approved

Executive Summary

Dŵr Cymru Welsh Water (DCWW) highlight that their Asbestos Cement (AC) water mains burst rate has increased rapidly in recent years; DCWW analysis has shown that the number of bursts on their stock of AC mains has been increasing by approximately 90 bursts/year over the last 14 years. In order to understand the situation better, DCWW requested that Ovarro DA Limited ("Ovarro") conduct an analysis of failure rates on AC pipes owned by DCWW, including comparisons against national data as used in the recent UKWIR Project 20/WM/03/24 "Asbestos Cement Water Mains Deterioration and Failure Prediction Models".

Ovarro's analysis concluded that certain differences between the DCWW AC mains asset base & environment, compared to national averages, are indeed causing DCWW AC mains burst rates to be higher than they otherwise would be. Factors having a significant effect are thought to be:

- **Distribution of pipe ages** – the DCWW asset base has a higher proportion of AC pipes that were installed *just after* 1960. Post-1960 AC is suspected to be problematic due to changes in the manufacturing process; this cohort was largely manufactured using autoclave curing and contains less free lime which may affect long-term deterioration rates. Analysis of burst rate vs age for different installation date cohorts seem to confirm this, and pipes installed *just after* 1960 are the oldest (and hence most deteriorated) of this problematic cohort. The overall effect is estimated to be small at 1.5% i.e. DCWW burst rates are around **1.5% higher** than they would be if the DCWW distribution of ages was identical to the national distribution.
- **Smaller average pipe diameters** – smaller pipe diameter of AC mains is associated with higher burst rates, and a higher proportion of AC pipes are in the smaller diameter bands (<100mm) at DCWW than is the case in the national data. This is estimated to be causing DCWW burst rates to be **4% higher** than they would be if DCWW had the same distribution of pipe diameters as the national distribution.
- **Lower average soil pH** – lower soil pH is associated with higher burst rates on AC mains, and soil pH in the DCWW area is particularly low compared to nationally. This is estimated to be making DCWW burst rates around **28% higher** than they would otherwise be.
- **Higher average soil moisture** – higher soil moisture (long term average – not considering seasonal variation) is associated with higher burst rates on AC mains, and typical soil moisture in the DCWW area is higher than in most parts of England & Wales (although not Scotland). This is estimated to be causing DCWW burst rates to be around **21% higher** than they would otherwise be.
- **Lower average hardness of conveyed water** – there is (at least to an extent) a relationship between hardness of water conveyed in AC mains and mains burst rate, with higher burst rates being seen on the pipes with the lowest water hardness levels. Water hardness in DCWW is typically significantly lower than the England & Wales average (although not Scotland). Based on national trends, the lower average hardness of water at DCWW is estimated to be making DCWW burst rates around **3% higher** than they would otherwise be.

Other factors that may be having an effect include:

- **Higher monthly rainfall** – higher rainfall in the DCWW area than the national average may be causing higher burst rates. The effect is estimated to be making burst rates around **8% higher** than they would otherwise be. However, this may be closely linked to the effect of soil moisture, reflecting the fact that high average rainfall is likely to be associated with high long-term soil moisture – rather than being an *additional* independent explanatory factor.
- **Some conveyed water chemistry parameters** appear to be associated with higher burst rates at DCWW, namely:
  - Higher **total chlorine** levels

- Lower **alkalinity**
- Lower **sulphate** levels

However, it is uncertain whether these are truly causative factors or whether they (particularly alkalinity) are surrogates for lower hardness.

Iron levels appear to be higher in DCWW than in the national average data, and high iron levels appear to be associated with lower AC main burst rates – meaning that iron levels in conveyed water may be a factor which is *reducing* the AC mains burst rate for DCWW compared to nationally. However, the effect appears to be weak, certainly much weaker than the several opposing effects described above that are likely to be increasing the burst rate. Furthermore, there is no obvious causal mechanism to explain such a relationship: there is no clear reason to expect low iron levels to make water more aggressive to AC, unlike with (for example) low water hardness levels.

The overall AC mains burst rate at DCWW is around 144% higher than the England & Wales average i.e. 2.44× higher.

Due to the uncertainties in how effects combine, we cannot precisely quantify the expected increase in AC main burst rates due to the factors identified. Nonetheless, there is strong evidence that features of the DCWW asset base and particularly the environment are likely to be causing AC main burst rates to be several tens of percent higher than they would otherwise be.

