TMS22 Enhancement Case: Long Term Water Quality Strategy Lead

Contents

1. Summary table

The table below summarises the key information included in this Enhancement Case document.

Table 1 – Enhancement Case Summary table

Reference	Long Term Water Quality Strategy Enhancement Case – Lead Control
Description	This Enhancement Case supports Thames Water's long-term ambition to further reduce public health risks and reliably supply safe drinking water to our customers. It also shares core objectives of the Drinking Water Inspectorate's (DWI) long-term strategic guidance: 'to strategically plan for the future by taking suitable approaches towards…achieving positive reductions of lead in drinking water'.[1] There are two water quality focus areas for AMP8: firstly, replacing lead in communication (comms) and customer supply pipes as a long-standing enhancement requirement that must continue due to the public health risk posed by lead in drinking water. Secondly, we and the DWI are concerned[2] about our four large London Process Plants (LPPs[3]) which use slow sand filtration (SSF) as the principal treatment process. Although SSF is an efficient process, it cannot be relied upon in all conditions to consistently remove/inactivate *Cryptosporidium* oocysts – a parasite that can cause a diarrhoeal disease if consumed in drinking water. Despite delivering on operational improvement plans and maintaining our works appropriately, this parasite is still sometimes detected in final water samples at our (SSF) LPPs - we must act now to address this, as it is an unacceptable situation. It is not possible to fully mitigate either of these public health risks through our base plan. We need to enhance the quality of the water supplied to customers, to ensure that it remains safe to drink and to realise our 2050 Vision. For Lead Control: we will invest in a lead communications pipe replacement programme and deliver an AMP8 customer trial to determine the most effective support we can provide customers in the long term to remove the public health risk posed by lead pipework in contact with drinking water. The DWI are very supportive of this work, and we are awaiting official support which can be forwarded upon receipt.
Outputs	Our targeted programme will remove 54k Lead comms pipes supplying some of our highest risk customers. A £8.625M customer trial in these target supply areas will look at ways, among other things, to both educate and financially support customers to remove supply pipes to at least the internal stop valve - recommendations from this trial(s) will be taken into PR29 planning.
Cost	Totex: £94.1m *(22/23 prices pre Frontier Efficiency)* (All) Capex: £85.4m lead comms pipe replacement & £8.6m customer trial
Spend apportionment	100% Water Network+ 100% Enhancement spend Total = (est.) £1.832bn over 5 x AMPs, AMP8-12 (step ups in AMP9 & AMP10)
Delivery year	Lead comms pipe replacement: flat annual profile 2025-2030 (and then every year to 2050)
DPC	The case has been assessed as not being suitable, as the construction and operations and maintenance risks could not be passed to a Competitively Appointed Provider (CAP). For more information, please refer to TMS38 Direct Procurement for Customers.

[1] Guidance Note: Long term planning for the quality of drinking water supplies, Drinking Water Inspectorate, September 2022
[2] Detailed in correspondence for site and company DWI technical audits, subsequent discussion, and specific enforcement notices
[3] LPP = Large Process Plants – all are in London, 4 operating as SSF Works and 1 (Walton WTW) as a chemical works, without SSFs

2. Introduction and description of investment

2.1. Our long-term water quality strategy will adapt to achieve customer outcomes

Our Public Health Plan[4] puts 'Water Quality First', to provide safe and reliable drinking water to our customers. This multi-faceted plan, alongside a Drinking Water Inspectorate (DWI) agreed Improvement Programme[5], aims to improve operational performance by understanding and reducing risk through base allowance investment. This plan is delivering through AMP7 and AMP8 – however, it is important that it then endures as part of a long-term strategy, adapting the priorities delivered through our base allowance to provide the public health risk reduction, and in turn further performance improvements our customers deserve.

One of Thames Water's Vision 2050 outcomes is 'we provide safe, clean drinking water'[6] and this is supported by our Public Health Policy, which states that we are 'committed to providing a safe water supply that maintains customer confidence'[7]. Water quality and public health risks are numerous and varied, and sometimes transient; our Drinking Water Safety Plans (DWSPs), with Enhanced Hazard Reviews, aim to identify and prioritise water quality hazards to ensure that the most appropriate risk mitigation is put in place, using either temporary or permanent approaches. This risk-based approach for the effective management of drinking water supply assets, drives effective investment strategies; through time, priorities to deliver the customer outcome(s) will change as we deliver on risks and others emerge.

The risk-based approach indicates existing and emerging issues. Therefore, we need a long term and adaptable water quality strategy, and this Enhancement Case continues to deliver on one of the priorities for this strategy. Emerging issues like PFAS[8], the persistence of micro-plastics and pharmaceuticals in the environment, are likely to need interventions in the future, but further research and investigations are required to understand the risk posed to our customers, the persistence of that threat and the most appropriate interventions needed (and when) to address risk. As an example, pesticide and nitrate investigations have been ongoing under WINEP[9] (see Annex 3) and are set to continue through AMP8 and beyond – however, they do not always result in investment once the risk is fully understood.

2.2. Thames Water has a multi-faceted AMP8 plan to deliver water quality improvements for our customers but focusses on two key priorities for enhancement

In AMP8, we are planning to deliver improvements in our water quality performance, thereby reducing public health risk, through a prioritised base allowance programme[10] and the elements presented here in this Enhancement Case. On the next page, we provide a tabulated summary of data lines relating to water quality (Table 2) – the purpose of this is to show we are prioritising lead pipe replacement (and *Cryptosporidium* Protection at LPPs) for enhancement investment in AMP8 and therefore the importance we place on this resolving these two public health risks.

[4] A brief outline of this is included in Annex 1
[5] Includes 23 (as of June 2023) DWI Enforcement Notices
[6] Vision 2050, Thames Water, 2023
[7] Protecting drinking water quality and safeguarding public health, Policy No.POL131, Thames Water, Nov 2020
[8] PFAS (per-and poly fluoroalkyl substances) is a chemical family consisting of at least 5,000 individual substances. They are sometimes referred to as 'forever chemicals' because of their persistence in the environment.
[9] WINEP: Water Industry National Environment Programme
[10] This is detailed more in the PR24 Water Quality document, submitted separately, but in essence prioritises asset deficit issues around treated water storage (service reservoirs and contact tanks), reducing the impact these issues have on water supply resilience and performance against the Compliance Risk Index

Table 2 AMP8 plan for enhancement for water quality (aligned to Ofwat data tables)

Water Quality Improvements	Ofwat data table reference	Units	Enhancement CapEx	Enhancement OpEx	Enhancement Totex	Comments
Improvements to taste, odour & colour (grey solutions); enhancement	CW3.91-93	£m	0	0	0	This is not observed as an issue for Thames Water and so investment is being prioritised elsewhere.
Improvements to taste, odour and colour (green solutions); enhancement	CW3.94-96	£m	0	0	0	
Addressing raw water quality deterioration (grey solutions); enhancement	CW3.97-99	£m	0	0	0	Climate change and the associated adverse weather is presenting a raw water challenge to our treatment resilience (see discussion in subsequent sections). We are not proposing any spend against these lines as there is no overall raw water deterioration but an intensification at certain times of the year on our SSF LPPs (primarily *Cryptosporidium*).
Addressing raw water quality deterioration (green solutions); enhancement	CW3.100-102	£m	0	0	0	
Conditioning water to reduce plumbosolvency for water quality; enhancement	CW3.103-105	£m	0	0	0	All supply zones deemed to require water conditioning have orthophosphoric dosing systems at the supplying water treatment works. Some ongoing upgrades to existing dosing plants are being done under capital maintenance (base).
Lead communication pipes replaced or relined for water quality; enhancement	CW3.106-108	£m	91.873[11] (85.435)	0	91.873 (85.435)	A programme of 54,000 lead comms pipes replacements (~97% proactive/targeted) is proposed in AMP8.
External lead supply pipes replaced or relined; enhancement	CW3.109-111	£m	0	0	0	No specific programme of works proposed on the supply side. There is a potential for some external and internal replacements, either directly or indirectly through funding, under the customer trial (see below), but this is not yet known.
Internal lead supply pipes replaced or relined; enhancement	CW3.112-114	£m	0	0	0	
Other lead reduction related activity; enhancement	CW3.115-117	£m	2.187[12] (8.625)	0	2.187 (8.625)	We are proposing a customer trial to determine the long-term removal of supply side lead pipes

[11] This is the cost in the data table. It is accompanied by commentary explaining the difference between it and the cost in this Enhancement Case (shown in brackets). In summary, the lead comms pipe replacement unit rate was reduced through realising efficiencies, lowering the cost to replace 54,000 lead comms pipes, and allowing a more significant customer side trial - the data table had been assured and locked by this time. The Totex for lead related data lines and the Enhancement Case are equal.

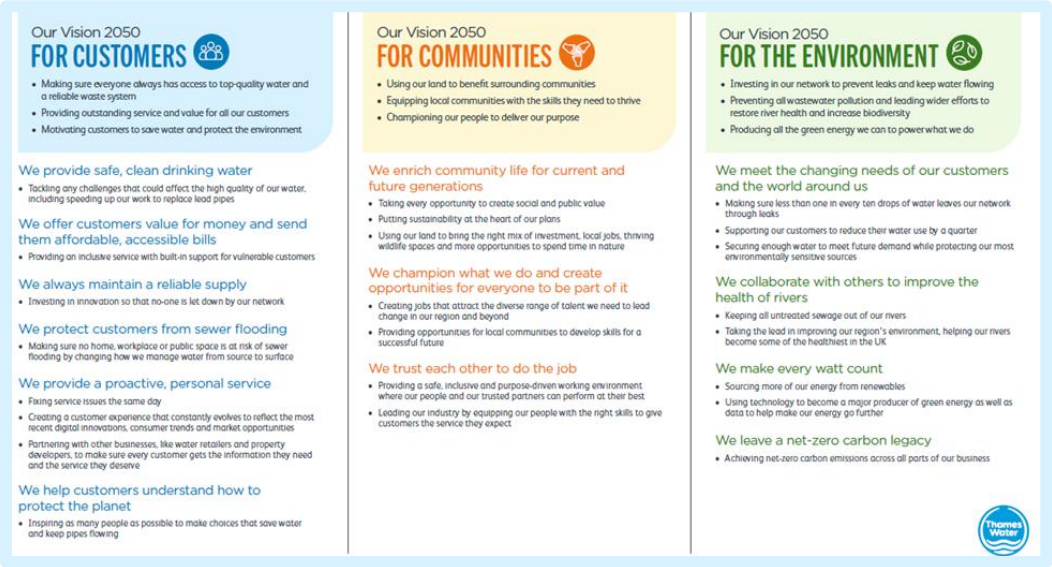
[12] As per footnote 11 - this is the cost for the customer side trial as populated in the data line, it is uplifted in this Enhancement Case (shown in brackets)

2.3. Our priorities for AMP8 are primarily delivered through base, but enhancement for Lead pipes is needed to reduce public health risk further

From a water quality perspective in AMP8, we are prioritising our base investment to address asset health deficit in parts of our network which present the greatest risk to water quality compliance and public health according to DWSPs: for example, at service reservoirs, contact tanks, and water treatment works. Investment in water quality drivers needs to be seen in this context – in addition to base, we have identified that there are two priorities which require enhanced investment in AMP8: one as part of an ongoing long-term programme of works, and one which presents a current and sustained, unacceptable risk at certain water treatment works (WTWs) and needs to be addressed as soon as practicable. This enhancement investment focusses on the first of these water quality drivers[13]: eradicating the public health risk of lead by removing lead material from comms and supply pipes. Due to the size of the problem, the outcome for lead can only be delivered over a number of AMPs (enhanced investment required to the end of AMP12).

Incorporating Lead Control and treatment enhancement for *Cryptosporidium* serves to contribute to our Thames Water Vision 2050 and as part of a multi-AMP delivery plan.

Figure 1 Thames Water Vision 2050



Source: Thames Water

It aligns with DWI's long-term guidance for drinking water compliance, which sets out an '*approach [which] should be efficient and sustainable and contribute to a lasting legacy of long-term benefit for both the company and its consumers'*[14], and to Ofwat's PR24 ambitions to provide a '*price review to support the right long-term solutions for customers'*.[15]

[13] The other proposed water quality investment is to remove the risk to public health of active *Cryptosporidium* oocysts entering the drinking water network by enhancing treatment processes at our slow sand filtration (SSF) WTWs in London and can be found in TMS23 Enhancement Case Long Term Water Quality Strategy Cryptosporidium).
[14] Guidance Note: long term planning for the quality of drinking water supplies, DWI, September 2022
[15] PR24 and beyond: Creating tomorrow, together, Ofwat, May 2021

2.4. It is important to consider solutions to investment needs against long-term ambitions, and how they provide best value to customers, communities, and the environment

Lead pipework in contact with drinking water presents an immediate public health risk – the size of the problem on Thames Water's and customers' side is vast and analysis shows that at the current replacement rate it would take until 2135 to replace all lead comms pipes, way after the ambition set by Vision 2050. This only solves half the problem, as we currently do not replace lead pipes owned by customers, so both the public health and compliance risk would remain.

For the public health, regulatory and business risk presented, and the need to have a different approach, this area of investment has been prioritised for AMP8 as part of our long-term water quality strategy. Customers always prioritise having a constant supply of safe, high-quality drinking water at good pressure. Our 2050 Vision aims to achieve this by ensuring that we tackle any challenges that could affect the high quality of our water, including speeding up our work to replace lead pipe, and investing in innovation so that no-one is let down by our network. Our AMP8 programme therefore aims to continue and build on the AMP7 transformation work to reduce water quality risk and improve public health; Table 3 provides details on what this proposed programme will output.

Table 3 Summary detail on the approach and what is planned to be delivered in AMP8

Lead Control
Target Area: We will use existing models to identify where Lead comms pipes are likely to be present and complement with external stakeholder data (*to be confirmed*) to target 'hot spot' areas with the highest risk customers[16]. The customer trial (see below) will focus in these areas too.
Targeted Lead Communications Pipe Replacement Programme: 97% of the total 54,000 Lead comms pipes removed will be through a targeted proactive programme, using a combination of open cut and moling[17] techniques, replacing pipework up to the customer boundary. As stated, replacement will be in the target area(s) chosen through modelling and other insight, and the programme will support the customer trial to deliver full lead replacement for customers (to at least the internal stop valve).
Reactive Lead Communications Pipe Replacement Programme: The remaining (on average) 3% of comms pipes removed yearly are either prompted by statutory sample failures (>5ug/l of lead in AMP8) at a customer's tap (with advice to the customer to replace the supply side) or customer led supply pipe replacement where we then will subsequently replace any lead comms pipework.
Customer Trial: A significant customer trial will focus educational and financial support for lead supply pipe replacement in the target area, in additional to collaborating with external partners and testing innovative digital solutions to optimise the delivery programme. It will prioritise highest risk customers, but not exclusively, with the aim to remove all lead pipe beyond the customer boundary and Thames Water's official responsibility.

2.5. Structure of document

Following this introduction, the need for enhanced investment in lead pipes, best value option for customers, cost efficiency of delivery and proposed customer protection(s) will be presented in turn, concluding with an adaptive planning section which links to the overall Thames Water Long Term Delivery Strategy (LTDS). Annexes are also provided for further information and reference.

[16] Unborn babies, babies, infants, and children are those most at risk from Lead, impacting brain development, and so target area(s) should have a higher proportion of this customer base (to have to highest public health benefit)

[17] Moling is a trenchless method of laying pipes or cables underground, where a pneumatically driven machine known as an Impact Mole forces a path through the ground, displacing soil rather than removing it https://moleutilities.co.uk/what-we-do/impact-moling/

3. Need for enhancement investment.

The water distribution network still has a lot of lead comms pipes which pose risks to human health

Figure 2 Need for investment summary (further details below)

3.1. Lead is detected in drinking water, sampled at customer taps

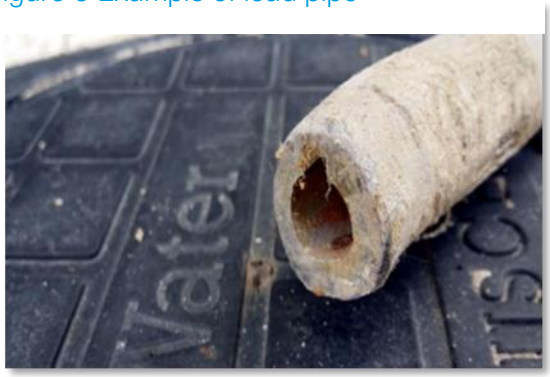
The primary driver for this element of the case is that samples taken at customers' taps through a statutory (and operational) sampling programme (currently around 5,000 samples per year), can detect levels of lead in the drinking water, and sometimes (at a rate of up to ~0.17%[18]) this fails the current lead concentration standard of 10µg/l in England & Wales. This failure rate is likely to increase as Thames Water start to match the rest of the industry of monitoring (and reacting to) a target of less than 5µg/l, by the end of AMP7 (failure rate estimated ~5% compared to ~2% currently working to >7µg/l).

3.2. Lead in water negatively impacts public health, especially for higher risk consumers

Lead can affect brain development, with young children, infants, and unborn babies most at risk; it may also harm kidneys, may contribute to high blood pressure, and has been linked to cancer in adults. As stated above, the current lead concentration standard is 10µg/l in England and Wales – however, the World Health Organisation states that there is no level of exposure of Lead that is known to be without harmful effects.[19]

3.3. Lead in drinking water comes from lead pipes, not from water treatment works

Figure 3 Example of lead pipe



Concentrations of lead at customers' taps do not come from WTWs – internal corrosion from lead pipes causes lead to be detected at customer taps. Due to its inertness and high ductility, lead was widely used to connect properties to the treated water network and for internal plumbing until it was banned in 1970, hence it is found today in some comms pipes and/or customer pipes (and/or plumbing) - all can come in contact with potable drinking water.

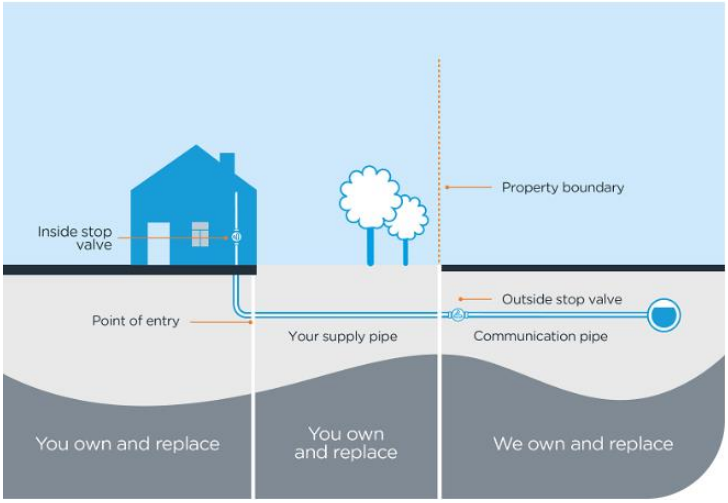
For clarity, it is important to state here that water companies are assessed for compliance to the Lead standard when a sample is taken at the customer tap. Water quality legislation[20] states, that following a lead standard sample failure, the lead comms pipe must be replaced by the water

[18] 2018: 17 failures, 0.16% failure rate; 2019: 16 failures, 0.15% failure rate; 2020: 7 failures, 0.13% failure rate; 2021: 5 failures, 0.04% failure rate; 2022: 17 failures, 0.17% failure rate (Thames Water, water quality data)
[19] See Lead poisoning (who.int)
[20] Water Supply (Water Quality) Regulations 2016

company (also the case if the customer has replaced their supply pipe and there remains a risk of lead in the drinking water). There is no obligation to have a proactive replacement programme.

Figure 4 shows that the water company is only responsible for the pipe to the outside stop valve (OSV), with the customer responsible for pipework and plumbing beyond that. This makes achieving the public health outcome required complicated, as the responsibility for fixing the problem (including funding) is split. Thames Water already replaces the comms pipe to the customer boundary (so, beyond the OSV) but going further than this is not currently supported by the regulatory framework.

Figure 4 Who is responsible for the pipework?



Source: ThamesWater.co.uk

In summary, the detection of lead in the water at the customer tap is a public health risk, and the hazard of lead pipes can persist across large sections of the local distribution network, including customer pipes, making it a difficult problem to solve.

3.4. Customers consider addressing the lead public health risk as a priority

Research into our Enhancement Cases has been conducted to understand our customer, community, and stakeholder views on the need for enhancement and as well as their preference of proposed solutions, where appropriate. Our engagement approach has combined an ongoing, iterative triangulation of insights over the course AMP7 as well as targeted research on specific Enhancement Cases for our PR24 plan. A full list of sources used is available in TMS04 What Customers, Communities and Stakeholders Want (WCCSW) document, which is our single unifying customer insight framework, underpinned by detailed insight. The WCCSW document shows continued support for water quality improvements – indeed, Figure 5 shows that water quality improvements, as you would expect, is high in the overall priorities for customers:

Figure 5 Extract from WCCSW, v18.3, Thames Water

Reducing the risk of lead in drinking water has been tested across several sources including Vision 2050 Customer Research in May 2022[21], PR24 Enhancement Case deep dives in February

[21] SP12 Vision 2050 Research, May 2022

2022[22] and PR24 Enhancement Options Package Research in September 2022[23]. The 'deep dive' with a representative sample of customers gave the following insight on the need:

Table 4 Customer insights on Lead Control

Insights: Lead Control	
Support for the need	• Knowledge of lead pipes is low among customers; many are vaguely aware of the health risks associated with lead but are not sure if they should be concerned. They were not clear on how much lead in water is harmful to health and because it is not widely talked about, customers assume the amount of lead in their water supply is inconsequential. Many are not aware if they have lead pipes in their own homes and generally believe it's the homeowner's responsibility to replace them (PR24-8). • When told about the amount of lead pipes in our water network (which includes supply pipes that are customers' responsibility), customers are concerned, particularly with the health risk that this could pose to children (PR24-8, PR24-12). Many customers are surprised this is not in the wider public consciousness and want to know what water companies are doing to protect customers (PR24-8). • Due to the potential health risks, our lead pipe replacement programme is a top priority to address for customers who thought it could be a win-win on an individual and societal level – protecting customer health and replacing the ageing infrastructure (which could reduce leakage), despite some non-household customers being concerned around associated disruptions to supply. Non-household customers in particular feel that replacing lead pipes was a higher priority amongst water service improvement areas compared to household customers (PR24-12). • Thames Water's long term goal of replacing all lead pipes is what customers believe is wholly necessary. Some understand that this will take time, others feel this should be accelerated. 94% of customers either somewhat or strongly support Thames Water's proposed plan to meet this goal. Many customers see this plan as a major undertaking, and some question why local authorities and housebuilders do not also have a role to play within it (SP12).

In terms of supporting the plan to remove all lead comms pipes by 2050, customers are overwhelmingly supportive, and broadly supportive of customer supply side removals too (see best value section for more information, Section 4.157).

Thames Water and water companies nationally have been mobilised since AMP5 to replace lead pipes and address the public health issue

3.5. The risk of lead pipes and drinking water - public health policy and legislation is changing

The DWI have an ambition to have a lead-free drinking water network by 2050[24]. They state that water companies will need to maintain upstream conditioning (primarily orthophosphoric dosing and/or pH adjustment) in the medium term, but they will need to replace all lead pipes to guarantee compliance to a lower regulatory standard at the consumer tap of 5µg/l or lower (this aligns to new standard recommended and enacted in the European Drinking Water Directive[25]). Our proposed investment and approach have been verbally endorsed by the DWI and we are awaiting a letter of support. The DWI acknowledge that regulatory compliance to this standard (and any further lowering over time – eventually to zero, as no level of lead is harmless) will be extremely difficult for all, if not impossible, without remediation all the way to the compliance point

[22] PR24-8 PR24 Deep Dives: Lead Pipes, February 2022
[23] PR24-12 PR24 Options research, September 2022
[24] DWI commissioned research: Long-term Strategies to Reduce Lead Exposure from Drinking Water, WRc, 26th January 2021
[25] European Recast Drinking Water Directive, 2022

(normally the kitchen tap)[26]. Hence, a solution(s) for the customer owned part of the drinking water network will need to be found and implemented.

In the PR24 strategic position statement to Ofwat, there was no mention of lead pipe replacement by Defra, thereby causing WaterUK and DWI to raise concerns (the DWI informed water companies that they expect to see lead pipe replacement in PR24 business plans). It does appear though that Defra's stance on lead pipe replacement, particularly pertaining to customer supply pipes and the aim of remediating all lead pipes to the compliance point, is now in line with the DWI's long term strategy mentioned above (it is referenced on the Defra website, as Rebecca Pow MP did when asked in parliamentary questions). However, no new legislation is forthcoming as yet.

3.6. There is collaboration across the industry, which is positive, but we have reached the limit of protection for the current chemical mitigation method and the lead risk remains

The water industry, along with health authorities, have a strong collaborative body (headed by the 'Lead Steering Board'), with the aim that through this and associated working groups we will be able to collectively influence regulatory bodies toward trialled and proven 'end-to-end' solutions to support all of our long-term ambitions for a lead-free network – this can be seen in a recently published report by UKWIR (Lead Trial Co-ordination[27]) which aimed to:

- Understand that scope of lead trials across the UK and Ireland
- Undertake a gap analysis of existing and previous trials to determine what trials are needed in the future
- Create a framework to support water companies in co-ordinating their business case submission, and relevant lead trials and projects in AMP8

Thames Water want to play a leading part in this collaboration, ensuring lead trials are supportive of the wider need to remediate lead pipes in the water network, as this is a collective need, and the most efficient solutions for customers will come from a joint effort.

Solving this collective aim is so important when you factor in the reduced longevity of our current 'treatment' mitigation. Since 1998, we have been dosing orthophosphoric acid at WTWs – 92%+ WTWs now have this equipment, showing just how widespread lead pipes are across our operational area. This chemical mixes in the water and when it encounters lead pipe it adheres to the inside to form a protective layer (see Figure 6), thereby reducing lead pipe corrosion, shedding and potential ingestion by the customer.

[26] Other keys findings and recommendations from this research: point of use systems cannot guarantee compliance; suggests a classification of zones from low to high risk; suggested 'societal' cost benefit in high and medium risk zones; proposal of a 2035 target for replacement in high risk zones

[27] Lead Trial Co-ordination, Report 23/DW/04/21, UKWIR, 2023 *[Please note: this is a restricted access document on the UKWIR website – it can be provided on request]*

Figure 6 Orthophosphoric dosing kiosk (left) and illustration of benefits of dosing (above)

The raw material used to manufacture orthophosphoric acid is phosphate ore – it is a finite material (with +70% of the world's reserves in Morocco) and used in the manufacture of certain fertilizers and industrial products at an increasingly alarming rate, meaning that at the current rate commercial and affordable reserves are expected to be depleted in 50-100 years, with peak usage in ~2030[28]. It is also already a very expensive chemical for Thames Water (current unit rate = £2650 per tonne, with ~£11m spent each year)[29] and this cost will only increase further over time as reserves reduce.

Another important point is an assessment by WRc[30] that orthophosphoric acid, as a mitigation method, is also reaching its limit of protection – as such, any tightening of the 10µg/l Lead standard at the customer's tap will challenge its effectiveness to achieve compliance. Therefore, investigations and innovation will be required to develop alternative mitigation methods (e.g., alternative chemical dosing, alternative methods of temporarily lining pipes to the ISV, or point of use filters) – and these need to be seen as a priority for the next two AMPs. The alternative, of course, to mitigation is removing the problem you are mitigating – i.e., replace all lead pipes.

3.7. Other cost drivers for investment

In addition to the high (increasing) cost of orthophosphoric acid dosing, we considered other cost drivers for this investment, especially those outside of management control; these include:

- Orthophosphoric dosing equipment has become standardised over time (and less complex with the move to direct, rather than batch dosing), reducing the number of costly bespoke parts – however, the small number of suppliers, installers and integrators is a business risk.
- Accelerated inflationary pressures on electricity prices (entering into long-term energy supplier agreements, etc, can mitigate this to some degree but not fully)
- Increasing costs for streetworks, especially in London on red routes
- National inflation leading to higher supplier, equipment, and labour costs

3.8. We have previously focussed on robust mitigation and on improving protection for the greatest concentration of the highest risk customers.

As mentioned above, since 1998 we have focussed on ensuring that most of our customers have water appropriately conditioned through the installation of orthophosphoric acid dosing at WTWs,

[28] Peak phosphorus - Wikipedia
[29] Thames Water Finance - OpEx
[30] DWI commissioned research: Long-term Strategies to Reduce Lead Exposure from Drinking Water, WRc, 26th January 2021

including the ongoing operation and capital maintenance of these plants – by the end of AMP6 we had full coverage of water supply as deemed necessary through risk assessment, therefore there were no new plants in the AMP7 business plan. This focus has significantly reduced the number of lead compliance failures (to the current lead standard), but some failures remain.

With mitigation established, from AMP6 this allowed us to start to focus on the replacement of lead comms pipes:

- AMP6 – removed ~36,500 lead comms pipes, targeting primary schools and nurseries in London
- AMP7 – on target to remove 53,837 lead comms pipes, targeting primary schools and nurseries[31] in Thames Valley and the Home Counties

The aim was to target where the highest concentration of those most at risk spend a significant amount of time - we deem that this was the correct, 'no regrets' approach and was supported by the DWI, with enhancement funding provided through Final Determinations.

(Further details on our lead strategy AMP5-8 can be found in Annex 2.)

3.9. Delivering public value

Delivering public value is about maximising the positive impact we have on customers, communities, and the environment, as we provide water and wastewater services. It is about being a force for good in our communities and the environment.

For us, public value is made up of all the things we do to make life better – through our essential services and our wider impact:

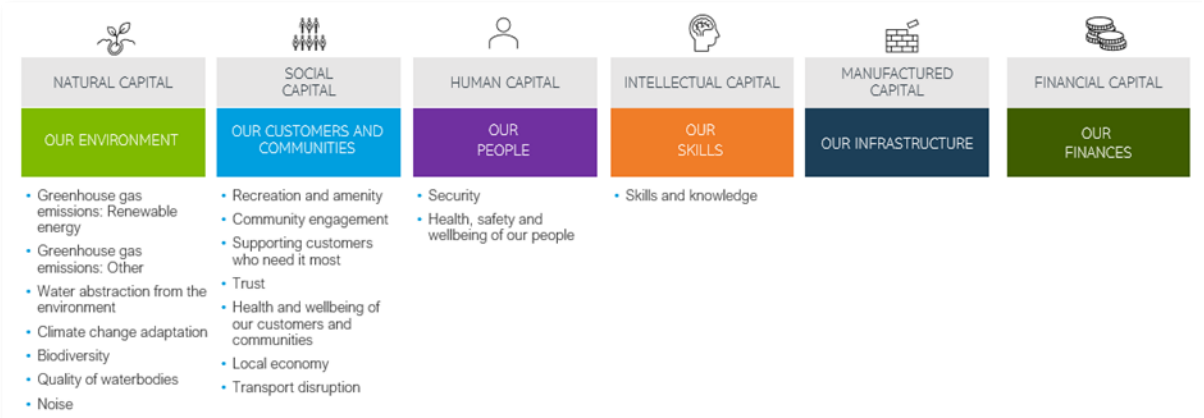
- To deliver our purpose, we have committed to incorporating public value within our investment thinking. With this approach we can identify every opportunity to make the biggest positive difference to customers, colleagues, communities, and the environment as we deliver our service.

We are starting to implement a new approach to guide and measure both the public value we create and the delivery of our purpose. The public value framework helps us identify, evaluate and deliver public value which balances cost and value to customers, community and the environment over the long term.

Our public value framework uses the capitals approach, an international decision-making framework. The capitals are categories of value that can be impacted by our activities. Our framework uses this approach to understand how our success is directly or indirectly underpinned by natural, social, human, and intellectual capital, as well as the traditional consideration of manufactured and financial capital. The capitals, along with Thames Water's customer-facing language for them and what is considered under each capital is set out in Figure 7.

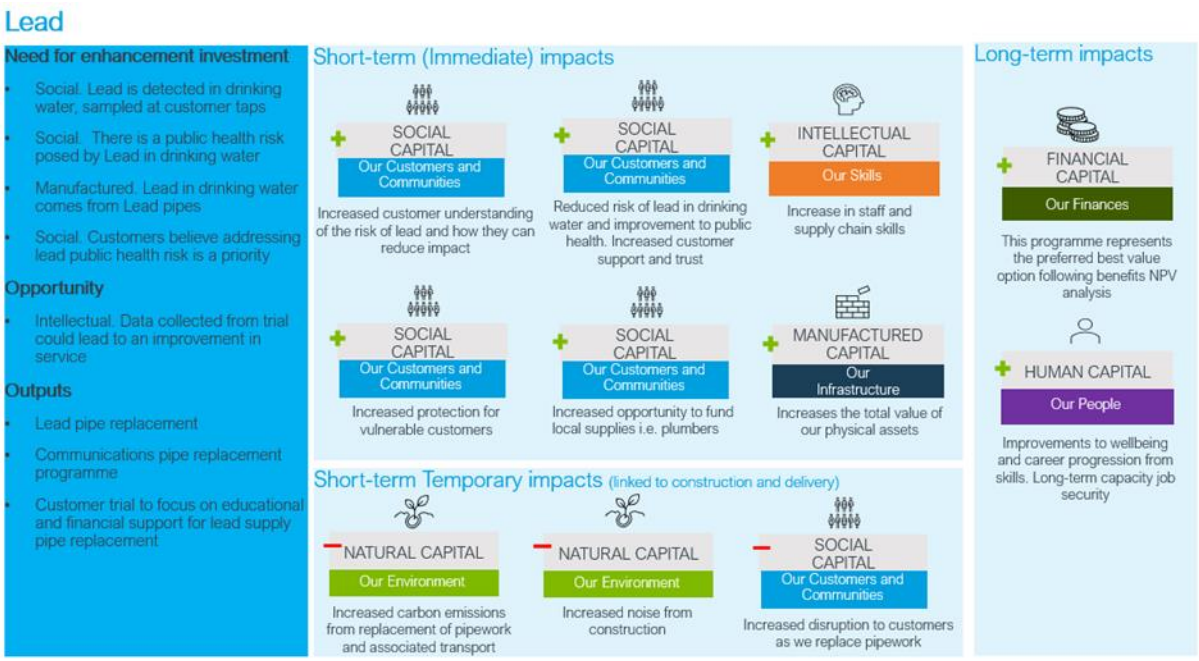
[31] During AMP7, it became apparent that there were a greater number of primary schools and nurseries than first thought (7,496 versus the original schools list of 3,837), and a large range of more informal childcare settings. Although some more sites than expected will be picked up in AMP7, these additional sites cannot be absorbed into the current programme – this also shows that replacement programmes need to be prioritised but also remain flexible

Figure 7 The six capitals



We applied the public value framework here to fully understand how this investment leads to impact on the six capitals. This investment grows value in social, people, intellectual, and manufactured capital. We discovered a range of short-term temporary, short-term immediate and long-term benefits and dis-benefits. The theory of change infographic Figure 8 shows how these benefits lead to impact on the capitals and the public value benefits this investment represents.

Figure 8 The short-term (temporary and immediate), and long-term impacts on the six capitals associated with the lead control Enhancement Case



3.10. Conclusion: Continuing the removal of lead pipes is the right thing to do

At PR19, we stated that we had ~1.2m lead comms pipe connections remaining but did not provide a long-term trajectory on rate of replacement to achieve the ambition of no lead in the network. At PR24, we are doing this to show the enormity of the challenge and our determination to carry on with both a proactive (and targeted) programme of lead comms pipe replacement and customer trials to support both our, and our peers', future AMP business plans – delivery public health improvements for all customers.

Maintaining a replacement programme in AMP8 is essential and the right thing to do: our business and our supply chain need to be able to 'ramp up' when we are in the best position to do so – stepping back from a targeted programme now, while we wait for innovation, technology, and legislation to catch up, would add cost and delays to future remediation programmes. On the other hand, ramping up too early would not be cost-effective as technological advances could not be exploited and we would have to return to those customers with lead pipes remaining on the supply side – hence the balanced business plan proposed (see Section 3).

3.10.1. The DWI require us to continue to address the lead risk

As previously mentioned, the DWI conclude that the only long-term solution is to remove contact between lead pipework and drinking water, including either replacing all lead supply pipes or internally lining them (this is in addition to replacing all lead comms pipes, prioritising highest-risk customers first). They recognise the challenge of doing this, due to ownership and a lack of full understanding of where lead supply pipes exist. So, they support the industry on collaborating through trials and continued innovation. To this end, and for the other reasons set out in the section, the DWI have verbally supported our approach and we are awaiting a letter of support to replace 54,000 lead comms pipes and undertake a customer trial to determine ways to support customers to remove supply side lead pipework (this can be provided upon receipt).

3.11. Our proposed enhancement does not overlap with base or previously funded projects

3.11.1. Delivering lead pipe replacement is not included in base and replacement rate is too slow

Programmes of Lead pipe replacement have been supported through enhancement investment during the last two AMPs, and there is no allowance for replacement in the base allowance. At the end of AMP7, Thames Water will have an estimated 1.14m lead comms pipe connections and there is an unknown number of customer supply pipes, customer plumbing, lead solder and lead fittings also in existence. At our current rate of lead comms pipe replacement (~54,000 per AMP)[32], it will take until 2135 to achieve our ambition of zero (against the 2050 target). Moreover, this does not include replacing (or removing) customer side lead pipe, and there is currently no agreed regulatory position on how this should be achieved, and therefore the principal outcome of protecting public health from lead cannot be achieved.

We do have base allowance to fulfil the statutory sampling programme at customer taps (currently 2,500 samples per year – a percentage of these are tested for lead depending on supply zone size), with the option (through prioritisation) of delivering a complementary operational sampling programme – the operational sampling programme will flex according to sampling prioritisation and can be more targeted (to test modelling results, for example).

Our base allowance funds the operation and maintenance of the orthophosphoric dosing at our water treatment works with capital maintenance interventions – normally through locally delivered projects (including replacement, refurbishment, and upgrades to dosing plants). In time, as the prevalence of lead pipe in the drinking water network reduces, there will be the opportunity to reduce (or 'disassociate') this chemical mitigation, and/or move to alternative mitigation methods, passing on savings to customers. It is important to recognise though that this will only be possible if we are confident that whole supply zones are 'lead free' (to tap).