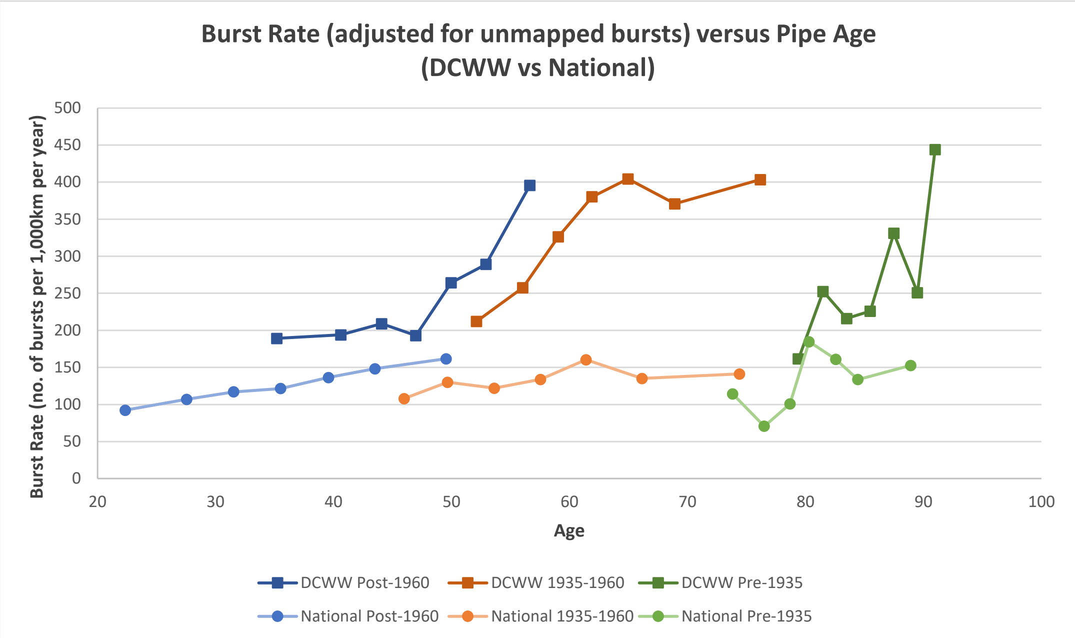
Appendix C – Burst rate versus pipe age - Ovarro Report

3.1.1 Burst rate versus age – comparison with UK

Figure 1 below shows how DCWW AC main burst rates (the *height* of the lines), and pipe deterioration rates (the *steepness* of the lines) compare with the rest of the UK. It can be seen that DCWW AC mains typically have a significantly higher burst rate than the UK average for pipes of the same age. Deterioration rates are often faster too. Post-1960 AC appears to be a particular 'problem material'.

There is some overlap in the lines for the different cohorts of pipe; this is because the analysis was undertaken on failure data across a number of years, therefore the ages of pipes from the beginning and end of different cohorts overlap in some years. The DCWW lines are shifted to the right compared to the national lines because the historical burst data from DCWW covers a longer time period and contains more recent years.

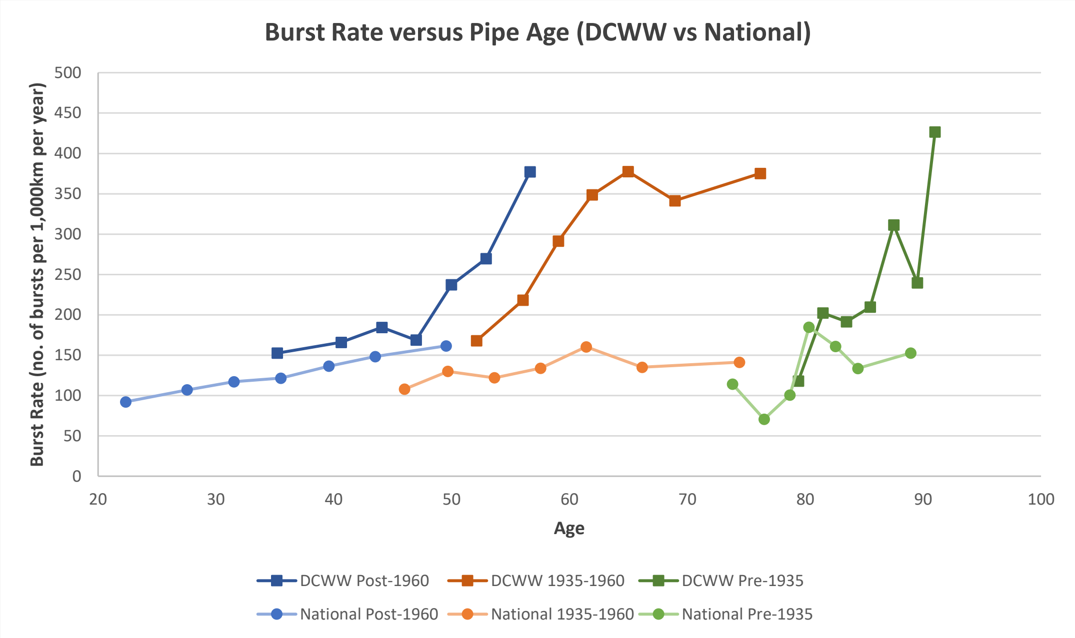
Figure 1: DCWW burst rate vs age, compared with whole UKWIR data set (adjusted for 'unmatched' bursts)



Source: Ovarro analysis of DCWW data

For completeness, a chart (Figure 2) was produced without applying the 'adjustment factors' described in section 2.2. This chart shows slightly lower burst rates because it is not compensating for the missing/unmatched bursts, but the conclusion is the same. Note, Figure 1 (not Figure 2) should be taken as the definitive / 'best attempt' comparison between DCWW and the UK.