[32] The AMP7 programme is supported through a PR19 Enhancement Case, providing a step up in removals from AMP6 (~36k)

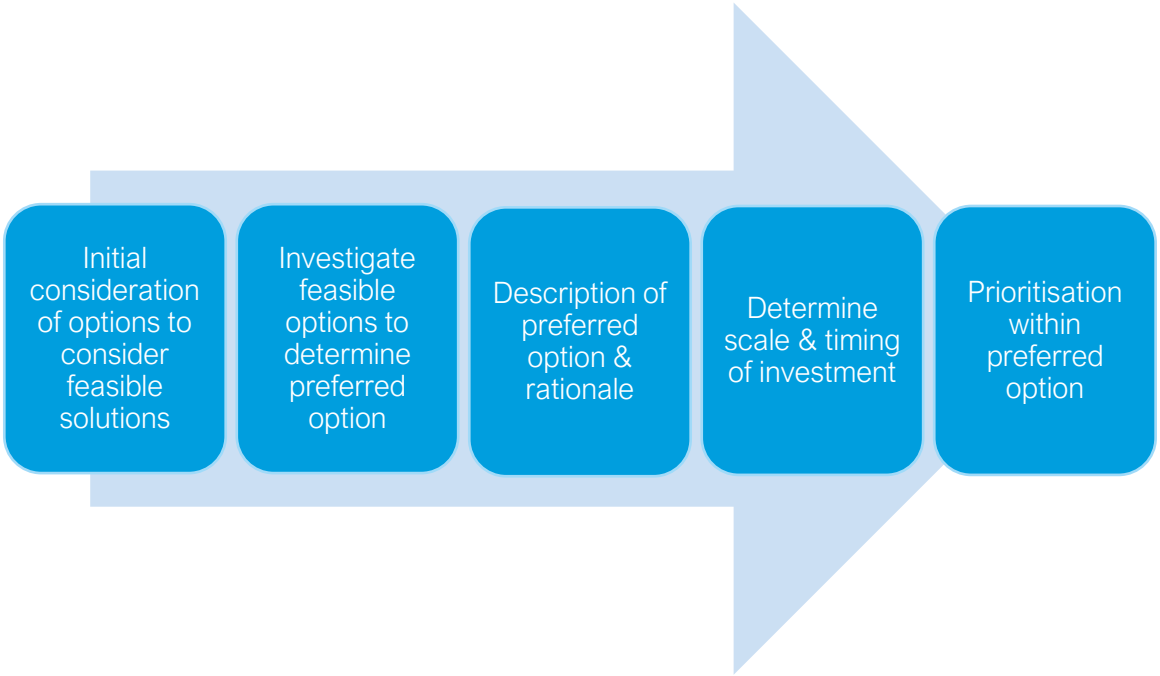
4. Best options for customers

In this section, we will consider the best options for customers to deliver on the need for Lead Control in AMP8.

4.1. Our approach to optioneering

To ensure that the solution or solutions chosen to deliver the desired outcomes provide(s) best value for customers, communities, and the environment, we adopted a logical, staged approach for our options development and assessment. Figure 9 below sets out this approach:

Figure 9 Our approach for best options for customers for Lead Control



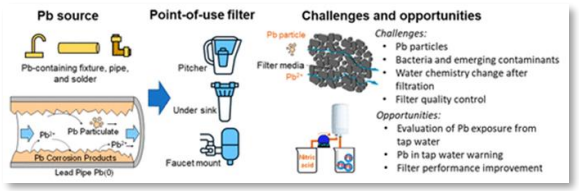
Annex 3 outlines the full details of the options analysis we undertook. Capital investment was the only viable solution to meet the need as presented in the previous section. As such, after the second stage of investigating the feasible options, we used this single solution to determine the preferred scale and timing of such investment to provide best value for customers. The long list of potential options considered are included in Annex 3 (Best options for customers, Table 20 and Table 21), with further narrative provided to aid understanding (the approach is generally based on a *source-to-tap* process flow).

4.2. Initial consideration of options

We started with a qualitative assessment across the seven solution types, by brainstorming what possible solutions may look like and whether these would meet our statutory obligations and the investment need for AMP8, as described in Section 3 ('Reducing the public health risk posed by lead pipe contamination'). The output of this assessment is provided in Table 5 on the following page.

Table 5 - Initial consideration of lead control option categories

Solution type	Option(s) considered	Decision	Rationale
Capital investment	Replacement of lead comms pipes through a mixture of open cut and moling methods, to the customer boundary	Proceed	The only long-term solution, as defined by the DWI, is the removal or replacement of all lead pipework in contact with drinking water. Only capital investment in the drinking water network can achieve this. • Continues to deliver a phased, multi-AMP programme of Lead comms pipe replacement • Works with customers & stakeholders to secure the capital investment required to remove Lead pipe on the supply (customer) side • Supports the long-term ambition of zero lead pipe by 2050
	Undertake a customer trial, to include lead supply pipe replacement		
Operational measures	Chemical dosing at WTWs to provide protection from Lead pipe internal corrosion	Discard (not enhancement)	Operational measures are short to medium term mitigation only – this is primarily orthophosphoric acid dosing in bulk at WTWs to provide a level of protection from Lead pipe leaching and delivered through the base allowance.
	Only replace lead comms pipes following sample failures or customer-led contact		Albeit compliant with the Water Quality Regulations, this approach would receive a lot of criticism from the DWI and public health authorities (and is out of sync with wider industry). It does not support the long-term public health outcome
Catchment management	n/a	Discard	*In this case, lead contamination is related to the comms and supply pipework and not the raw or treated water quality; catchment partnerships and interventions are therefore not relevant.*
Nature-based	n/a	Discard	*In this case, lead contamination is related to the comms and supply pipework and not the raw or treated water quality; nature-based solutions are therefore not relevant.*
Behavioural change		Discard	Unable to change or remove Thames Water's need to invest in the replacement of lead comms pipes, nor a solution to the customer lead supply pipes.
Partnership workings	Non-identified	Discard*	No suitable partnership identified, given Thames Water's legislative responsibility to adhere to Water Quality regulations.
Modular or adaptive solutions	Point of use filters fitted on the drinking water tap in domestic and commercial properties	Consider	The supply and/or installation, and ongoing 'maintenance', of point of use filters could provide a medium-term solution for those with lead pipes at point of use and help spread out the cost of capital investment. This could allow time for technology (both find and fix) to advance further – making replacements more efficient - and a solution to the customer supply side problem to be put in place – making 'to tap' replacement more efficient and cost effective.

			Point of use filters would be required for all properties with Lead pipe – this is likely to be greater than the ~1.2m lead connections Thames Water currently has. This solution could be scaled back and included in capital investment option. Challenges and opportunities for point of use filters are summarised below:  Figure 10 - Overview of opportunities and challenges regarding the application of POU filters for Lead removal from tap water[33]

**It is important to state here, the proposal for capital investment in AMP8 (and beyond) does include a customer trial which will work, in partnership, with local authorities and possibly other stakeholders, to more effectively target appropriate housing stock / properties occupied by higher risk customers. This trial will be defined in detail during 2024 and discussed at a high level later in this section.*

As detailed in Table 5, only capital investment – in the form of lead pipe replacement (or equivalent) – can solve the public health need in the long term. An additional customer trial will aid the design of future 'step ups' for the replacement programme and provide insight on how to solve the customer supply side issue by replacing through different mechanisms some customer supply pipework. Point of use filters could be a solution wholesale (although considered impractical), but more feasibly used in a targeted way as part of the capital investment solution. Operational measures – funded under the base allowance as chemical dosing at WTWs – only serve to mitigate (to a point) the public health risk posed by Lead pipe leaching, so cannot be seen as a plausible solution in the long term (also due to its limit of protection, as discussed in the previous section).

4.3. Lead control: Investigate feasible options

From the options initially considered, two were initially identified to proceed to further investigate feasibility. For comparison purposes, we did consider one of the discarded options: making no increased investment. This is presented alongside the others in Table 6, and for the sake of completeness was assessed on the principle of least cost and best value for customers, while achieving compliance with relevant legislative requirements – included in Annex 3 – however, it will not be included in the development of options as it does not achieve the need in the short term, nor longer term. Please note that orthophosphoric acid dosing as mitigation continues for all options and is funded through the base allowance.

[33] Source: Point-of-Use Filters for Lead Removal from Tap Water: Opportunities and Challenges, Weiyi Pan and Daniel E. Giammar, *Environ. Sci. Technol., March 2022*

Table 6 – Investment options to be progress to feasibility assessment

Investment option		Summary description
Option 1	No Enhancement Case Investment	Deliver a compliant statutory sampling programme (base, not assessed) and undertake reactive replacements of lead comms pipes (sample failure and customer-led) – this will average approximately 300 per year (base, as too small a number to meet enhancement criteria)[34]
Option 2	Network Investment (including customer trial and possible customer side pipe removals)	Alongside a compliant statutory sampling programme (*as in Option Lead 1*), undertake an associated operational sampling programme (align to AMP7) (in base, not assessed), respond reactively to sample results ≥5µg/l and customer-led replacements (both enhancement) and deliver 54,000 targeted lead comms replacements, with a customer side trial (education, support, and funding) (both enhancement)
Option 3	Point of use removal or deactivation	Alongside a compliant statutory sampling programme & reactive replacement (*as per Option Lead 1*), point of use filters could be deployed wholesale to all customers with Lead comms and/or supply pipes, or part of a much smaller, targeted deployment under the customer trial (see Option 13, Annex 3) (both enhancement)

4.4. Description of preferred option for lead control

4.4.1. Our preferred option is capital investment with a customer trial

Through discussion, it was subsequently decided that due to point of use filters not guaranteeing compliance at the tap[35] this option (Option 3) would also not be included in the cost benefit analysis – like the 'no enhancement option' (Option 1) the cost benefit is included in Annex 3 for reference. Therefore, it has been determined that capital investment is the only feasible option to solve the need, specifically to maintain the rate of targeted & reactive Lead comms pipe replacements as AMP7 and incorporate a customer focussed trial, with the following details:

Statutory and operational sample programme (Botex):

- Deliver the minimum statutory water quality sampling programme, with lead tested for in a designated proportion of the samples (from at least 2,500 samples per year[36])
- Additionally, deliver an equivalent (~2,500 samples per year) operational water quality sampling programme

Capital investment - reactive replacements (Enhancement):

- Replace lead comms pipes upon sample failures (>5µg/l) or customer-led contacts - ~1,500 per AMP (~300 per year)

Capital investment - targeted replacements (Enhancement):

- Replace lead comms pipes in a targeted area(s) (54,000 over the AMP) to customer property boundary (as per AMP7 arrangement) – focus on older housing / building stock and higher risk customers (e.g., areas with greater concentration of families with young children) with engagement with local authorities and other stakeholders

[34] To clarify, Investment option Lead 1 has been presented not as a genuine 'do nothing' option, but as a statutory compliant minimum option – i.e., there will be no enhancement investment above the base allowance funded statutory sample programme and reactive (sample failure or customer-led) Lead comms pipe replacements (amounting to about 300 replacements in an AMP).

[35] This is because it relies on appropriate installation, with regularly (and uninterrupted) maintenance of the point of use filters by customers – so, therefore not controllable by the supplying water company

[36] As per total statutory sampling requirement per year laid out in Water Supply (Water Quality) Regulations 2018 (https://www.legislation.gov.uk/wsi/2018/647/schedule/3/made) with the lead testing frequency based on Group B1 water supply zone size and number

Customer Trial - target area(s) (Enhancement):

- Customer trial – aligned to target area(s) – to test different approaches to removing supply pipes and/or lead risk at point of use (e.g., refund customers, through bills, who replace their lead pipes); this will include customer engagement, education, and support
- Results shared with industry and regulators/policy makers, and fed into PR29 plans

We will now discuss this option further, the optionality we have around the delivery, and present how the above is the best value option for customers.

4.5. Capital investment makes sense as it is the only option to resolve the long-term need

Remediation of lead pipes through capital investment is deemed as the only long-term solution to the need presented in Section 3 and has been supported through at least the last three Price Reviews for many water companies, including Thames Water in PR09, PR14 and PR19. Indeed, this approach is supported by the DWI for PR24, as previously detailed.

Looking internationally, the USA, Canada and France have been tackling the issue of lead pipes more extensively, for longer and as detailed in the recent UKWIR report[37] remediation of lead pipes (including the customer side) has been the primary solution to the lead pipe issue. They have also developed many different approaches to identifying more accurately where lead pipes are – including a strong customer interface – to ensure that programmes of investment are effective and efficient. Two examples in the USA: the District of Columbia used a cross-section of external data sources to identify where lead pipes might be prior to prioritising replacement, a customer incentive scheme (up to 100% of the cost to replace with copper pipe covered) and mailed out lead test kits; and the City of Newark, New Jersey, where they have combined a lead pipe replacement programme and an aim to educate customers on how to reduce their exposure to lead in drinking water using a comprehensive cloud-based management system with an address look-up tool and real-time replacement tracker. Both examples put capital investment and a strong customer interface at the heart of their lead pipe remediation programmes.

4.6. Engineering options are limited but there is optionality on pace of investment and target areas

Having determined that capital investment is the best and preferred option, there are only three elements to consider:

- Type of engineering solution for remediation of lead pipes
- Pace of investment in AMP8 (and how this impacts the long-term ambition)
- The pipes / customers to be targeted in AMP8

4.6.1. Engineering options

Different engineering options for 'remediation' of lead pipes are very limited – currently, the only plausible, scalable option is open cut and/or moling to remove and replace lead pipes. Internal pipe lining is a potential option, as is directional drilling and pipe splitting. There have some trials by other water companies in the UK and organisations in the USA and Canada, on comms pipes and customer side pipework[38], but there is not any current potential to scale up.

The other two elements will be considered next.

[37] Lead Trial Co-ordination, Report 23/DW/04/21, UKWIR, 2023
[38] Also, see the Lead Trial Co-ordination, Report 23/DW/04/21, UKWIR, 2023, for a good summary

4.7. We have chosen the right pace of replacement

4.7.1. Scale and timing of capital investment

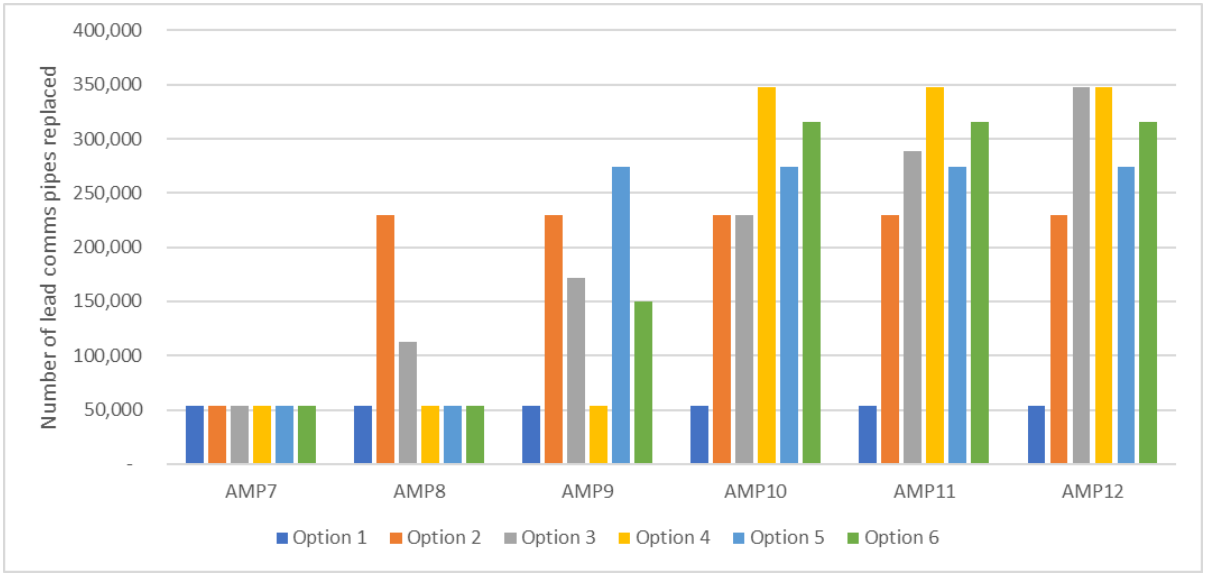
There are several programmes which could be deployed to remove all lead comms pipe by 2050, and that includes the number of replacements in AMP8. What is clear from Option 1 (see below), is that there will need to be a sustained 'step up' – in terms of replacement rate – at some point in future AMPs (assuming 1,149,663 of lead comms pipes left at the end of AMP7[39]).

Below we present five options (shown graphically and in table form including costs, Figure 11 and Table 7 which all have the continuation of a lead pipes replacement programme *(Option 1 is for reference to show that a flat rate would leave 934,315 remaining in 2050)*:

- Option 1 Flat > No increase (does not achieve zero by 2050)
  - Using the AMP7 replacement rate as a flat profile to 2050
- Option 2 Step up > Flat (achieves zero by 2050)
  - Step up in the replacement rate for AMP8 and then flat profile to 2050
- Option 3 Step up each AMP (achieves zero by 2050)
  - Successive 'step' up in replacement programme AMP on AMP
- Option 4 Flat > Step up (later) > Flat (achieves zero by 2050)
  - 'Maintain'[40] AMP7 rate in AMP8 & 9, step up AMP10 and then flat to 2050
- Option 5 Flat > Step up (earlier) > Flat (achieves zero by 2050)
  - 'Maintain' AMP7 rate in AMP8, step up in AMP9 and then flat to 2050
- Option 6 – Flat > Step up > Step up > Flat (achieves zero by 2050)
  - 'Maintain' AMP7 rate in AMP8, step up AMP9, step up AMP10, then flat to 2050

It is important to reiterate that all these options are just targeting lead comms pipe removal. As stated, it is essential that from AMP9 onwards there is an industry agreed parallel/synergistic programme of customer side lead pipe removal, either delivered by water companies and/or alternative mechanisms. Without this, the lead in drinking water public health risk will persist, despite an ambitious comms pipe replacement programme.

Figure 11 Graph showing programme options for the lead comms pipe replacement programme



[39] As previously stated, this is an estimate based on Thames Water modelling using 'hot spot' (sample failure) data.
[40] Rounding up AMP7 programme to 54,000

The run rate used is £1,582[41] to replace each lead comms pipe – this is discussed further in Section 5 (Cost efficiency) and is calculated from the outturn costs (including overheads) observed during Years 1 – 3 of AMP7. Please note, the costs in Table 7 do not include any other proposed investment, like the customer trial (see Section 4.10).

Table 7 AMP8-12 programme options 1-6 with costs (22/23 prices)

Option	AMP8 (£M)	AMP9 (£M)	AMP10 (£M)	AMP11 (£M)	AMP12 (£M)	Total cost (£M)
1. Flat	£85	£85	£85	£85	£85	£426
Lead comms pipes replaced	53,837	53,837	53,837	53,837	53,837	269,185
2. Step Up > Flat	£364	£364	£364	£364	£364	£1,819
Lead comms pipes replaced	229,933	229,933	229,933	229,933	229,770	1,149,502
3. Stepped	£178	£271	£364	£457	£549	£1,819
Lead comms pipes replaced	112,640	171,280	229,920	288,560	347,100	1,149,500
4. Flat > Step > Flat	£85	£85	£549	£549	£549	£1,819
Lead comms pipes replaced	54,000	54,000	347,167	347,167	347,167	1,149,501
5. Flat > Step > Flat	£85	£433	£433	£433	£433	£1,819
Lead comms pipes replaced	54,000	273,875	273,875	273,875	273,875	1,149,500
6. Flat > Step > Step > Flat	£85	£237	£499	£499	£499	£1,819
Lead comms pipes replaced	54,000	150,000	315,167	315,167	315,167	1,149,501

Options 2 to 6 are all profiled to remove all lead comms pipes by 2050, as per our ambition, and as such have the same number and cost to remove. The key difference between the options is when the 'step up' is initiated from the current AMP7 replacement rate (it is assumed that this rate is maintained as a minimum in AMP8). Options 4 to 6 delay that step up to beyond AMP8. Accepting that a step up is required at some point to be able achieve the long-term objective, we considered the advantages and disadvantages of delaying the step up until after AMP8:

4.7.2. Advantages of delaying the step up until after AMP8:

- Lower cost impact on the PR24 Business Plan
- Allows more time to consolidate learning from AMP7 (and subsequent AMP8) delivery programmes and trials (e.g., Green Economic Recovery schemes), and then apply to future price reviews
- Allows more time for digital solutions, modelling, and find and replacement technologies to be developed, tested, and deployed to scale

[41] Outturn unit rate (using AMP7 Yr1-3 costs) is £1,315, indexed to 17/18 prices is £1,183 and converted to 22/23 prices using index 1.18 CPIH (April 2023) = £1,396, then central overhead is added at 13.3% = £1,582

- Enables greater stakeholder engagement – this includes local (health) authorities, regulators, policy makers, supply chain, and of course customers
- Allows more time to develop national policy on customer side lead pipe replacement (influenced by AMP8, and possibly AMP9 customer trials)

4.7.3. Disadvantage of delaying the step up until after AMP8:

- Exposes customers to potential lead in drinking water for longer
- Makes the replacement programme larger in the future and we may be unable to respond in time to an early lowering of the lead standard (even below the 5µg/l expected to be the next level set)
- Greater generational impact (£)
- Later possibility of orthophosphoric dosing disassociation and greater exposure to cost increases
- In light of to lack of policy and agreement on the customer side the risk of more 'return visits' to customers who only have comms pipes replaced in the first instance – will be less efficient and more costly for customers overall

Considering these advantages and disadvantages, we placed greater emphasis on being able to deliver an efficient 'end-to-end' solution for customers in a larger replacement programme, by having an understood, agreed, and funded mechanism to be able to complete lead comms and customer side. This requires between a one- and two-AMP delay in stepping up the replacement rate, narrowing options down to 4, 5 or 6.

On balance, our preferred long-term programme is Option 6: maintain the PR19 approved replacement rate, have an initial step up AMP9, a further one in AMP10 and then flat profile to 2050. This way we hit the 2050 ambition; allowing two AMPs to fully work out and implement (across the industry) the customer side approach, while maintaining a reasonable replacement programme - retaining the skills, supply chain capacity, etc, to enable it to be scaled up when required. It also allows for innovation and technology to improve and provide cost and programme benefits to the 'step ups'. Option 4 is too heavily backloaded, and Option 5 has a very large, single step up in AMP9 which would be difficult to support efficiently and effectively.

In all options (2-6) uncertainties around the deliverability of such a long-term programme with significant step ups in replacement rate do exist, for example:

- Availability of suitable contractors to fulfil such a large programme (a long-term funding commitment would aid secure commercial arrangement), especially if replacement rates are ramped up nationally
- Internal capacity to appropriately contract manage commercial arrangements to maintain performance against targets and control costs
- Improvements to modelling / desktop identification tools to ensure an efficient programme, especially as the number of lead comms pipes reduce over time
- [At a later date / if applicable] the ability to integrate a customer side lead pipe replacement programme and remain efficient to obtain commercially favourable rates
- When we will be confident to turn off orthophosphoric plants to realise cost savings
- Whether the programme can be funded all the way to 2050

The AMP7 replacement rate has proven achievable, and we are confident of our AMP8 delivery programme. Effective programme management even gave us the option to potentially do more in

Year 5 (AMP7), but additional funding submitted through Economic Green Recovery[42] was denied.

4.8. Our customers support the 2050 target to remove all lead comms pipes

The customer insight previously mentioned in the need for enhancement investment section also provided insight to solutions and preferred timings.

During the April 2022 deep dive – with the thinking at the time – we provided customers[43] with three possible approaches to removing lead comms pipes from the network:

- Replace all Thames Water owned lead pipes 2025 to 2050 (£1.68/year extra on bills)
- Replace all Thames Water owned lead pipes 2025 to 2080 (48p/year extra on bills)
- Replace all Thames Water owned lead pipes 2030 to 2080 (50p/year extra on bills after 2030)

Table 8 Customer insight on solutions for Lead Control

Insights: Lead Control	
Support for the solution	• From the PR24 deep dive research on lead pipes, 80%* of customers supported our proposal to replace all Thames Water owned lead pipes 2025 to 2050 (£1.68/year extra on bills) (PR24-8) • Of the different options tested, there is strong support for Thames Water's initiative to replace 67,000 customer owned supply lead pipes between 2025 to 2030 (86%* of customers) (PR24-8) • Furthermore, 88%* support Thames Water's initiative to replace 3,000 water fountains in schools. Most customers support Thames Water's initiative to replace all 3,000 water fountains in schools that still have lead pipes between 2025 and 2030 on the basis that it protects those most vulnerable to the negative health consequences of lead pipes. (PR24-8)

*Note: the percentages shown are based on a relatively small qualitative sample size, they are shown to indicate direction of sentiment only

It is also important to state here that due to the nature of the investment within the water treatment process on site, it is not applicable for third-party funding and as such this is not discussed any further.

4.9. We need to continue to prioritise customers at the highest risk

Part of the proactive lead comms pipe replacement programme in AMP7 is to remove lead pipework (to property boundary) supplying all nursery and primary schools. This approach was predicated on the fact that the youngest consumers are the most at risk from the effects of lead in drinking water. It became obvious the number of 'childcare-based' settings is wide and varied (for example, they can be in churches, cricket clubs, village halls, residential dwellings) and we are still only fixing part of the problem. We need a re-focus on delivering, as a collective, a solution for Lead all the way to the tap (and beyond as necessary) and the priority for the next two AMPs is to target areas where there are the highest densities of properties with Lead pipes and the most at-risk customers. This will mean working with local authorities, including health agencies, to target the lead comms pipe replacement programme in such areas. We have discussed this approach with the DWI, and they are broadly supportive if it is co-ordinated across the industry and results shared for all the benefit – we will be doing so.

4.10. We want to deliver customer trial

In these same target areas, we propose to deliver a customer trial to educate, support and fund customer side lead pipe replacement, helping to achieve an end-to-end solution to the lead risk.

[42] We put in a bid to do an additional 16,000 lead comms pipe replacements under this mechanism, but it was not supported
[43] 55 customers signed up with 50 completing the research; they were from a cross section of the customer base with 42 from the Thames Water Customer Voices Panel, 3 future customers (18-24 years old, non-bill payers and 5 business customers

With the money proposed for the AMP8 trial, we will be ambitious in terms of scope (Figure 12), aiming to expand our understanding on how we engage and fund customer side lead pipes, test different termination points (depending on property type and customer preferences), and whether shorter term mitigation like point of use filters can form part of the solution for certain situations. It is also essential that work better with stakeholders across the board. Some of these activities will be building on trials undertaken by others, but testing against some of the unique settings we have - especially in London - and some will be industry firsts.

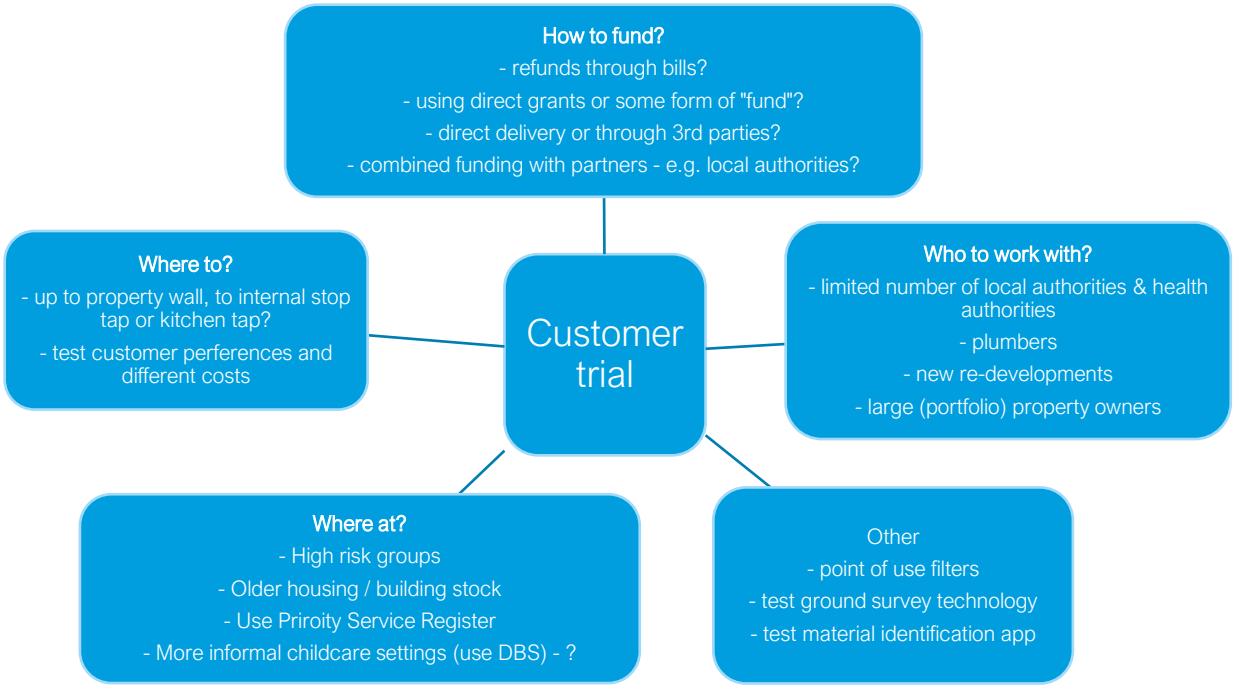


Figure 12 Examples of elements being considered for the customer trial

As this is a trial, certain elements of the scope may be focussed on more than others, depending upon initial findings, successes or otherwise. This scope also aligns well with many of the potential gaps identified by UKWIR in the previously mentioned Lead Trial Co-ordination report, such as:

- (4) Customer identification (mapping and customer engagement)
- (6) Mixed demographics (consider customer type and demographics when engaging)
- (7) Vulnerability (consider vulnerable customers when testing engagement approaches)
- (8) Incorporating external stakeholders (best approach – need to align across companies
- (11) External wall of property (test replacement to outside wall of some properties)
- (12) Point of Entry (test replacement to internal stop tap of some properties)
- (13) Compliance Point (test replacement to compliance point – i.e., kitchen tap)
- (16) Subsidised / Part Funded (part funded by us)
- (17) Repayable loan (loan provided by us)
- (19) Fully funded (fully funded by us, delivery through 3rd party)
- (32) Point of Use removal (supply point of filters to some properties)

We are currently building up the components of the trial in more detail – we will take learning from past (and current) water company trials to develop a trial which builds upon these industry experiences and will start engagement internally and externally ahead of our proposed AMP8 trial. Such a trial has been discussed with the DWI, and they are supportive of the concept and the input it can provide into the industry to help tackle the lead issue nationally. It is expected that we will need to deliver a more extensive trial in AMP9 to build on the outputs from the AMP8 trial, but this will also be delivered alongside a larger lead comms pipe programme.

As evidence of our greater commitment to engaging with customers on the risk of lead pipes and further building our understanding on where lead pipes are and customer preferences on remediation, starting later this year (2023) and through the rest of AMP7 we will include lead questions and data collection as part of our Smarter Home Visits. Our Smarter Home Visits target customer properties (household and non-household) with high water usage to build a personalised water efficiency plan, but also uses the opportunity to discuss other aspects such as our Bin It, Don't Block it campaign.

4.11. Summary of proposed investment AMP8-12

As part of a multi-AMP programme of works, it is proposed that AMP8 will deliver a continuation of the AMP7 rate of Lead comms pipe replacement and provide valuable insight for PR29 on how the customer side Lead pipe issue can be solved, alongside a staged step up in the rate of Lead comms pipe replacement from AMP9. With the customer trial proposed above and a subsequent one in AMP9, we can estimate a ~£1.832B programme to remove all lead comms pipes, using the preferred Option 6 (see Table 9 for summary). This forecast spend does not include the cost to replace supply side pipes, so this overall cost could easily double.

Table 9 Summary of proposed Lead Comms Pipe Replacement programme and customer trials to 2050 (EXCLUDING POST AMP9 CUSTOMER SIDE REPLACEMENT COSTS) (all in 22/23 figures)

Option	AMP8 (£M)	AMP9 (£M)	AMP10 (£M)	AMP11 (£M)	AMP12 (£M)	Total cost (£M)
6. Flat > Step > Step > Flat	£85	£237	£499	£499	£499	£1,819
Lead comms pipes replaced	54,000	150,000	315,167	315,167	315,167	1,203,500
Customer trial	Yes	Yes	No	No	No	n/a
Customer trial cost (£M)	£9[44]	£5[45]	0	0	0	£14
Sub-total (£M)	£94	£242	£499	£499	£499	£1,832

4.12. Public Value Framework: Benefits analysis

Our public value framework uses a semi-quantitative, multi-criteria analysis approach, where values are weighted using customer preferences[46]. There are 19 measures in our public value framework which are used to assess an option.

The public value framework assessment includes a wide range of measures such as biodiversity, waterbody quality, recreation, amenity and local economies, while the financial capital measure continues to be captured in other parts of our investment planning processes. The framework considers both short and long-term impacts, looking approximately 30 years ahead.

The degree of impact between the capitals varied. These are outlined in Figure 13:

- The investment strongly benefits social capital across one of more measures. Improving our drinking water quality to protect public health, particularly for the vulnerable, in turn improves customer and stakeholder trust. Our education and outreach programme will

[44] Customer trial in 22/23 prices with central overhead included at 13.3%
[45] Follow on customer trail in 22/23 prices
[46] Public value research, May 2022 Verve

lead to increased customer understanding of how they can reduce impact of lead in drinking water which will lead to further public health benefits. Capacity of the workforce will need to increase to deliver the multi-amp programme, which will create new jobs and apprenticeship opportunities. There will be disruption to transport during construction as Streetworks will be required to deliver the improvements

- There is also a strong benefit to manufactured capital as the replacement improves asset condition and value. We expect an improvement in asset health which will support reducing leakage on our network
- There is positive benefit to intellectual capital. Employees will receive training to support customer engagement activities
- In turn, we expect a positive benefit to human capital as wellbeing improves and career progression opportunities increase. The multi-AMP programme results in long-term capacity needs and job security for employees
- There is positive benefit to natural capital. Asset replacement using new materials improves the pipework's resilience to climate change scenarios which are likely to increase bursts and leakages. Short-term dis-benefits include some disruption to customers during one-off installation periods, increased carbon emissions as we deliver the replacement and increase noise from construction
- An overview on financial capital is included in Section 5.

Figure 13 Public value for lead control

We will continue to seek public value opportunities through delivery, e.g., by stakeholder engagement.

5. Cost efficiency: Meeting lead standards

In this section, we cover the approach we have taken to arrive at our option costs and how we have considered the top-down efficiency of our proposed option for meeting lead standards.

Firstly, we set out the overall approach we have taken to developing our costs for this case. We describe in detail the bottom-up engineering costing in section 5.1. Next, in section 5.2, we demonstrate how we have challenged these bottom-up costs through the application of different operational efficiency levers. We describe the process we have followed and show how we arrived at our costs alongside the supporting evidence, calculations, and key assumptions.

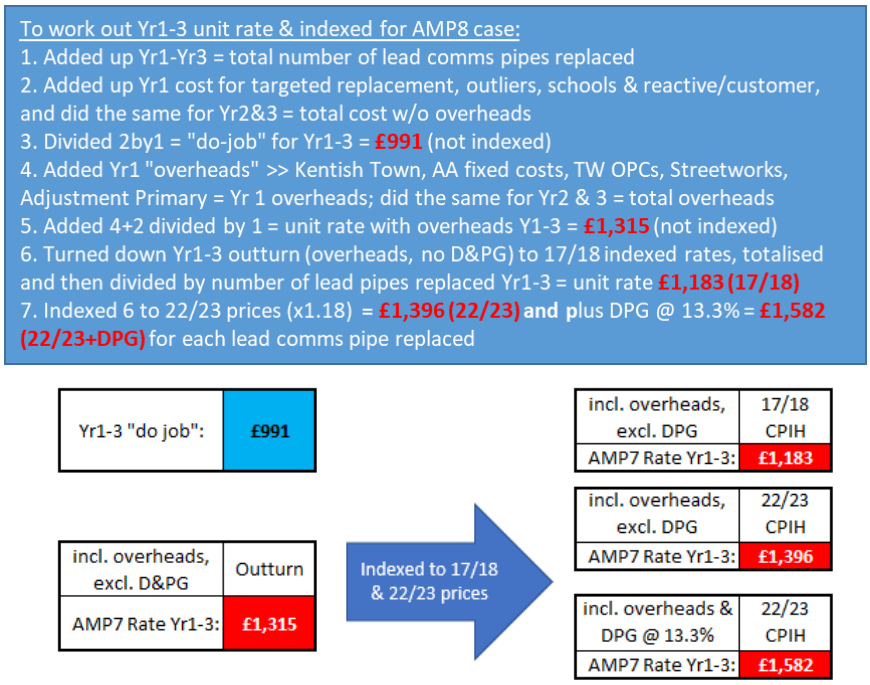
We then set out how we have considered efficiency of our proposed costs using benchmarking in section 5.3. For this case, we recognise that Ofwat is likely to use econometric models. We provide our view of the approach to determining cost efficiency and considerations Ofwat should make in section 5.4.

Finally, section 5.5 provides a recommendation for how Ofwat should assess the cost efficiency of our proposed enhancement.

5.1. How we arrived at our bottom-up engineering costing

Our unit cost rate was based on our PR19 agreed rate, which in 2017/18 base figures was £1,250 per lead comms pipe replaced. Through the first three years of AMP7 we have been able to become more efficient and now realise a comparable unit rate of £1,183 (17/18 prices). This run rate includes overheads such as staff costs, depot costs, street works charges, but it excludes central overheads. The realised unit rate is an average cost of all types of lead comms pipes and methods of replacement, including targeted replacements (£954/pipe actuals) and reactive replacements following sample failure (£2,568/pipe actuals). Figure 14 below provides our detailed methodology of how this rate was calculated, with base data included in Annex 4 for reference.

Figure 14 Methodology and results of run rate analysis for 'do job' , outturn and indexed



Another point to note is that a programme shift towards targeted domestic settings, from one focussed on schools and nurseries which have a higher unit cost, could lead to lower costs, although this is likely to be offset by inflationary pressures.