Figure 2: DCWW burst rate vs age, compared with whole UKWIR data set (NOT adjusted for 'unmatched' bursts)

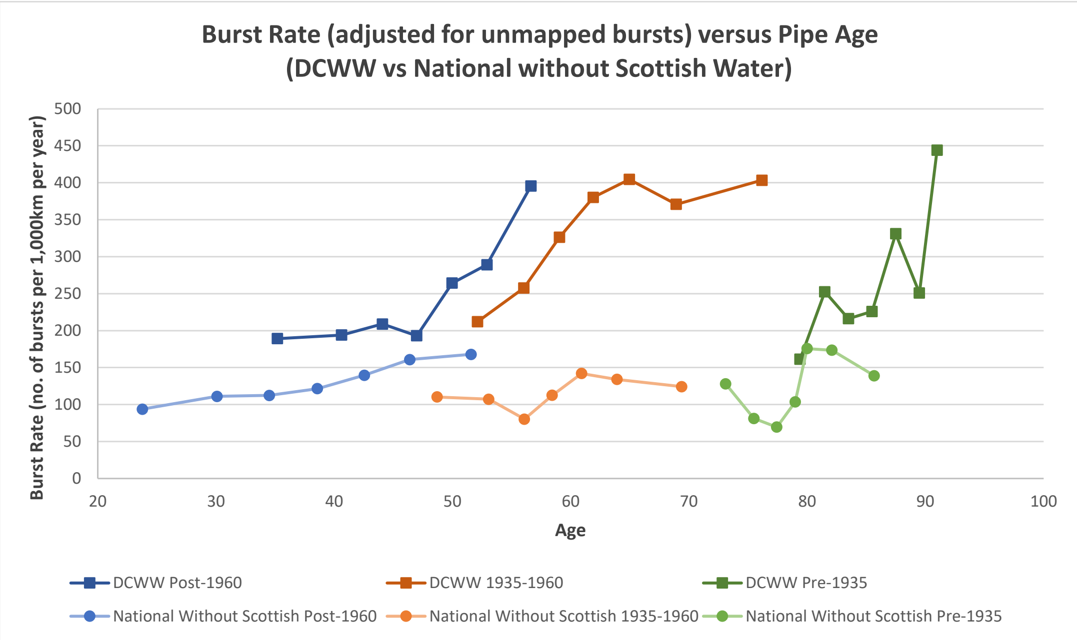


Source: Ovarro analysis of DCWW data

3.1.2 Burst rate versus age – comparison with England & Wales only

Figure 3 below shows a comparison of DCWW AC mains burst rates versus age to the England & Wales averages only. The conclusion remains similar; DCWW AC mains are significantly worse than average. Note that the DCWW lines are identical to those in the equivalent graphs in section 3.1.1; also note that the "UK average" and the "England & Wales" average are not greatly different, given that excluding Scottish Water is only removing one company from the 'average'.

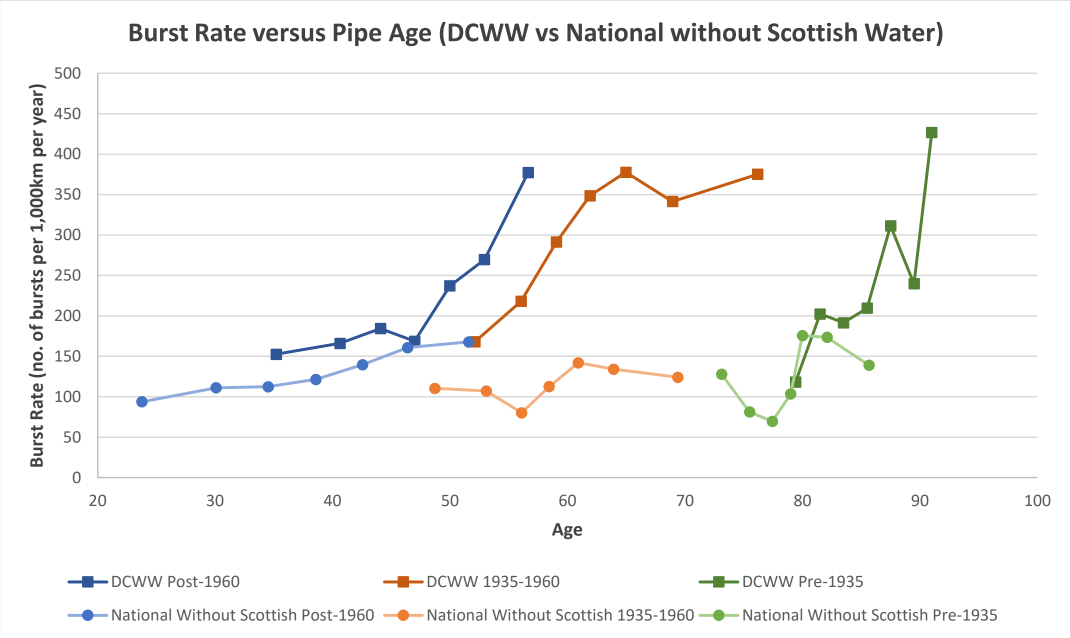
Figure 3: DCWW burst rate vs age, compared with England & Wales only (adjusted for 'unmatched' bursts)



Source: Ovarro analysis of DCWW data

As in section 3.1.1, for completeness another chart (Figure 4) was produced without applying the 'adjustment factors' described in section 2.2. Again, the "with adjustment" chart (Figure 3) should be taken as the 'definitive' result.