5.2. How we have challenged our proposed costs

The methodology for identifying the efficiencies to be achieved in this Enhancement Case, considering the optimism bias associated with achieving the stated results, is outlined in TMS33 Capital Cost, Efficiency and Assurance.

We used nine efficiency levers to identify efficiency opportunities across our PR24 Enhancement Cases. Horizontal levers are specific to each Enhancement Case – the relevant ones for this Enhancement Case are presented below – whereas vertical levers are applicable across all Enhancement Cases.

5.2.1. Vertical levers

Table 10 below provides a list of the vertical levers which we will utilise across all Enhancement Cases in capital delivery.

Table 10 Vertical efficiency levers

Lever	Description	Total efficiency across the programme
Programme optimisation	Programme optimisation is a strategic view of a programme of works, which identifies efficiency through grouping and synergies, including process type, geography, site, scope, procurement, delivery route.	<5%
Digital, tech and data analytics	The use of digital technology and solutions to improve project delivery, such as Building Information Modelling (BIM), Asset Information Modal (AIM), digital rehearsals using 4D, the use of augmented and virtual reality. The implementation of digital paperwork solutions, on-site tablets etc. This can be integrated with drones, laser scanning, LIDAR, digital data capture. Data analytics to optimise the solution.	<1%

5.2.2. Horizontal levers

The main opportunities for efficiency savings in the lead control Enhancement Case fall primarily in the following horizontal levers, which will be used to control future costs and realise potential cost savings:

- Strategic procurement: Based on the engineering scope for this Enhancement Case, it is anticipated that opportunities for strategic procurement will be limited due to the bespoke design and replacement of lead pipes, however with a very small potential that could be realised.

Final efficiency potential: The anticipated total efficiency savings across the five core levers applicable to this Enhancement Case is limited at 0.1%. The low to high efficiency range is 0 – 1.5%. These values incorporate the anticipated optimism bias necessary for achieving these results.

5.3. Our approach to determining cost efficiency

We have considered the most appropriate approach to assess efficiency is a benchmarking model, using the framework set out in TMS33 Capital Cost, Efficiency and Assurance. We reviewed the Enhancement Case against a set of criteria, covering:

- The benchmarking process at PR19: Ofwat used two models based on the forecast data for the 2020-25 period to assess meeting lead standard costs: a) a unit cost model using the number of lead comms pipes replaced for water quality purposes as denominator, and b) a benchmarking model using this denominator as a cost driver. A modelled allowance was estimated based on the average of the estimates of these models.
  For companies whose submissions suggested unique and material costs not captured by Ofwat's model, Ofwat conducted a deep dive using the information provided by the company. Ofwat carried out a separate deep dive for three companies including Thames Water for their work on replacing customer supply pipes. We expect that Ofwat will use an econometric model to assess efficient costs in this area at PR24 in a broadly similar manner to that which was used at PR19.

- Thames Water deep dive at PR19: At PR19, Ofwat conducted a deep dive on Thames Water's costs for lead replacement. We proposed a £15m variance from the modelled allowance, to consider the need for additional allowance for activities on customer pipework. Ofwat allowed an additional allowance for the forecasted replacement of 5,000 supply pipes, in recognition of our work in replacing customer side lead pipes, which exceeds industry norms. Ofwat granted a partial allowance reflecting the uncertainties surrounding the regulatory expectations, industry developments, company forecasts, unit costings and customer support. This adjustment was reflective of a Regulation 28 notice which revised the standard for lead to 5µg/l, half of the previous standard.
  Our proposal for lead pipe replacement at AMP8 will again go beyond statutory obligations with a trial of customer side lead pipe replacement approaches. This trial will enable us to test approaches to tackling customer side drinking water lead exposure, paving the way for us to deliver against the DWI's target of a fully lead-free drinking water system by 2050 with effective delivery of solutions in AMP9 and AMP10.

- The comparability of the data: At a high level, this Enhancement Case is comparable to schemes being proposed by other companies. Data on the cost of lead pipe replacement programmes delivered by all water companies will be available for modelling and comparison. However, Ofwat should consider the following factors, which are outside our management control and were not captured in the PR19 models, to determine our efficient allowance:
  - London costs: We face higher labour and logistics costs due to our operations in London. This programme will involve working across central London sites, raising both our fixed and variable costs. This was accounted for in the base cost models where the density and the squared term of the density driver was included to account for these requirements. Hence, a consistent approach should be considered when determining our expenditure allowance.
  - Customer side lead pipe replacement trial: Our approach to lead pipe replacement goes beyond the statutory obligations, including a customer trial to deliver customer-side lead pipe replacement. This trial will test a range of options to address lead exposure that originates beyond the boundary of our company's asset ownership. This will lay the groundwork for work in further AMPs, which will be critical to meet the DWI target of a fully lead-free drinking water network by 2050. Other companies are likely not to propose the same work on customer-side lead replacement, meaning a benchmarking model of

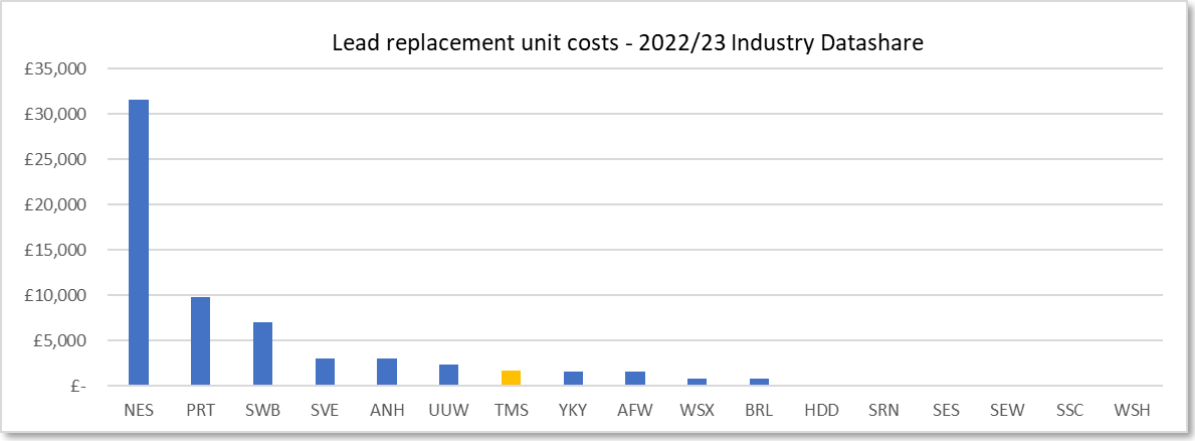
enhancement costs would likely underestimate our costs to deliver this programme of work.

- The availability of the data: We recognise that Ofwat undertook a benchmarking exercise at PR19, and that the data requested as part of the business plan data tables submission indicate a similar approach will be used. We understand that AMP7 costs are available for the delivery of similar tasks, and that Ofwat will likely conduct a similar benchmarking exercise using AMP7 costs and company forecasts for AMP8 lead pipe replacement costs.

- Whether there is a clear cost driver (or cost drivers): Given the process used at PR19, we recognise there is a clear set of well-established cost drivers in this Enhancement Case. For lead replacement, we have based our cost estimates based on our actual costs per lead comms pipe replaced for the first three years of AMP7, as explained in section 5.1. We used the first three years of AMP7, as in April 2023 we entered into a new commercial agreement with MWS. Due to this being a new arrangement, it is too early to provide an accurate cost with confidence. Nevertheless, early indications are that costs from MWS (including overheads) are comparable with the those seen in the first three years.

As stated earlier in this section, our proposed AMP8 lead comms pipe replacement unit rate is £1,396 or £1,582 with central overheads @ 13.3%. Our Final Determination (FD)2019 unit price was £1,463, indexed to 2022/23 prices. A recent industry Datashare shows that our unit rate is comparable against others (see Figure 15), but this does depend upon how companies are spending money on lead risk reduction, and hence our recommendation in Section 5.5.

Figure 15 Lead replacement unit costs England and Wales water companies 2022/23



This same Datashare showed that the Thames Water lead replacement programme was removing nearly three times more lead comms pipes than the next largest programme (13,388 v 4,662 at United Utilities) and significantly more than most other water companies. Due to economies of scale this does assist our unit rate but is a symptom of the number of lead comms pipes remaining in our network and the uplift in replacement rate we requested through enhancement in PR19 (as we apply such significance to this public health risk, as discussed in the need for investment section).

5.4. Further considerations Ofwat should make when setting our efficient costs

We also recommend Ofwat to consider the impact of COVID lockdowns, which have impacted the delivery of lead pipe replacement rates during AMP7. This means that replacement rates during that period will not be reflective of likely delivery during AM8. Ofwat should take this impact into account when developing its assessment approach for lead replacement at AMP8. Without

considering the impact of COVID lockdowns on lead replacement at AMP7, Ofwat's modelling may underestimate the companies' ability to replace lead pipes at AMP8.

5.5. We recommend that Ofwat undertakes a partial deep dive to assess our Enhancement Case

Our proposal on meeting lead standards forms a cohesive package that goes beyond statutory obligations and builds a basis of research that will enable us to deliver against ambitions for complete lead removal by 2050.

We recognise that Ofwat will likely use benchmark models based on companies' business plan tables. We recommend that Ofwat follows the same approach it used to assess Thames Water's PR19 costs, with a cross-company modelling complemented by a deep dive into our relatively higher costs in London and our customer side lead pipe replacement trial. A simple modelling of costs would expose us to direct comparison with companies that are delivering much simpler programmes of work in this area and facing relatively lower costs. Furthermore, Ofwat should account for the impact of COVID lockdowns for all companies.

6. Customer protection

Given the materiality of our programme, we propose a Price Control Deliverable (PCD) for this Enhancement Case.

Although funded through this Enhancement Case, we have excluded the customer 'trial' from this PCD because it not possible to determine levels of uptake and therefore set targets. We consider the amount of funding requested is immaterial and is not relevant for any Totex calculation relating to the replacement of lead comms pipes.

6.1. Price control deliverable

Table 11 Price Control Deliverable mechanism for lead control

Scheme delivery expectations	
Description	Replacing up to 54,000 of lead comms pipes in the 2025-2030 period. Activity covered by the PCD includes: 1. Targeted (proactive) replacements in trial area(s) (based on property and demographic risk profiling) 2. Reactive replacements following customer requests (when they have replaced the supply side), and 3. Reactive replacements following failed statutory (water quality) samples Replacement of lead pipes covers all activities, including pipes whose long-term health risk is removed using innovative technologies developed in the future and approved by the DWI.
Output measurement and reporting	The number of lead comms pipes replaced annually, reported to zero decimal places. Number of led comms pipes as reported in the company APR data, Table 6C item 9.
Conditions on scheme	Excludes replacement of customer-side lead pipes.
Assurance	The company must commission an independent, third-party assurer to assure, to our satisfaction, that the above conditions have been met and the outputs of the scheme set out above have been delivered.

We propose a straight-line delivery profile consistent with previous AMPs:

Deliverable	Unit	Forecast deliverables				
		2025/26	2026/2	2027/2	2028-29	2029/30
Number of lead comms pipes replaced	Number	10,800	10,800	10,800	10,800	10,800

6.2. PCD payment

We propose to calculate our end of period PCD payment rate based on an average cost:

PCD payment unit	Calculation (£ Totex/ # units)	PCD payment (£) (22/23 price base)
£ per comms pipe not replaced	85,435,345 ÷ 54,000	1,582

We propose the PCD payment should be calculated from the difference between forecast cumulative pipes and actual cumulative pipes. As per Ofwat's guidance, IN 23/05, we consider where the difference is due to schemes that are going to be delivered early in AMP9, this amount should be excluded.

We understand Ofwat will apply cost sharing as part of its draft determinations and the end of period reconciliation will occur with the Totex reconciliation models, including the time value of money adjustment.

6.3. ODI impacts

There are no common or bespoke Performance Commitments that are appropriately protect customers in the event of non or under-delivery of this Enhancement Case. Although lead does impact the Compliance Risk Index (CRI) and the 'customer contacts about water quality' Performance Commitments, the impact is typically negligible in any given year.

6.4. Time incentive (TI)

For late delivery, we propose a time incentive payment rate based on the PCD payment:

TI payment unit	TIM calculation	TI payment (£)
£ per comms pipe not replaced	1,582 x 3.5%	55.37

We propose the time incentive payment should be calculated from the difference between forecast deliverable and actual deliverable for each year of the AMP.

6.5. Protecting customers from third party delivery of investment

As stated, our lead comms pipes replacement programme is now delivered using MWS (Morrisons Water Services) from April 2023. Thames Water entered into a Framework Agreement with MWS, following a successful tender process. FA1594 has an expected number of lead comms pipes to be replaced per annum and a Schedule of Rates forecasts expected costs with the contractor using the expected proportion of replacement methodology[47].

A Thames Water contract manager oversees the FA – supported by the programme manager, they ensure that performance against target number is achieved, and replacement methods are as expected – for example, moling is expected to account for ~80% of replacements as this is a cheaper method of replacement, but open cut can sometimes be seen as the easier option.

[47] The cost per replacement method differs depending on length of pipe and whether it's through moling or open cut

7. Adaptive planning: Long-term water quality

We will show how the need and best value, efficient solution for customers is set against a long-term delivery strategy and how adaptive planning will ensure that the outcome can still be effectively delivered under different future scenarios.

Adaptive planning provides a framework for exploring how sensitive a plan may be to alternative scenarios, risks, and uncertainties, to ensure that the plan is flexible and resilient to different futures. The approach identifies where thresholds and trigger points for alternative adaptative pathways exist, providing the basis for monitoring and review of the strategy and interventions, mitigating the risk that short-term decision making might reduce or jeopardise choices in the future.

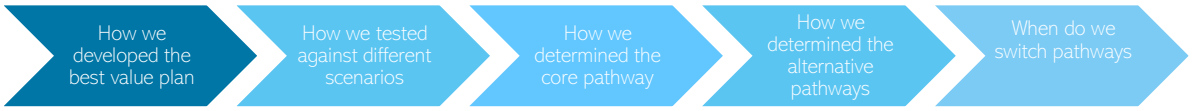
Adaptive pathways provide clarity on the decisions that may need to be taken to address future uncertainties, and agility/flexibility to the latest data; for example, climate science, population growth, or understanding and innovation in the range and type of options that may be deployed. This avoids the risk of being 'locked-in' to specific and inflexible solutions and helps communicate and make more timely decisions on investment.

Adaptive planning is central to Ofwat's LTDS (Long Term Delivery Strategy) guidance. We have followed this guidance by prioritising no- or low-regret activities, demonstrating the benefits of planned investment against future uncertainties and risks; and deferring investment until the benefits are more certain. Our approach to adaptive pathway planning has considered:

- A range of plausible futures
- A broad range of feasible solutions that could be deployed to meet the future scenarios
- Thresholds and trigger points that determine alternative decisions or pathways
- A framework for monitoring against those thresholds and trigger points
- Those solutions that are common to all futures and which may form the core of the strategy formulation
- The range of alternative decision or pathways and the potential trade-offs and risks of investing in emerging options sooner or later

7.1. Best value pathway

The chevron graphic shows how we have structured our narrative on adaptive planning. We identified and showed our best value pathway for this Enhancement Case in the last section, and here we identify potential turning points from that pathway, presenting any alternative(s).



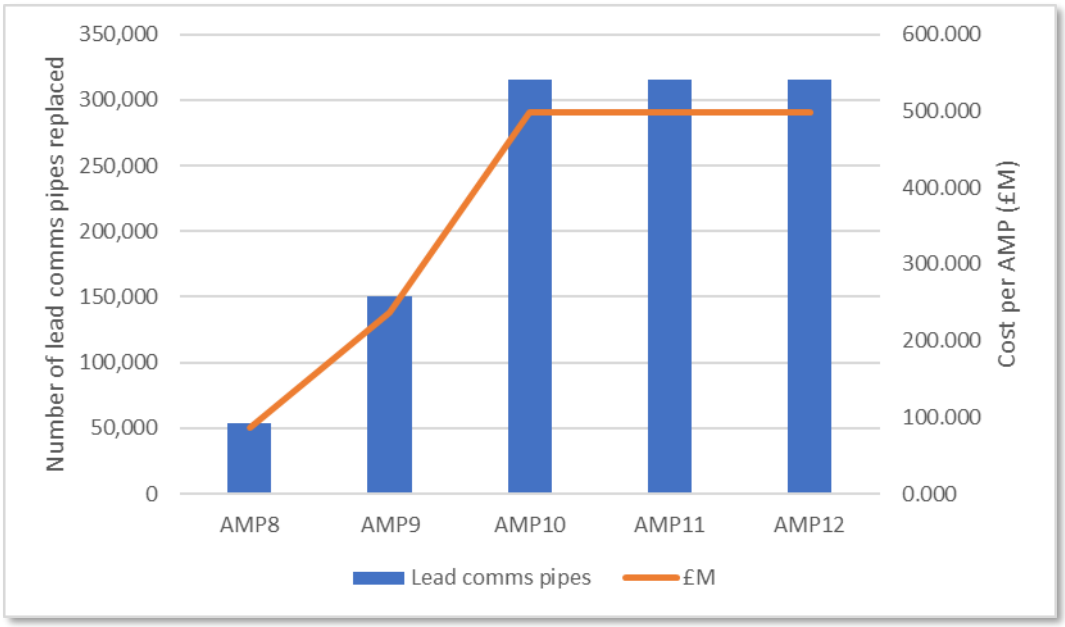
Our best value pathway for lead control is provided as a reminder in Table 12 (next page), shown in terms of cost and replacement rate per AMP. The pathway involves two 'step ups' in the Lead comms pipe replacement rate (first one in AMP9 and another in AMP10), followed by a sustained programme at the AMP10 rate to remove all comms pipes by 2050. To reiterate, this alone will not achieve the outcome of 'lead free by 2050' and there will need to be a parallel programme – yet to be determined – to resolve the customer supply side; hence the reason for a customer trial in AMP8, and an additional one in AMP9. It is assumed that technology (see later in section), along with an increased delivery capacity, will service the required increased rate of replacement of Lead comms pipes over the AMPs. The scale and timing of this approach is supported by customers and stakeholders, all agreeing a strategy to move to Lead free by 2050.

Table 12 Best value pathway for each element of this Enhancement Case (22/23 prices)

		AMP8	AMP9	AMP10	AMP11	AMP12
Lead control	Number of lead comms pipes replaced	54,000	150,000	315,167	315,167	315,167
	£m	£94.060*	£242.320*	£498.637	£498.637	£498.637

**This includes a £8.625m customer trial in AMP8 and a follow on £5m one in AMP9*

Figure 16 Graphical representation of Table 12 showing number of Lead comms pipes removed per AMP & cost (excluding customer trials) in the best value pathway



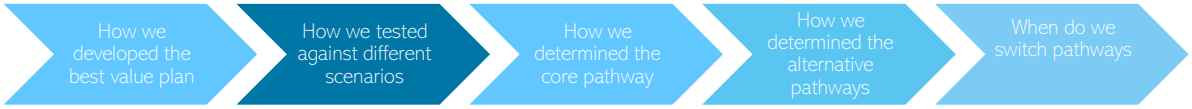
This approach:

- Enables us to make best use of the new technology needed to deliver the work efficiently and effectively
- Starts to address customers' desire for us to act and deliver immediate performance benefits while being affordable and deliverable in the short term, and
- Enables us to step up activity as a lead free to tap targeted solution becomes clear.

The best value plan has been assessed against a public value framework to ensure we account for wider benefits. Our plan strongly benefits social capital across the 19 measures. Improving our drinking water quality to protect public health, particularly for the vulnerable, in turn improves customer and stakeholder trust.

7.2. How we defined scenarios for Lead Control

We now focus on the subsequent four chevrons, starting with scenario testing.



We followed Ofwat's LTDS guidance by considering 'common reference scenarios' to test against our preferred plan. The common reference scenarios are a set of benign and adverse scenarios covering four material drivers of uncertainty: climate change, technology, demand, and abstraction reductions. A summary of a workshop held with our innovation department and other key stakeholders is provided below, with a decision on which scenario(s) would be developed further.

Table 13 Summary of the impact of common reference scenarios on lead control

Reference scenario	Summary of discussion and conclusion	Decision
Climate change	More sustained, hotter weather could have a slight impact on water chemistry, which could possibly affect how warmer water interacts with Lead pipes and/or the effectiveness of chemical dosing mitigation. These potential impacts were negligible.	Discount
Technology	Technology could have a marked impact on how we model, locate and fix Lead pipes (both comms and supply side), impacting the effectiveness and efficiency of any delivery programme, moving towards a lead-free network more or less quickly at lower or higher costs. It could also impact alternatives to current mitigation methods. These potential impacts were considered tangible and potentially significant.	Progress
Growth	As the presence of Lead is historical and based on property age, population growth does not have an impact on the case.	Discount
Abstraction reductions	Reductions in abstraction rates across the system(s), even if this leads to changing supply routes (e.g., if the current WTW supply route is shut down and source route(s) change), this will not impact the delivery programme or public health risk from the current position.	Discount

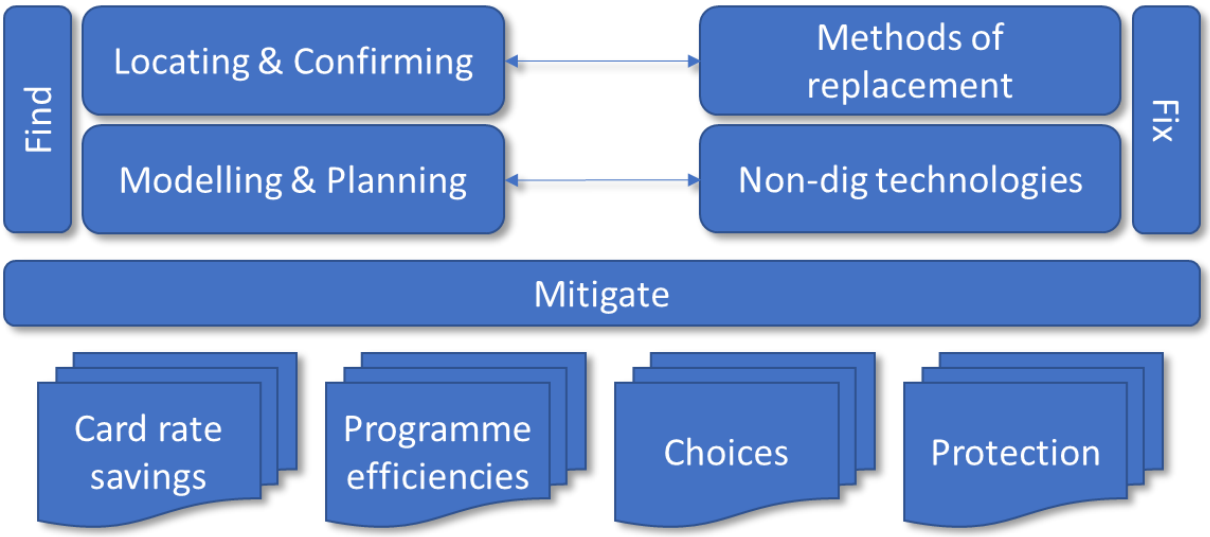
For lead control, we therefore focussed on technology only, as the other scenarios were deemed to have no or negligible impact on how we deliver against the need and desired outcome.

7.3. Technology scenarios

The key considerations for how a technology scenario might impact our 25-year delivery strategy are illustrated in Figure 17 on the next page and can be summarised by technology associated with either finding lead pipes (desktop and on the ground), fixing (replacing the pipes), or mitigating the public health risk. On the last point, mitigation does not achieve the outcome, so can only be seen as a medium-term strategy – however, it may provide two options:

- If alternatives to orthophosphoric acid dosing at WTWs are found and prove to be more effective in achieving compliance to lower Lead concentration standards (i.e. ,≤5µg/l), more sustainable over a longer period (resolving the finite raw material issues) and/or are cheaper (reducing OpEx or impact of price rises), then this could reduce the overall Totex for Lead Control (including costs covered under base), and/or be re-invested to accelerate the programme of replacement
- Enable some more difficult Lead pipe replacements (especially on the customer side) to be pushed beyond the 2050 target (e.g., installing a point of use filter), without compromising public health protection, providing programme and bill impact options

Figure 17 Illustration of interaction between find and fix, and how the long term programme could be affected



Below, in Table 14, we have summarised how we defined the forecast for different scenarios under alternative technology scenarios:

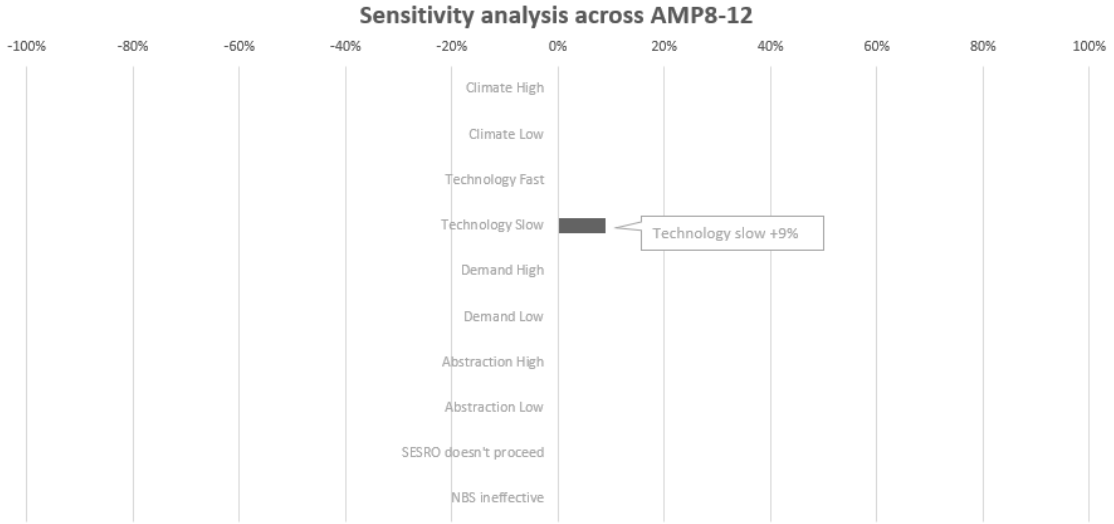
Table 14 Impact of technology scenario on Best Value Pathway for Lead Control

Slow/Adverse Technology	Base assumptions	Fast/Benign Technology
Replacement methods (and therefore unit rates) will remain largely unchanged in the medium to longer term, using a combination of open cut and moling methods, as per AMP costed schemes, and no customer side pipe replacement innovation become available. Fix Improvements in cross-stakeholder, open data, and insight on risk profiling of properties and customers, with improvements in modelling to determine presence of Lead pipes in the network, much slower, impacting the efficiency of	Innovation and associated technological advances will increase gradually throughout the next 25 years, providing small but consistent opportunities for innovative no-dig / low dig replacement methods (including the customer side). This will result in cost efficiencies from 2035 onwards. Fix Improved cross-stakeholder, open data, and insight on risk profiling of properties and customers, linked to improved modelling to determine presence of Lead pipes in the network, will aid a prioritise and	Innovation and associated technological advances will increase more rapidly throughout the next 25 years, providing consistent opportunities for innovative no-dig / low dig replacement methods (including the customer side). This will result in more significant cost efficiencies from 2035 onwards. Fix Improved cross-stakeholder, open data, and insight on risk profiling of properties and customers, linked to improved modelling to determine presence of Lead pipes in the network, will aid a prioritise and

Slow/Adverse Technology	Base assumptions	Fast/Benign Technology
the delivery programme. This is particularly impactful from 2040 as the prevalence of Lead in the network is reduced. Find The same impact occurs if improvements in 'lead location' devices and methods are not realised, not allowing for improved contractor performance and confidence around cost efficiencies. Find If alternative mitigations are not found from 2035 and delivered to provide sustained and effective protection at lower lead concentrations, then costs would have to increase to accelerate replacement and/or the public health risk is heightened as the programme is not delivered by 2050. Mitigate	effective delivery programme from 2035. Find Improvements in 'lead location' devices and methods from 2030 (could include customer-led water quality sampling) will improve contractor performance and confidence around cost efficiencies. Find Alternative mitigations are found from 2035 and delivered to provide sustained and effective protection at lower lead concentrations, to enable the delivery of the programme up to 2050. Mitigate	effective delivery programme from 2035. Find Improvements in 'lead location' devices and methods from 2030 (could include customer-led water quality sampling) will improve contractor performance and confidence around cost efficiencies. Find Alternative mitigations are found from 2035 and delivered to provide sustained and effective protection at lower lead concentrations, to enable the delivery of the programme up to 2050. Mitigate

This analysis shows that there is not a 'fast/benign' technology scenario for lead control - the base plan assumes a high level of technological improvements and innovations in finding and fixing Lead pipes, as well as new risk mitigation while the programme delivers the outcome by 2050. Further analysis and estimations, conclude that there would be an increase in cost of 9%[48] under a slow technology scenario (see Figure 18).

Figure 18 Comparing our best value plan to the scenarios we tested



[48] Established through analysis by Innovation department at Thames Water using horizon scanning and technical judgement

We considered how these technology-related factors might impact our best value plan in qualitative internal discussions. We also sought the advice of external subject matter experts in some cases. As a result of these discussions, we determined that the impact of varying technology assumptions would likely be felt on the effectiveness or targeting interventions towards higher risks and on the unit cost of interventions. We concluded that it would not have a material impact on the overall rate at which lead comms pipe replacement might be achieved.

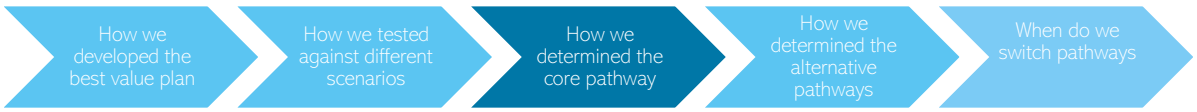
The table below summarises the impact on our best value plan under each technology scenario. It shows that the impact is on the cost of interventions rather than the rate of intervention.

Table 15 Impact of scenarios on Best Value Plan: Moving to a Lead-free water network

Best Value Plan			Impact of applying selected scenarios	
Investment	Planning Horizon	Best Value Pathway	Technology Adverse/Slow	Technology Benign/Fast
Customer side replacement trial	2025-2035	Yes	Yes	Yes
Lead comms pipe replacement [nr]	2025-2030	54,000	54,000	54,000
	2030-2035	150,000	150,000	150,000
	2035-2040	315,167	315,167	315,167
	2040-2045	315,167	315,167	315,167
	2045-2050	315,167	315,167	315,167
Total Cost (£M)		1,832*	1,974**	1,832

*Includes customer trial costs in AMP8 & 9 **applying the 9% uplift on costs for an adverse or low technology scenario

7.4. How we determined the core pathway for lead control



Based on the results of our testing against the common reference scenarios, we identified a 'core adaptive pathway' which generates a no-regrets investment plan, as per Ofwat's LTDS guidance, to achieve the desired outcome. For lead control the core pathway assumes a Fast Technology scenario. The means that under a core plan, no-dig and lead pipe targeting technologies (both desktop and in the field) will have sufficiently advanced to lower plan costs. As our best value plan already assumes these developments will happen in the future it aligns to a core pathway approach.

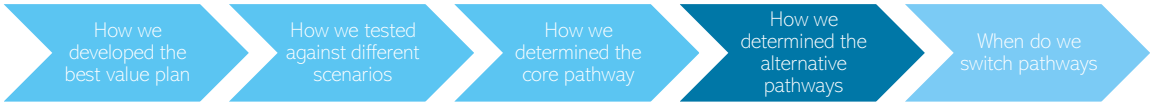
All elements of the plan meet at least one of the criteria for inclusion in the core pathway. A programme of Lead replacement is required in each AMP period and as explained above the scenarios tested do not materially alter the rate of pipe replacement. The customer trial is needed in AMP8, supported by a further trial in AMP9, in order to enable future modes of Lead reduction, all the way to the compliance point. Enhanced mapping, risk profiling and identification tools are also needed on an ongoing basis to better prioritise and make efficient pipe replacement delivery.

The table on the following page sets out our best value/core pathway plan in terms of the different activities over the 25-year period to achieve the long-term outcome of zero Lead pipe by 2050:

Table 16 Programme requirements in all scenarios (including customer trials in AMP8 & 9)

Investment	Planning Horizon	Best value	Needed in all scenarios	Needed in most scenarios	Needed to keep future options open	Needed in the short term	Core Pathway? ('000 pipe replacements)
Customer trial	2025-2035	Yes	Yes	Yes	Yes	Yes	Yes
Lead comms pipe replacement (nr)	2025-2030	54k	Yes	Yes	Yes	Yes	54k
	2030-2035	150k	Yes	Yes	No	No	150k
	2035-2040	315k	Yes	Yes	No	No	315k
	2040-2045	315k	Yes	Yes	No	No	315k
	2045-2050	315k	Yes	Yes	No	No	315k
Total cost	£M	1,832					1,832
		The scope (and cost) of solutions is the same or more than the best value plan					
		The scope (and cost) of solutions is less than the best value plan					

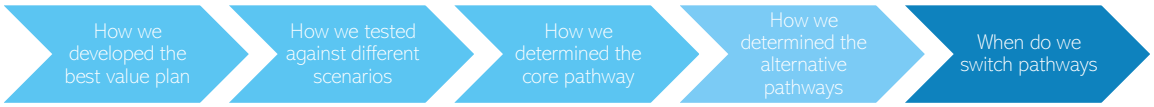
7.5. How we determined alternative pathways for Lead Control



Having established our best value plan and core pathway, we developed and tested an alternative pathway that meets our long-term ambition over a range of plausible futures.

The slow (adverse) technology scenario has the most material impact on our best value plan, so we have used this as our alternative pathway. This means slow development in identification and no-dig technologies would generate a higher investment trajectory from 2035 onwards.

7.6. When do we switch pathways for lead control



As technology change forecasts drive most change to the best value plan, these forecasts drive a switch to a different pathway. There are no specific one-off 'hard' triggers for considering moving to an alternative pathway. Rather, what will put us onto a different path is the delay in the emergence of new modelling & data insight, or replacement methods, generating a higher investment trajectory from 2035 onwards. We will continue to monitor industry best practice and in particular lead replacement unit rates. For the purposes of compliance to LTDS guidance we show a nominal trigger point of 2035 in our adaptive planning tube map (see Figure 19).

The programme to eliminate Lead from our drinking water network is highly adaptable. The lead pipe replacement rate can be accelerated or decelerated as different risk profiles or technologies emerge which allow for improvements on mitigation, targeting, finding, and replacing lead pipes. The stable AMP8 replacement programme running alongside customer trials provides the ability

to step up activity as a lead free to tap targeted solution becomes clear and maximise the potential from benefits of linkages with other network programmes such as smart metering.

Figure 19 Graphic showing alternative pathway to best value and core pathway

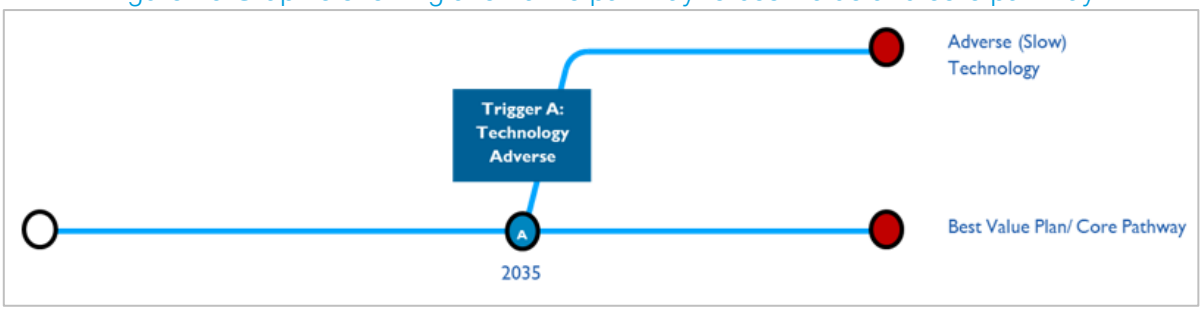


Table 17 Lead pipe replacement alternative pathways

Pathway name	Decision/trigger dates	Description
Core pathway / best value plan	N/a	As described above. It assumes a fast technology scenario
Slow/adverse technology pathway	2035	Technology has been identified as having a potential material impact on our plans. We have front end loaded trials to maximise the benefits from technology change. Should technological efficiencies not occur, this could materially increase the cost of our plans from 2035 onwards.