Figure 4: DCWW burst rate vs age, compared with England & Wales only (NOT adjusted for 'unmatched' bursts)



Source: Ovarro analysis of DCWW data

3.1.3 Box-and-whisker plots

DCWW wanted to understand better the spread of AC mains burst rates between individual companies, for the different installation year cohorts. Ovarro combined the new DCWW data and company-level outputs from the UKWIR report analysis, to create box-and-whisker plots (Figure 5 and Figure 6) summarising the mean burst rates by company, for DCWW and the companies in the UKWIR report.

Within these figures:

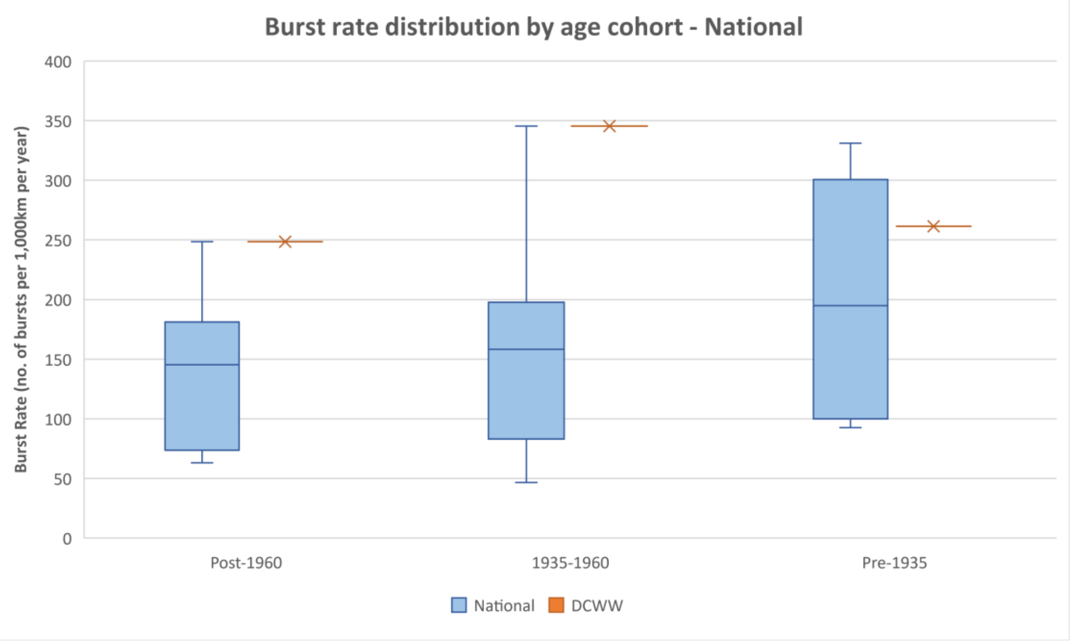
- The 'box' ranges show the 25th and 75th percentiles of company average burst rates i.e. the burst rates that are higher than for 25% of other companies, and for 75% of other companies.
- The horizontal line inside each box shows the median burst rate i.e. the burst rate of the company that is in the 'middle' of the range
- The vertical lines (the 'whiskers') show the maximum[3] and minimum burst rates of the included companies.
- The DCWW mean burst rates for each cohort are shown as separate comparison lines.

Figure 5 shows a comparison with the UK national data; Figure 6 shows a comparison with England & Wales only.

3 One company was excluded because its burst rate values (which were ~3× higher than any other company) suggested that bursts were being counted in a different way to the rest of the companies, and hence inclusion in the comparison would not be 'fair'. Ovarro also removed two data points where the companies only had very short lengths of pre-1935 AC main and hence there was not enough data for the cohort burst rate to be considered reliable.