7.7. Adaptive pathway summary

In summary, the main insights from our adaptive pathway planning for long-term water quality strategy, lead control are:

- Technology was the key, and only driver for an alternative pathway for our programme of investments to move to a lead-free network
- Our programme of investments to move to a lead-free network has been costed at £1.832B. However, this forecast could increase by up to 9% (representing a slow/adverse technology change scenario)
- Our focus on working with external stakeholders and levering programme efficiencies provide the basis for resilience to slow/adverse technology risks
- Lead comms pipes proliferate across our whole region and currently are large in number (~1.2M). This makes the plan easier to accelerate or decelerate according to how the technology is changing – this will obviously get more difficult as the number reduces
- The solution(s) to the customer supply side lead pipes is the most reliant on a wider industry approach and innovations, supported by national agreement on policy and possibly legislation

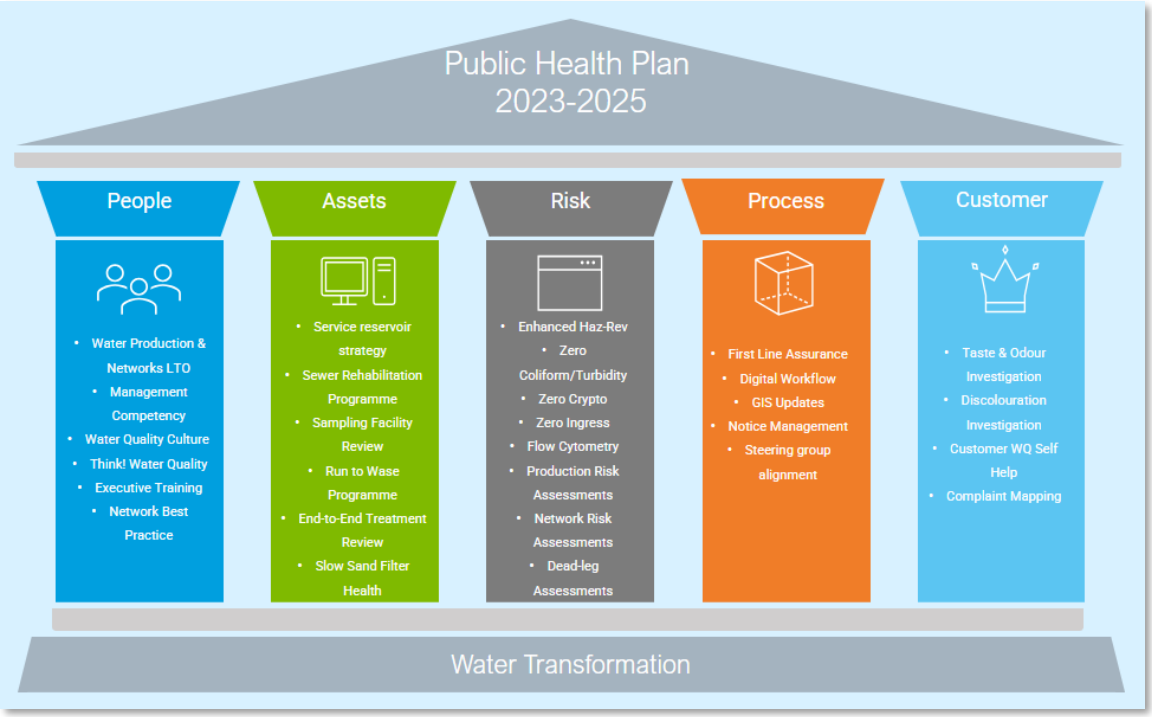
8. Annex 1 – Summary and Introduction

8.1. Public Health Plan

Our Public Health Programme will align with our company policy to aspire to be, and be recognised as, the industry leader for our approach to protecting drinking water quality and safeguarding public health. The Public Health Programme comprises of five overarching pillars: People, Risk Mitigation, Process, Customer and Assets. Within each pillar sits strategic workstreams that will allow us to move beyond transformation whilst still delivering key information to the DWI regarding notices and milestones.

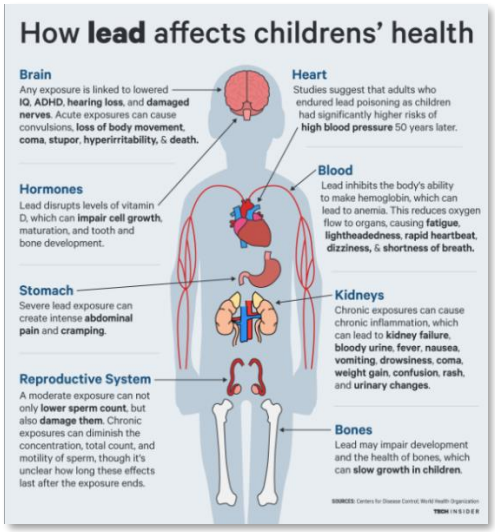
Each of our pillars holds strategic plans to demonstrate our commitment to continually improving our water quality performance and culture. The plans have an accountable owner and a progress review at the bi-monthly Public Health Steering Group.

Figure 20 Public Health Plan pillars



Working groups are the main delivery mechanism for our programme these have been created to sit in line with each pillar and have a designated point of accountability. Examples of working groups are the *Cryptosporidium* Working Group under the Risk Pillar, Service Reservoir Working Group under the Asset Pillar and Competency Working Group under the People Pillar.

9. Annex 2 – Need for enhancement investment



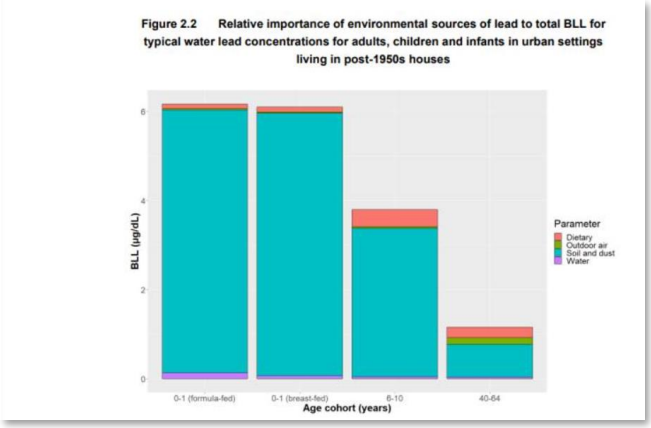


Table 18 Lead Control - Drivers for investment

Driver	Description
Customer / Consumer driver	• Public health protection and/or improvement – supporting a national agenda • Provide education and help to protect water quality in the home / work place • Determine most effective financial assistance package to fix the Lead issue on customer side
Legislation compliance driver	• Lead standard will tighten over time • Current chemical mitigation has reached limit of protection • Long term aim is to have no Lead in contact with drinking water – influence position on customer side and accelerating removal
Environmental driver	• Reduce reliance on current chemical mitigation (protection of raw material and reduction in carbon impact)
Economic / Cost driver	• Chemical mitigation costs will increase as raw material reserves reduce • Chemical dosing not best value for customer – remove the root cause (i.e., Lead in the drinking water network) – optimise to become more efficient
Regulatory driver	• Impact on CRI (Compliance Risk Index) • Potential new regulatory drivers as Lead problem gets more understood

9.1. Summary of investment drivers

As has been shown, many drivers exist for the investment to remove the lead public health risk from the drinking water network. Figure 21 (next page) summarises this section into priority drivers in AMP8 for this investment need before we move on to discuss why this investment should be enhancement.

Figure 21 Prioritised investment drivers for lead control

Table 19 Thames Water recent AMPs Lead Strategy

AMP	Thames Water approach	Lead comms pipes removed
Pre-AMP5	There was no targeted lead comms pipe replacement programme. Focus was on the installation of orthophosphoric dosing plants as mitigation to lead leaching in comms and supply pipes.	Zero *(with Lead as the driver)*
AMP5	Targeted lead comms pipe replacement at areas/properties where it can be clearly demonstrated that there is a significant risk of elevated lead concentrations. This mainly focussed in the Enfield area of North London, based on lead sample failure rates. Enhanced lead sampling programme to gain better understanding lead hotspots to better prioritise future lead comms pipes replacement programmes Installation of new orthophosphoric dosing plants at four WTWs in Thames Valley and the Home Counties (TVHC)	<5,000
AMP6	Targeted lead comms pipe replacement at primary school & nurseries across London, highest concentration of the most at risk consumers in London Installation of new orthophosphoric dosing plants at two WTWs in TVHC	~36,500
AMP7	Targeting lead comms pipe replacement at primary schools & nurseries across TVHC, highest concentration of the most at risk consumers in TVHC	53,837 (target)
AMP8 (proposed)	Target higher risk customers in their homes and other properties (e.g., less formal childcare settings[49]), based on property age and likelihood of lead pipes being present	54,000 (target)

[49] Less formal childcare settings could be in churches, village halls, cricket clubs, private households, etc

9.2. Need for enhancement

Having established that there is a need for investment, this section will demonstrate that there is an enhancement investment need. Figure 22 shows the thought process, and we will step through each element in turn. We then present the scale and timing, customer and stakeholder support for this investment, along with how it does not overlap with any base funding.

Figure 22 Enhancement need summary for Lead Control

Lead Samples

Historic data 2017-2021

- **All Samples** include:
  - Statutory sampling
  - Operational Sampling
  - Customer Complaint Sampling
  - Lead Replacement Policy Sampling
  - Investigational Sampling
  - All Other Sampling
- **Non-Operational** sampling includes all the above **except** Operational Sampling

All Samples		Non-Operational Samples	
Result	Average % of samples with result	Result	Average % of samples with result
>=10	1.70	>=10	2.43
>=9	2.08	>=9	2.87
>=8	2.55	>=8	3.36
>=7	3.14	>=7	3.97
>=6	4.08	>=6	5.01
>=5	5.38	>=5	6.31

10.Annex 3 – Best options for customers

10.1. Initial consideration of options

To determine feasible solutions to solve the need(s), a qualitative assessment of the two elements of the case was undertaken, across thirteen potential option categories and mirroring (from Option 3 onwards) a 'source-to-tap' process flow. Table 20, below, summarises our conclusions, with follow on narrative discussing the high-level likely effectiveness, feasibility and cost benefit of the various potential options.

Table 20 Initial consideration & description of option categories to solve the need(s)

Ref.	Option category	Option description
		Lead control
1	Do nothing	Stop operational and statutory sampling programme, proactive and reactive comms pipe replacement programme
2	Reactive	Stop targeted lead comms pipe replacement programme and just respond to statutory Lead sample failures or customer-led replacements, replacing to customer boundary as per our legal obligations
Note	*Source water*	*The general nature of water in Thames Water catchments is already relatively non-aggressive, so lower Lead risk*
3	Catchment partnerships and raising awareness	n/a *In this case lead contamination is related to the comms and supply pipework and not the raw or treated water quality; catchment partnerships and interventions are therefore not relevant*
4	Catchment Interventions Catchment funds	n/a
5	Catchment Interventions (nature-based solutions)	n/a
6	Catchment monitoring (including sewage treatment works (STW) discharges & overflows)	n/a
7	Tertiary treatment at STWs	n/a
8	Abstraction management	n/a
9	Pre-treatment (stored water)	n/a
10	Treatment (at WTWs)	(Continue) bulk dosing orthophosphoric acid (or future alternatives) to the treated water at WTWs
11	Treatment (in the water network)	(Move to) targeted orthophosphoric acid (or future alternatives) in the water network
12	Network investment (including possible customer side pipe removals)	Remove or replace all lead pipes and other lead containing products in contact with drinking water - this could include lining in the medium term
13	Point of use protection	Barrier or treatment at the customer tap

10.1.1. Option 1 – Do nothing

For lead, there cannot be a 'do nothing' option, as there are numerous related regulations water companies must legally comply with, so:

Lead – We have a legal obligation under the Water Supply (Water Quality) Regulations 2016, to maintain a statutory lead sampling programme at customer taps, and react, by replacing lead comms pipes, if samples exceed the Lead standard of 10µg/l. By AMP8, our commitment is to respond to statutory sample failures ≥5µg/l (our regulatory minimum is 2,500 samples per year, and the current rate of failure is 7%[50] with ~300 sample failure and customer-led reactive jobs per year) – there is also a legal obligation[51] to replace lead comms pipes if there is a risk of it contributing to amount of Lead in the drinking water and the customer informs us that they have replaced their Lead supply pipe (customer-led). Adopting a 'do nothing' approach would be a failure to comply with the regulations and would Lead to prosecutions and a threat to our operating licence.

10.1.2. Option 2 - Reactive

Lead – Adopt a reactive-only approach to lead comms pipes, only replacing following statutory sample failures (or customer-led replacements) to the customer boundary, as per legal obligations. The implication of such an approach is an unacceptable level of public health risk to customers over the long term, especially those at higher risk to lead; replacement unit rates (£/pipe) for reactive replacements are more than double of those undertaken as part of a proactive programme. Under Section 30 of the Regulations there is no legal requirement to have a proactive Lead comms pipe replacement programme, however it would be out of step with the rest of the industry and would receive criticism from regulators.

10.1.3. Option 10 – Treatment (at WTWs)

Lead – Maintaining the current approach of bulk dosing orthophosphoric acid at the WTWs (for LPPs this is normally dosed just upstream of primary disinfection) which, despite not being a permanent solution to lead pipe in the network, is a proven mitigation method to protect public health. If this method of mitigation is used into the longer-term future (most likely as part mitigation), then alternative chemicals / treatment will need to be sought prior to complete eradication of lead pipe from the network.

10.1.4. Option 11 - Treatment (in the water network)

Lead – This approach moves away from dosing chemicals in bulk at WTWs, as a mitigation to lead pipes, to targeted dosing (either in an area or even down to street level), thereby reducing costs whilst providing the same level of mitigation for those properties which need it. This is a sensible strategy, but only possible both a comprehensive (and complete) view on where lead pipes are in the network (including inside customer properties) and a much reduced number of lead pipes in the system as a whole – i.e., a longer term strategy for Thames Water.

10.1.5. Option 12 - Network investment (including possible customer side pipe removals)

Lead – the only long-term solution to lead pipes is removal, and this approach continues the current (AMP6 & 7) programme of proactive Lead comms pipe replacement – this needs to be stepped up at some point and extended beyond the customer boundary to provide the desired long-term outcome: public health protection from lead contamination. *Note: continuing at the current pace of replacement would take until ~2135 to replace all of Thames Water owned comms pipes, and it does nothing to tackle the customer side risk and extends the risk to public health beyond a level of acceptability.*

10.1.6. Option 13 – Point of use protection

[50] Thames Water, Water Quality reporting
[51] Section 30, Water Supply (Water Quality) Regulations, 2016

Lead – There are various 'point of use' protection trials (e.g., installation of a filter under the sink in homes) either in place (across the UK and abroad) or proposed by the UK water industry working groups for lead[52] and these could provide some useful (customer targeted) mitigation options to support a long-term removal programme (including solving the customer side issue).

10.2. Selected feasible options

Table 21 below, to identify a short list of feasible options. These factors facilitated decision-making and enabled the choice of a preferred solution.

Table 21 Selected options with decision on whether to progress further

Option		Comment	Progress?	Enhancement?
1	Do nothing	Lead – Unacceptable public health risk, does not comply with minimum standards set out in water quality legislation, and does not solve the need for investment	Reject	n/a
2	Reactive	Lead – Public health risk extends too far into the future, customers do not support, does not address customer side risk and does not achieve desired outcome. However, it could be an AMP8 strategy.	Potential	No *Sampling programme covered under base allowance*
10	Treatment (at WTWs)	Lead – Proven mitigation to plumbosolvency and provides a good short to medium term approach	Preferred (short term)	No *Chemical mitigation at WTWs funded through base*
11	Treatment (in the water network)	Lead – Not viable in the near to medium term due high numbers of Lead pipe remaining in the drinking water network; it would be possible to target chemical dosing in the longer term though	Reject (potential in the longer term)	n/a
12	Network investment (including possible customer side pipe removals)	Lead – Removal or replacement is deemed by most stakeholders as the only long term solution to Lead containing material in contact with drinking water lead, but it needs to be addressed beyond the boundary of the customer property for provide full protection in the long term	Preferred	Yes *This would be enhancement (including any customer side trials)*
13	Point of use removal or deactivation	Lead – Has proven successful across the world as a good short to medium term mitigation, especially for customer side lead pipe; could reduce risk whilst undertaking long term delivery programme	Potential	Yes *Could be used as part of customer trial (i.e., within enhancement)*

10.3. Discussion of the preferred option(s) for lead control

Combining the outputs from *the above two tables* the preferred option(s) for lead control is:

1. (Option 10 - Base) Continue to dose orthophosphoric acid (in bulk) at our (relevant) WTWs, maintaining and investing in the assets to ensure they operate consistently and

[52] See WaterUK – Lead Learning Outcomes Co-ordination, March 2023

compliantly, and analysing network sample data to ensure the effectiveness of this mitigation (adjusting doses as required but aiming for stable performance);

2. (Option 12 - Enhancement) Continue a lead comms pipe targeted replacement programme, maintaining the AMP7 rate of replacement (step up in future AMPs) with a customer supply side focus trial to determine future 'step up' replacement rates and customer support packages.

This is the preferred approach, and was then development in Option 6 (in terms of pace of the enhancement spend – Option 12 above)

We should also investigate, working with industry partners, the potential of alternative mitigation methods at the point of use (Option 13 - Enhancement) to influence future strategies on protecting the highest risk customers and providing different options as Lead pipework prevalence starts to reduce – this is not wholesale deployment, but a tool used as part of the customer trial.

10.4. Initial cost benefit assessment included here for reference:

10.4.1. Lead control - Assessment criteria

To promote a consistent and robust options assessment for the Lead Control proposal, we developed a set of quantitative and qualitative assessment criteria. We set out our assessment criteria in Table 22.

Table 22 - Lead control options assessment criteria

Criterion	Description
Cost	We will rank the options from least cost (1, best) to highest cost (3, worst). For each option, we assessed the total expenditure (Totex) - refer to Section 4 'Cost efficiency' for our cost estimation methodology.
Expected benefits	We will rank the options from meeting the need and highest public value (1, best) to not meeting the need and lowest public value (3, worst). We will undertake a cost benefit analysis of benefits and cost for each feasible option. These will be ranked 1 (best) to 3 (worst).
Stress testing	We have stress tested our options against the *Technology 'slow'* scenario
Customer views	We will evaluate the extent an option aligns with customer preferences and assess whether increase or decreases our benefit assessment.
Risks and uncertainties	We will identify likely risks for each/multiple options and scope the expected consequence. Where appropriate, we will propose any mitigations measures and consequential impacts on option cost or benefits.

10.4.2. Lead control - Options shortlist

To provide further detail on the options being taken through the next stage of assessment, see Table 23 for the three options for lead control.

Table 23 - Three lead control options

Option title	Description
Lead Option 1 No Enhancement Case investment (reactive only – base allowance)	No increased investment. Scale back AMP7 targeted lead comms pipe replacement to ZERO, no operational sampling programme and no customer trial(s) Statutory sample programme (Botex): • Deliver the minimum statutory water quality sampling programme, with lead tested for in a designated proportion of the samples (statutory programme is at least 2,500 samples per year[53]) Capital investment - reactive replacements (Botex): • Only replace Lead comms pipes upon sample failures (>5µg/l – industry expectation, actual standard is 10µg/l) or customer-led contacts - ~1500 per AMP (~300 per year) This option would not be supported by the DWI, be out of sync with the rest of the water industry and would not align with the ambitions in Vision 2050
Lead Option 2 Network investment (including customer trial with possible customer side pipe removals)	Maintain the rate of targeted and reactive lead comms pipe replacements as AMP7 and incorporate a customer focussed trial. Statutory & Operational sample programme (Botex): • Deliver the minimum statutory water quality sampling programme – (as per Option 1) • Additionally, deliver an equivalent (~2500 samples per year) operational water quality sampling programme Capital investment - reactive replacements (Enhancement): • Replace Lead comms pipes upon sample failures (>5µg/l) or customer-led contacts - ~1500 per AMP (~300 per year) Capital investment - targeted replacements (Enhancement): • Replace Lead comms pipes in a targeted area(s) (54k over the AMP) to customer property boundary (as per AMP7 arrangement) – focus on older housing / building stock and higher risk customers (e.g., areas with greater concentration of families with young children) with engagement with local authorities and other stakeholders Customer Trial - target area(s) (Enhancement): • Customer trial – aligned to target area(s) – to test different approaches to removing supply pipes and/or lead risk at point of use (e.g., refund customers, through bills, who replace their lead pipes); this will include customer engagement, education, and support • Results shared with industry and regulators/policy makers, and fed into PR29 plans This option has been discussed and formally submitted to the DWI for consideration and issuing an AMP8 Enforcement Notice
Lead Option 3 Point of use removal or deactivation	Follow Lead Option 1 premise (no increased investment, statutory sampling programme only, reactive replacements following Lead failures), but supply and/or install, and maintain, point of use Lead filters at similar rate to Lead Option 2. Point of use filters (modular/adaptive): • Supply (at least) 54,000 properties with a point of use filter (e.g., under kitchen sink or on tap). • Two filters per household (kitchen and bathroom). Assumption filters would be delivered by post. • Allowance for some (10%) to be installed by approved plumber, • Fund replacement & disposal of filter every year through AMP.