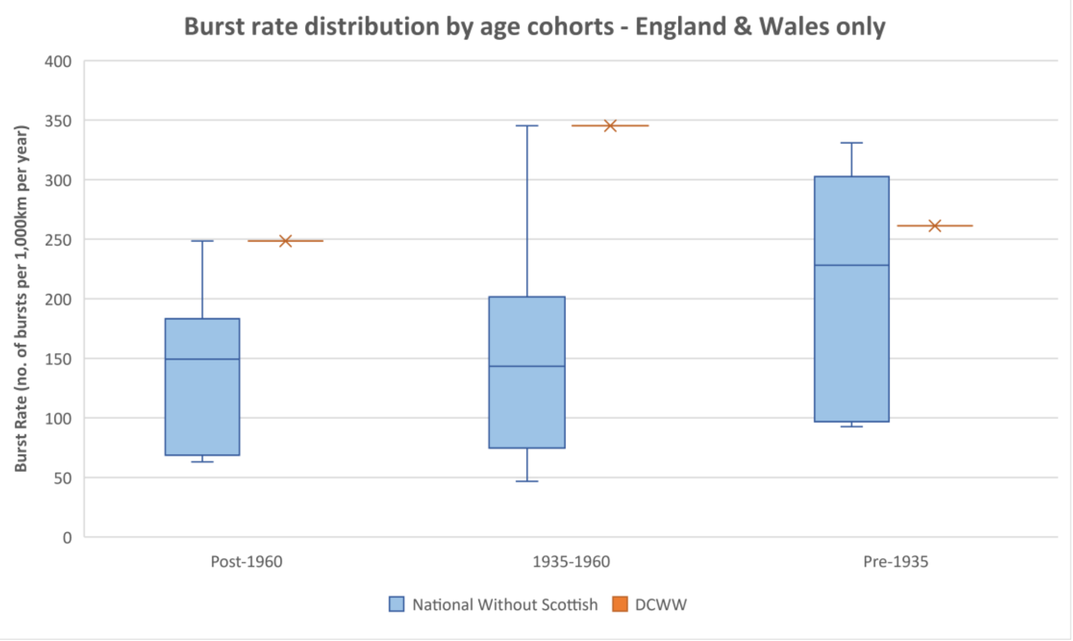
In both figures it can be seen that there is a significant spread of AC main burst rates between companies; even the interquartile range shows more than a factor of 2 variation. It can also be seen that DCWW is the highest burst rate company on 1935-1960 AC mains and post-1960 mains; these two cohorts contain a total of 96% of DCWW's AC mains. DCWW also has a higher burst rate than the majority of companies on pre-1935 AC mains (somewhere above the median, but below the 75th percentile) although this is less important for overall burst rates as this cohort only contains 4% of DCWW's AC mains.

Figure 5: Box-and-whisker plot comparing DCWW average burst rates with other UK companies



Source: Ovarro analysis of DCWW data

Figure 6: Box-and-whisker plot comparing DCWW average burst rates with England & Wales companies



Appendix D – Quantification of pipe attribute & environment effects - Ovarro Report

7 Quantification of pipe attribute & environment effects

In this section Ovarro have attempted to estimate the degree to which features of the DCWW assets and environment would be ***expected to*** lead to higher AC main burst rates, for those factors which are thought to be potentially influencing the burst rate.

Combined with estimates of the degree to which DCWW AC main burst rates are ***observed to be*** higher than the national average, this enables an estimate to be produced of the ***extent to which the higher DCWW burst rates are explained*** by attributes of the DCWW pipes and environment.

7.1 Estimated effects of features of the DCWW assets & environment

The general approach used to estimate effect of an attribute on the AC mains burst rate is as follows:

1. Draw a trend line through the national (UKWIR project) chart of AC mains burst rate vs attribute value
2. Calculate the mean attribute value for DCWW, and place this on the trend line, in order to read off the expected burst rate of an AC main which is 'average' in DCWW in terms of this attribute
3. Do similar calculations as (2) above for the national[12] data, in order to get the expected burst rate of an AC main which is 'average' nationally
4. The ratio of the burst rates estimated for (3) versus for (2) above, is the estimate of the degree to which differences in this attribute for DCWW are causing the burst rate to be higher than the national average.

The charts in the subsections below illustrate what is being done.

Note that for pipe age, the analysis is slightly more complex because of

- the need to consider different pipe installation date cohorts
- the need to ensure that pipe ages are being compared in the same year; otherwise the fact that the UKWIR data was from 2-3 years earlier would cause the UKWIR data average age to appear 2-3 years younger even if the distribution of installation dates was identical at DCWW to the national distribution.

7.1.1 Pipe diameter

The figure below shows that:

- DCWW AC mains have a mean diameter of 121mm, which corresponds to an expected burst rate of around 130 bursts/1000km/year given the linear fit to the burst rate vs diameter trend plot
- Nationally, the mean AC main diameter is 133mm, which gives an expected burst rate of around 125 bursts/1000km/year.

[12] National average (i.e. including Scotland) were used rather than England & Wales averages only. The summary data still available from the UKWIR project, did not enable England & Wales averages to be calculated. Note that although inclusion of Scotland is likely to change the national average, the effect is unlikely to be major (Scotland being <10% of the UK population). Therefore the estimates of "effect that differences in average attribute value are having on burst rate", should not be drastically dissimilar to if "England & Wales only" was being used as the comparison.