[53] As per total statutory sampling requirement per year laid out in Water Supply (Water Quality) Regulations 2018 (https://www.legislation.gov.uk/wsi/2018/647/schedule/3/made) with the Lead testing frequency based on Group B1 water supply zone size and number

10.4.3. Lead Control - Assessment of investment options

Replacement of lead comms pipes is part of a phased, multi-AMP programme, aligned with Vision 2050 and our move to a lead-free drinking water network. To fully realise this ambition and provide the desired public health outcome, Thames Water also need to work with the industry to propose and help deploy solutions to the customer supply side if it contains lead.

We sequentially present how each option performs against our assessment criteria, defined in Table 22, above.

10.4.4. Cost

Our cost assessment summarised in Table 24 concluded that the 'no investment' option was the least cost solution for customers. The Option 2, to replace lead comms pipes at rate detailed above, plus a £8.6M customer trial, was the most expensive option.

Table 24 – AMP8 enhancement Totex for each option (£M all indexed to 2022-23)

	Option 1: No enhancement	Option 2: Capital (Network) Investment	Option 3: Point of use filters
Capex (£M)	£0	£85.4	£42.03
Opex (£M)	£0	£0	£43.57 (averaged)
Totex	£0[54]	£85.4	£85.60*
Ranking	1	2	3

**Using the same number of lead comms pipes proposed to be replaced in AMP8 (54,000), to ensure comparable numbers, as the total number of filters required - the calculation applies the following, using the IWA approach[55]: total cost per Reverse Osmosis point of use filter is US$648 over five years - $318 initial cost for filter unit, $65 per year after first year for filter cartridge replacement and $35 every other year for membrane cartridge replacement, exchange rate used US$1:GBP£0.8). Note: not all of the filters would be delivered immediately at the start of the AMP but for the purpose of this calculation, the full 5-year cost for all 54,000 filters has been presented. Assumption two filters per household,* delivered via courier/ post, 10% of population (PSR customers) will have filters delivered and installed by TW.

10.5. Cost benefit assessment

10.5.1. Expected Benefits – Lead Control

We determine expected benefits by using the Thames Water public value framework (PVF) and a cost benefit analysis (CBA) of each option. For each investment, we incorporate the PVF outputs into the qualitative decision making of the investment programme, by scoring the public value benefits from strongly negative to strongly positive for each of the feasible solutions. The PVF tool helps each Enhancement Case identify and factor benefits into decision making.

After using the PVF to identify the range of benefits, we determined monetised benefits across the range of measures. We have followed Ofwat's hierarchy for sourcing robust marginal benefit values from ODI rate research to WINEP and then to other publicly available, robust valuations. The identified benefits across all three options, and those benefits that could be robustly quantified are listed in the tables below.

[54] This is not a nil cost to the business though, but base Totex would have to continue to fund sampling, reactive Lead comms pipe replacements, orthophosphoric acid dosing, etc

[55] Cost-benefit analysis of point-of-use devices for health risks reduction from pathogens in drinking water, Marc Verhougstraete; Kelly A. Reynolds; Jennifer Pearce-Walker; Charles Gerba, October, 2020, International Water Association

10.5.2. Benefits that apply:

Table 25 Benefits that apply to the option scenarios

Benefit	Description of benefit application:
Improved health outcomes, reduce ingestion of lead	Helping our customers stay healthy and well is the primary driving benefit of this case. Considered but not monetised.
Greenhouse gas emissions from transport	Construction transport for replacement of comms pipe and collection of point of use filters. Monetised as per DFT TAG metric
Greenhouse gas emissions from construction.	Emissions during the replacement of Lead comms pipes. Monetised as per The Green Book. Unable to quantify.
Traffic congestion	Considered, application to both options 2 for transport to replace Lead comms pipes.
Noise impact of traffic	Impact of construction transport, monetised, but unable to quantify.
Waste to Landfill	Considered through the reference to option 3, installation of point of use filters, required to be changed every 12 months to remain compliant with manufacturing standards.
Wellbeing, impact on quality of life	Applies to collection and installation of point of use filters. Requires customer collection and installation every 12 months. Unable to monetise.
Contribution to local economy	There will be job creation at contractors as result of the increase in Lead comms replacement programme & Option 3 through to 2050. Beyond AMP8, unable to quantify.

After screening for feasible options, we undertook a workshop to identify and quantify benefits and units across the three different options. This process aimed to determine where benefits varied or remained consistent across the options and why.

During the CBA process, we recognised that certain benefits lacked a robust approach to estimate their quantified impact. As a result, only the benefits that could be quantified effectively by publicly available third-party sources or Performance Commitments were included in the analysis of each option, as listed in table above. This approach ensured that the CBA focused on reliable and measurable quantifiable benefits, allowing for a more accurate assessment and comparison of the options. Benefits that did not meet this criterion were excluded to maintain the integrity and validity of the analysis.

Those benefits that could be monetised were quantified, based on the assumptions identified in the table below.

10.5.3. Monetised benefit:

Table 26 Quantified and monetised benefits

Benefit	Basis and assumptions of quantification & profile for Lead control		
	Option 1	Option 2	Option 3
Greenhouse gas emissions from transport	Statutory minimum sampling 2500 per year, carried forward to 2050. Assumption statutory sampling requirement remains constant in future AMPs, not impacted by population growth. 1 mile travel = 1L fuel burnt. Sampling routes are undertaken by region, optimised sampling route distance between sample is assumed at 3 miles.	Option 1 profile, doubled to account for comparable operational sampling programme. 54,000 replacements x 3 miles per of travel between reach replacement. As per Option 1.	Profile as per Option 1. 10% PSR customer installation of POU filters = 5400. Assumption of 3 miles of travel between installations.
Waste to Landfill	Comms pipe 5m replacement length (as per AMP8 forecast CW6) 1m Lead pipe @25mm = 1.6kg 8.2kg per replacement 300 replacements per AMP.	Option 1, doubled to include operational replacement. 54,000 replacements per AMP. Profiled for compliance with LTDS best value plan, 2050 target.	Option 1 plus, Point of use filter replacement every 12 months. Each AMP, 300 fewer households require replacement (due to statutory replacement programme). Point of use technology remains constant. Weight of one point of use filter = 5kg POU filter to be replaced every 5 years. Internal filter membrane = 1kg, replaced every 12 months.

It is important to note that only two benefits could be monetised benefits to determine an NPV of benefits for each of the three options. The values are negative as all benefits considered are *dis-benefits*, meaning that when comparing options, the lowest negative number has the largest benefit. The key drivers for these benefits are the tonnes of CO2 removal and the kilograms of waste to landfill prevented.

Table 27 NPV disbenefits summary of results

Option	Benefit NPV (30 years)
1 – No enhancement	-£325,074,165.32
2 – Capital network investment	-£680,901,376.26
3 – Point of use filters	-£1,064,462,823.84

The model detailing the NPV benefits calculation is saved in the evidence folder, titled *LTWQ CBA.*

10.5.4. Non-monetised benefit:

One of the key benefits of Lead control is improved health outcomes through reducing ingestion of Lead in the community. The impact of improved health benefits to 2050 is relevant to understand the contribution of each option type to achieving lead ingestion risk targets. We have qualitatively assessed the differences in impact on health outcomes from each option in AMP8 and to achieve the target to remove any risk of lead from Thames Water network by 2050.

Table 28 Non-monetised benefits of the three Lead options

Option	Health benefit of reduction of Lead	Contribution to 2050 target
Option 1	No change from current	No additional contribution, reactive replacements
Option 2	Most beneficial: Control/removal of sources of risks	Progress, but increases are required to achieve full removal
Option 3	More beneficial: Mitigates consequences above base	No additional contribution, reactive replacements

It is estimated that Option 2 has better long-term health benefits as removing the Thames Water side Lead comms pipes will remove the risk of lead ingestion. The proposed customer side trial will also Lead to an increased profile of health benefits to 2050 as the profile trial will Lead to implementation of support to customer side lead removal.

Option 3 is estimated as having the greatest health benefit in AMP8, as ingestion from both Thames Water and customer side leakage is managed if installed correctly. However, this benefit does not scale through the profile, as with Option 2, as replacement is required just to keep the same health benefit. although there is no scale to this programme.

10.5.5. Well-being, impact on quality of life.

- Increase in water quality concerns due to lead filter in house. Even with education and guidance some people may experience fear/ stress due to alert and requirement to filter for Lead. Customers may move to bottled water to avoid new known risk
- Disruption to everyday life, through inconvenience of installation of filter every twelve months. 10% of PSR customers will have increased communication and visits to install

There is no method through which the benefit of removing Lead from ingestion can be monetised, and so this benefit is reported as a non-monetised benefit of this CBA.

We included the following assumptions in our CBA modelling of the options:

- Benefits are applied in full the year after they commence, no benefits have been applied part way through the year
- We have taken the mean forecast of costs and benefits for each option over the 30-year time horizon
- The discount of benefits over time has been taken as the social time preference rate, as set in The Green Book, which is 3.5%
- Costs and benefits have been adjusted to 2022-23 price base

10.5.6. Expected costs – Lead control

Cost NPV for each alternative option are detailed in the data table W15.

10.5.7. Output:

Table 29 Results for Lead Control CBA (£M 2022-23)

	Option 1: No enhancement	Option 2: Capital (Network) Investment	Option 3: Point of use filters
Benefit NPV (negative/ disbenefit)	-£325,074,165.32	-£680,901,376.26	-£1,064,462,823.84
Benefit, non-monetised ranking.	3	1	2
Cost (*NPV to be fed through from data tables once complete)	£0	£85.435M	£85.60M*
Ratio			
Choice:	2	1	3

10.5.8. Risks and uncertainties:

We are relying on customers to install the filters themselves, or to organise their own plumber to install a point of use filter every six months.

- No legislative control over installation and use
- Limited quality assurance of installation of point of use filters

We are relying on customers to place the filters on the kitchen and bathroom tap, and only to drink from these two taps in their household.

- Two filters per household are provided, however no regard for the size or number of people living in the household
- Literature and education campaign will be required to only use the filtered taps for drinking water

Future changes to legislative agenda of replacement of lead comms pipes to 2050.

- Option 1 low cost now but delays future costs to meet our ambition

Proactive benefit for replacement programme

- Options 1 and 3 meet minimum statutory requirements, but this is out of step with the DWI directive to progress Lead replacement of all comms pipe by 2050. Selecting this option will delay the replacement programme to further AMPs, shortening the window to make improvements

10.5.9. Customer and stakeholder preferences

The customer insight previously mentioned in the need for enhancement investment section also provided insight to solutions and preferred timings:

- From the PR24 deep dive research on lead pipes, 80% of customers supported our proposal to replace all Thames Water owned lead pipes 2025 to 2050 (£1.68/year extra on bills) (PR24-8)
- Of the different options tested, there is strong support for Thames Water's initiative to replace 67,000 customer owned supply lead pipes between 2025 to 2030 (86% of customers) (PR24-8) *(Note: we presented a slightly larger programme of Lead comms pipe replacement in AMP8 to customers, but have since reduced this to bring in the customer trial)*

The DWI is expected to issue a Letter of Support detailing the need to replace lead comms pipes as part of a long-term programme of works.

Table 30 summarises the assessment and shows that first and second least cost options is unacceptable to our customers, the DWI and does not move us toward the Vision 2050 outcome for lead – only capital investment will fulfil their preferences.

Table 30 Assessment of options against customer preferences

	Option 1: No enhancement	Option 2: Capital (network) investment	Option 3: Point of use filters
Customer	×	✓	×
Stakeholder (DWI)	×	✓	×

10.5.10. Summary of assessment – Lead control

Table 31 Summary of best value for customers assessment for lead control

	Option 1: No enhancement	Option 2: Capital (network) investment	Option 3: Point of use filters
Cost ranking	1	2	3
Benefits ranking (monetised and non monetised)	1	2	3
Customer Ranking	3	1	2
Total	5	5	8
Ranking		1	

Our analysis demonstrates that Option 2 is the preferred option. Although the overall scoring total is equal between Options 1 and 2, Option 2 has a significant preference as Option 2 demonstrates a profile to meet our lead removal target by 2050, in line with DWI and is the best value option for customers.

11.Annex 4 – Cost efficiency

Base data costs for Year 1-3 AMP7 – used to develop average lead comms pipe unit rate

				ACTUALS + FORECAST															
	ACTUALS	Yr 1	Yr 2	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Yr 3	Yr 4	Yr 5	AMP 7	
	REPORTING WEEKS			4	4	5	4	4	5	4	4	5	4	4	5	TOTAL				
ACTUALS / FORECAST	Outputs			Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Actual	Y3 Forecast	Y3 Forecast	Y4 Forecast	Y5 Forecast	AMP Forecast	
	Gangs			19.00	19.00	19.00	19.75	20.00	19.60	20.25	20.50	18.33	20.00	20.00	20.00	Q3RF Forecast	Q2RF Forecast	Q2RF Forecast		
	Outputs/week			9.97	12.62	10.01	14.52	12.79	13.43	14.94	16.43	8.73	15.46	14.79	11.27					
	Targeted Replace	10,556	14,359	743	959	951	1,132	974	1,318	1,195	1,351	800	1,236	1,166	1,127	12,952	11,000	2779	51,646	
	Outliers	25	14	0			0	0	0	0	0	0	0	0	0	-	0		39	
	Schools/Social Hc	76	101	15			15	49	-2	15	-4	0	1	17	0	106	100		383	
	Reactive & Custon	262	476	30	30	10	38	17	38	40	24	39	27	33	50	376	416	416	1,946	
	OUTPUTS	10,919	14,950	788	989	961	1,185	1,040	1,354	1,250	1,371	839	1,264	1,216	1,177	13,434	11,516	3,195	54,014	
	Avg Cost per unit																		-	
	Targeted Replace	884	940	921	937	1,009	939	988	911	900	901	958	981	985	1,039	1,043	1,069	1,069		
	Outliers	3,865	3,865		-															
	Schools/Social Hc	2,591	2,646	2,720		2,625	2,625	2,720	2,720	2,720	2,720	2,720	2,720	2,720	2,720	2,720	2,720			
	Reactive & Custon	2,498	2,582	2,623	2,498	2,498	2,498	2,623	2,623	2,623	2,623	2,623	2,623	2,623	2,623	2,623	2,623	2,498		
	AA Total Costs																		-	
	Targeted Replace	9,333,685	13,503,137	684,244	899,021	959,601	1,062,657	962,262	1,200,536	1,075,817	1,216,988	766,132	1,212,216	1,148,398	1,170,949	12,358,822	11,468,717	2,897,415	49,561,777	
	Outliers	96,635	54,105.96													-			150,740.96	
	Schools/Social Hc	196,890	267,227	40,803	-	-	40,803	133,290	(5,440)	40,803	(10,881)	-	2,720	46,243	-	288,341	272,020	-	1,024,478	
	AA Fixed Costs															-	-		-	
	Kentish Town Dep	144,000	147,846	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	144,000	144,000	-	579,846	
	AA Staff Costs	2,286,035	2,397,726	240,177	240,177	240,177	240,177	240,177	240,177	240,177	240,177	240,177	240,177	240,177	240,177	2,882,119	2,882,119	549,400	10,997,398	
	TW Total Costs - TW To update															-	-		-	
	TW OPC's	348,373	570,149	50,107	50,107	50,107	50,107	50,107	50,107	50,107	50,107	50,107	50,107	50,107	50,107	601,284	601,284	601,284	2,722,374	
	Streetworks Charg	250,055	359,971	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	300,000	300,000	12,782	1,222,808	
	Reactive & Custon	654,578	1,228,963	78,700	74,940	24,980	99,686	44,596	99,686	104,933	62,960	102,310	70,830	86,570	131,166	981,356	1,091,302	1,039,168	4,995,367	
	TW D&PG	2,662,051	3,705,825	294,068	338,324	341,085	397,912	381,532	421,737	402,698	415,051	310,889	419,393	418,209	423,644	4,564,540	4,357,455	1,326,013	16,615,883	
	Adjustment Prima	479,523	712,662	74,149	106,449	37,047	112,816	53,570	173,976	59,000	191,842	68,000				876,849	(52,131)	(4)	2,016,900	
	Adjustment DPG	95,905	142,532	19,279	27,677	9,632	29,332	13,928	45,234	15,340	49,879	17,680	-	-		227,981	(13,554)	(1)	452,863	
	TOTAL INC D&PG	16,547,731	23,090,145	1,518,526	1,773,694	1,699,629	2,070,490	1,916,462	2,263,012	2,025,874	2,253,123	1,592,294	2,032,443	2,026,703	2,053,042	23,225,291	21,051,210	6,426,057	90,340,435	Gov
	Primary Total	13,789,775	19,241,788	1,205,179	1,407,693	1,348,912	1,643,246	1,521,002	1,796,042	1,607,837	1,788,193	1,263,725	1,613,050	1,608,495	1,629,399	18,432,771	16,707,310	5,100,045	73,271,689	73,569,683
	Q2RF															17,390,527			73,359,643	

12.Annex 5 – Adaptive planning

12.1. Alternative technology scenarios for lead control

The base case(s) assumes delivery of lead comms pipe replacements through current modelling and replacement methods. As the prevalence of lead in the network reduces over future AMPs and it becomes more difficult to find or much more spread out, the risks on the efficiency of the replacement programme increase, driving up costs. It will therefore be essential for new or enhanced existing technology to aid delivery to achieve the overall outcome of zero lead.

Potential technological improvements in a Technology High scenario can be split into three main categories:

1. Identification (or Find)
    a. Improved modelling of lead pipework presence (supporting by GIS) – this could include providing greater visibility for customers (see Newark, USA example[56]), which will assist education and engagement on this public health issue
    b. Improved, cross-stakeholder, open data, and insight on risk profiling of properties and customers to continue to prioritise – combining outputs/successes of customer trial(s)
    c. Improved and new 'locating devices' for lead pipework to reduce 'dry hole' type issues, which in turn would improve contractor performance and confidence around cost efficiencies
    d. Customer (-led) water quality sampling (supply side)
2. Method of replacement (or Fix)
    a. Alternative (more efficient) non-dig ways to replace comms pipes
    b. Supply side non-dig options
    c. Improvements with spray lining methods (could form a medium-term strategy)
    d. Development of slip lining options – comms and supply side
    e. Small scale pipe bursting options
3. Mitigate *(this will not affect the efficiency or cost of the replacement programme, but could provide choices in the future on programme)*
    a. Development of an alternative chemical dosing mitigation to orthophosphoric acid – may be cheaper and/or offer protection to lower levels of lead
    b. Inter-zone chemical dosing (would be useful as pockets of lead become prevalent, rather than whole zones)
    c. Street level filters – does not help customer side so would have complement this method of mitigation, but could provide a short-term strategy if lead comms pipes unable to be replaced for some reason
    d. Point of use filters

[56] Lead Trial Co-ordination, Report 23/DW/04/21, UKWIR, 2023 *[Please note: this is a restricted access document on the UKWIR website – it can be provided on request]*

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