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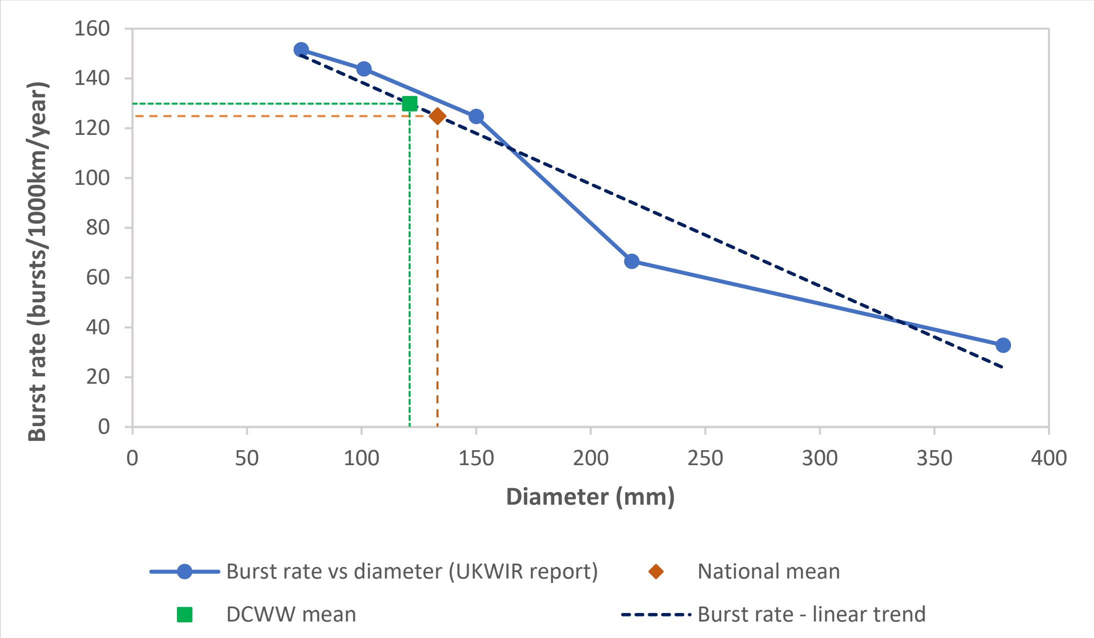
Based on this, DCWW burst rates would be expected to be around **4% higher** than the national average, solely due to the effect of average pipe diameters being smaller in DCWW than nationally.

Figure 65: Burst rate vs pipe diameter trend, for estimating effect on DCWW burst rates



Source: Ovarro working

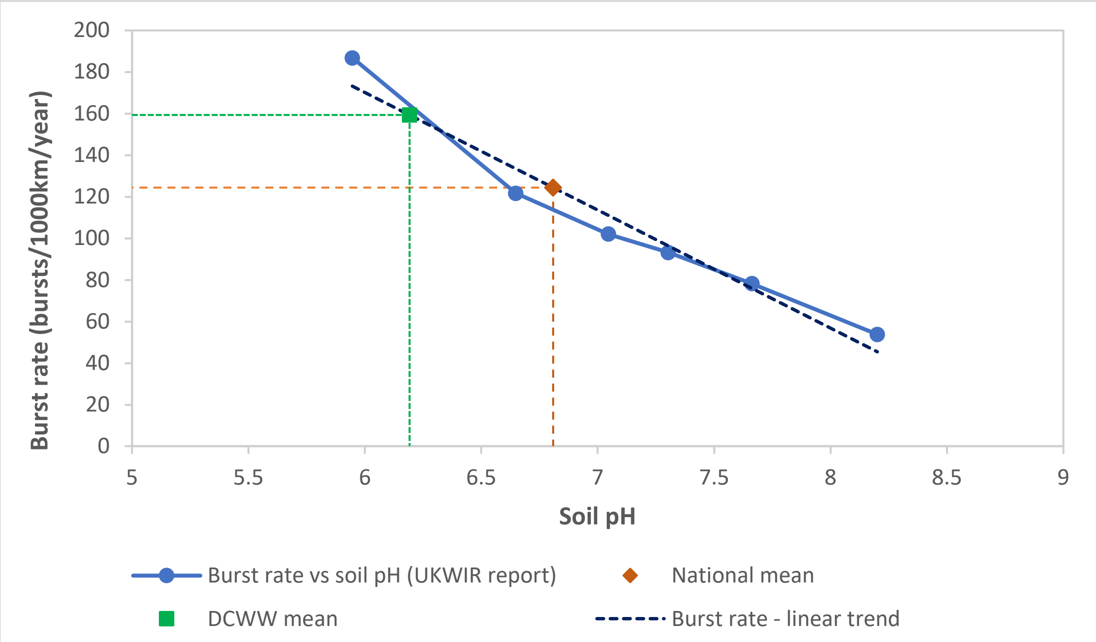
7.1.2 Soil pH

The figure below shows that:

- DCWW AC mains have a mean soil pH of 6.19, which corresponds to an expected burst rate of around 159 bursts/1000km/year given the linear fit to the burst rate vs soil pH trend plot
- Nationally, the mean AC main soil pH is 6.81, which gives an expected burst rate of around 124 bursts/1000km/year.

Based on this, DCWW burst rates would be expected to be around **28% higher** than the national average, solely due to the effect of average soil pH being lower in DCWW than nationally.

Figure 66: Burst rate vs soil pH trend, for estimating effect on DCWW burst rates



Source: Ovarro working

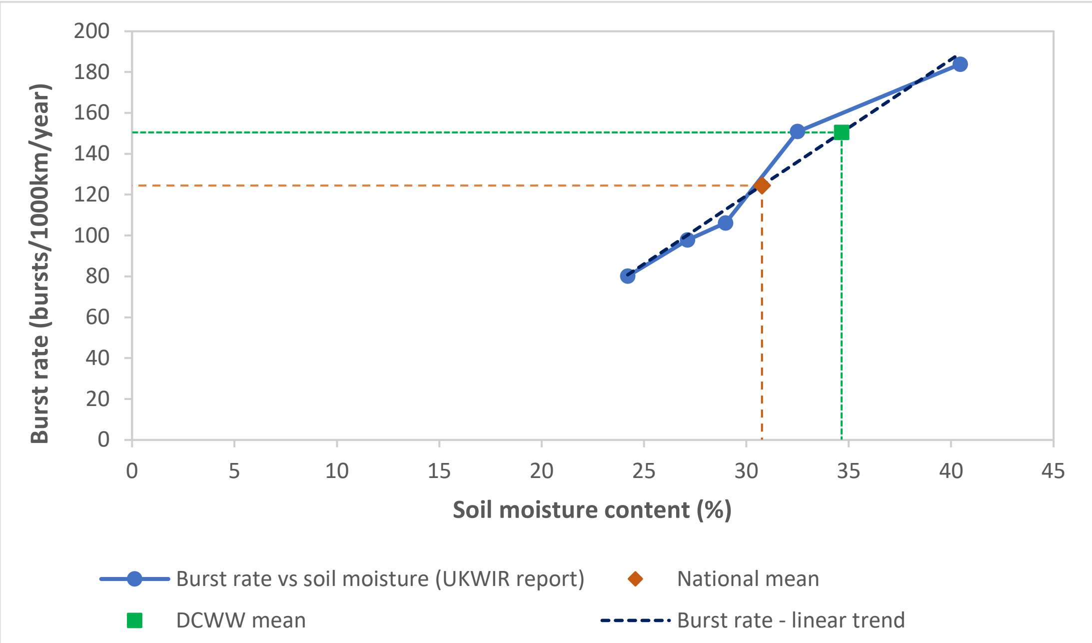
7.1.3 Soil moisture

The figure below shows that:

- DCWW AC mains have a mean (long term average) soil moisture of 34.7%, which corresponds to an expected burst rate of around 150 bursts/1000km/year given the linear fit to the burst rate vs soil moisture trend plot
- Nationally, the mean AC main soil moisture is 30.8%, which gives an expected burst rate of around 125 bursts/1000km/year.

Based on this, DCWW burst rates would be expected to be around **21% higher** than the national average, solely due to the effect of average soil moisture being higher in DCWW than nationally.

Figure 67: Burst rate vs soil moisture trend, for estimating effect on DCWW burst rates



Source: Ovarro working

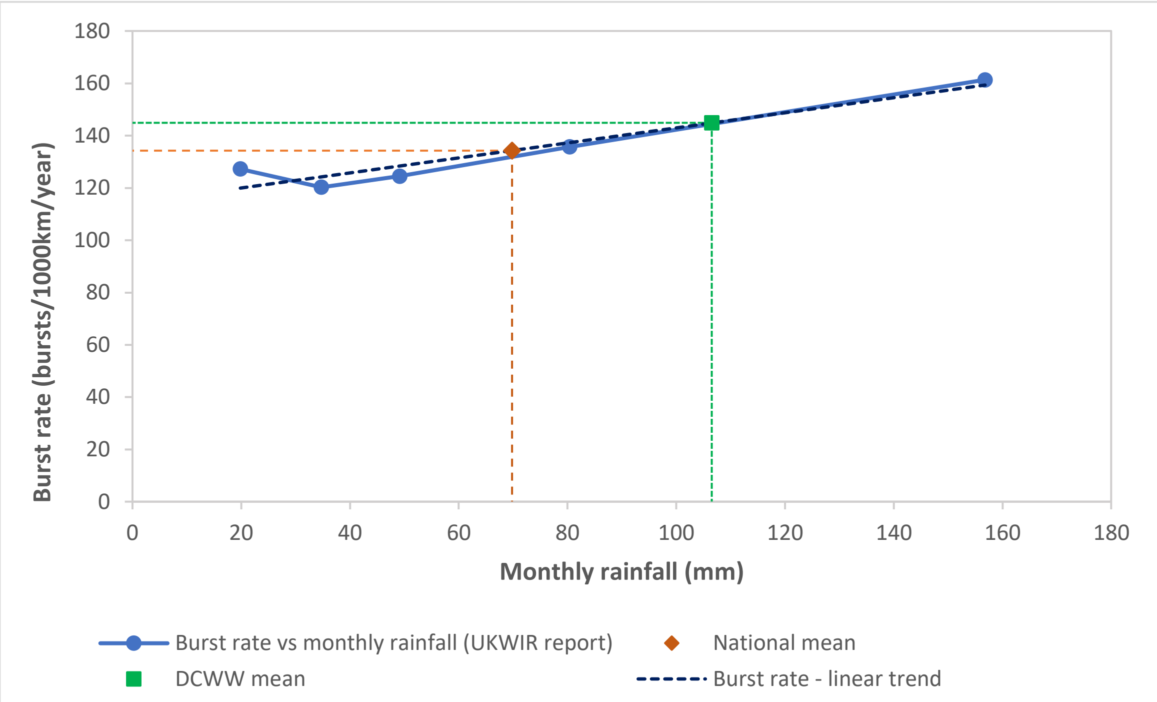
7.1.4 Monthly rainfall

The figure below shows that:

- DCWW AC mains have a mean monthly rainfall of 107mm, which corresponds to an expected burst rate of around 145 bursts/1000km/year given the linear fit to the burst rate vs monthly rainfall trend plot
- Nationally, the mean monthly rainfall at AC pipes is 70mm, which gives an expected burst rate of around 134 bursts/1000km/year.

Based on this, DCWW burst rates would be expected to be around **8% higher** than the national average, solely due to the effect of average monthly rainfall being higher in DCWW than nationally.

Figure 68: Burst rate vs monthly rainfall trend, for estimating effect on DCWW burst rates



Source: Ovarro working

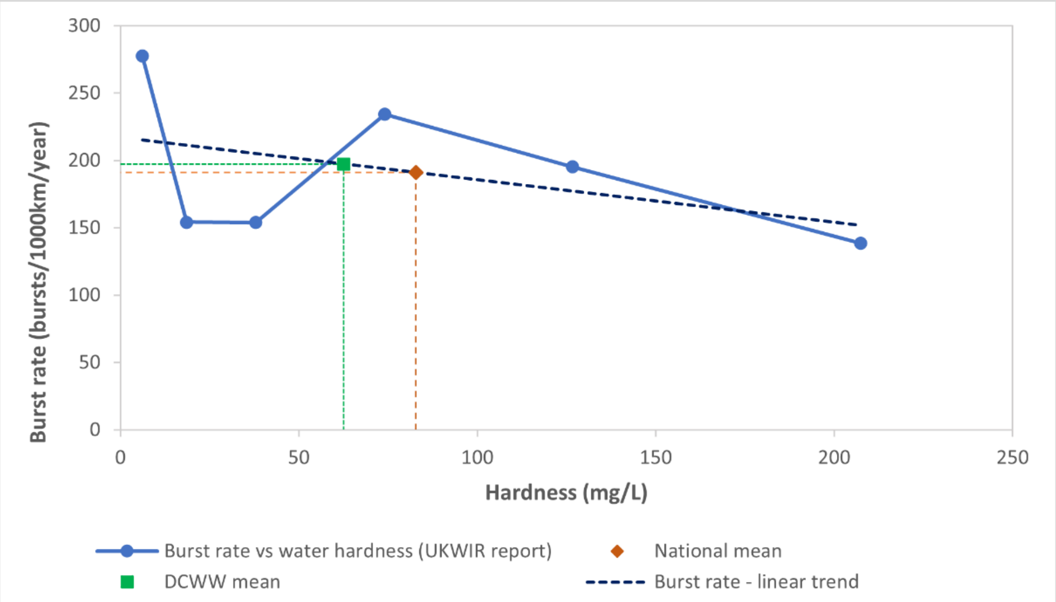
7.1.5 Water hardness

The figure shows that:

- DCWW AC mains have a mean (long term average) hardness of conveyed water of 62mg/L, which corresponds to an expected burst rate of around 197 bursts/1000km/year given the linear fit to the burst rate vs hardness of conveyed water trend plot
- Nationally, the mean AC main hardness of conveyed water is 83mg/L, which gives an expected burst rate of around 191 bursts/1000km/year.

Based on this, DCWW burst rates would be expected to be around **3% higher** than the national average, solely due to the effect of average hardness of conveyed water being lower in DCWW than nationally.

Figure 69: Burst rate vs hardness of conveyed water trend, for estimating effect on DCWW burst rates



Source: Ovarro working

It should be noted that the relationship observed between water hardness and burst rates in the UKWIR project was surprisingly weak given the known impact of water hardness on AC deterioration. It was speculated at the time that this is due to UK companies in the main having a fairly narrow range of water hardness, thus the observable trend is confounded by inter-company differences which could include a myriad of factors.

Given that the relationship seen in DCWW data is far stronger (see figures in section 4.2), it is believed that the 3% figure above could be significantly underestimating the impact of water hardness; however, in the absence of further research in this area the true impact cannot be quantified.