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9 June 2023

Dear Ofwat

Early Cost Adjustment Claim Submission

I am pleased to attach Yorkshire Water's early cost adjustment claim submission.

At this stage we are submitting two claims covering Phosphorus Removal costs and the impact of combined sewers. We also include some additional narrative on capital maintenance challenges and the impact of recent high inflation where we have concerns that Ofwat's PR24 methodology will not appropriately fund companies into the future.

We note that some areas of our plan are still to be decided due to ongoing strategy decisions and affordability considerations and may result in us submitting non-symmetrical claims alongside our plan when we can provide appropriate evidence on the materiality, cost efficiency and need.

The submission consists of

- This letter and its Annex which provides the narrative of our claims
- A populated set of Excel 'early cost adjustment claims' data tables (please note we have only completed lines CWW18.1 – CWW18.20 as we are only submitting two claims at this stage).

Modelling datasets to allow Ofwat to replicate our analysis completed in support of our claims will be available should you require them.

If you have any further questions, please do not hesitate to contact us using the email address regulation@yorkshirewater.co.uk.

Yours faithfully,

Richard Hepburn

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Annex

Contents

1 – Ongoing Operating Costs of AMP7 WINEP Phosphorus Removal Programme

1.1. Executive Summary

This document provides Yorkshire Water's evidence for a cost adjustment claim related to the ongoing operating costs associated with our AMP7 WINEP Phosphorus (P) Removal Programme in Wastewater Network Plus (WWN+).

Yorkshire Water (YW) is delivering schemes to meet tightened Phosphorus consents at 80[1] sites in the 2020-25 period with all schemes expected to be completed before 31/3/2025.

Enhancement cost models developed by Ofwat and built on by the CMA at PR24 allowed YW a Totex value of £549.8m (17/18 prices) in Wastewater Network Plus to deliver P-removal at 80 sites serving a population equivalent of c. 4,460,000. No allowance was made for the ongoing operation and maintenance of these assets.

The current modelling process assumes that ongoing costs of maintaining compliance become base maintenance in future periods. An additional allowance is only available however if the investment programme impacts on a cost driver that is used in the cost models (e.g. an increase to treatment complexity).

We will have a large increase in treatment costs associated with this P-removal programme which have no impact on the cost variable in the models

Our total claim for P-removal after the reduction of a calculated implicit allowance is **£22.7m** p.a. or **£113.5m** for the 2025-30 period.

The sections below set out:

- A background on our PR19 submission and the WINEP requirement
- Our approach to identifying the best solution within our AMP7 allowances and estimating the ongoing operating costs.
- Economic analysis – top down and bottom up to set out evidence that YW's costs are efficient at an industry level.
- Discussion of implicit allowances and symmetrical adjustments.
- A Customer Protection mechanism

Table 1.1 below points to the locations in the document where we address Ofwat's cost adjustment claim assessment criteria.

[1] Please note this includes Huddersfield which has two separate outfalls; however, we are treating these as one scheme

Cost Adjustment Claim Assessment Criteria	Sections
Need for adjustment	1.2, 1.3, 1.5
Cost efficiency	1.4, 1.6
Need for investment	1.2
Best option for customers	1.4
Customer protection	1.8

Table 1.1 References in Document to Ofwat's Cost Adjustment Claim Criteria.

1.2. Introduction

What is the Water Industry National Environment Programme (WINEP)?

Ahead of PR19, Yorkshire Water (YW) worked with the EA and Natural England to apply and interpret their Water Industry Strategic Environmental Requirements (WISER) to our region. The final WINEP3, agreed with these environmental regulators, listed the extensive statutory obligations to meet these regulatory requirements and ambitions.

The WINEP programme required of YW at PR19 was the most extensive and ambitious ever. The range of solutions varied from conventional engineering approaches, to the largest ever programme of catchment interventions.

Phosphorus Removal

The key driver impacting on the scale of Yorkshire Water's WINEP3 programme was Phosphorus (P) removal. The P Drivers set out in WINEP3 for each company came under one of 3 drivers:

- Urban Wastewater Treatment Directive (UWWTD) Improvement U_IMP2
- Water Framework Directive (WFD) – Improvement WFD_IMP G,M
- Water Framework Directive (WFD) – No deterioration WFD_ND

Each site in the programme had one or more of the above drivers and an associated permit limit for the works to achieve to meet the driver. Typically, the WFD_IMP drivers are more stringent than the UWWTD_IMP driver on the same site. Yorkshire Water had no obligations under the WFD_ND driver.

The key variables impacting on the relative efficient cost of meeting P removal obligations set by environmental legislation included the following:

Number and size of sites. The scale of STWs that are affected by obligations. Companies with more affected sites, or larger sites, will – all else being equal – face greater costs of meeting their obligations. The size of sites is typically measured by load or by a site's Population Equivalent (PE)

Permit level. The lower the absolute level of permit, the more costly it is to achieve. For example, it is more costly to achieve a permit level of 0.5mg/l than it is to achieve a permit level of 1mg/l. This is because lower limits require additional treatment units and additional chemicals leading to increased capital and operating costs.

Change in permit level. Enhancement costs reflect step changes from current levels of service. The extent to which permit levels change can vary between companies, and therefore this drives differences in costs between companies. Companies that have received enhancement cost allowances in the past to achieve the UWWTD (typically a set 1 or 2 mg/l limit), may have less of a change to meet the WFD standard (set based on the output of river modelling) than a company that currently has no permit and has to achieve both standards.

Type of obligation. The type of designation affects what solutions can be applied to achieve the required permit levels. The UWWTD is clear in that permit levels must be achieved by treating wastewater before it is discharged from the treatment works. Whereas the WFD applies no such restrictions. Therefore, less costly technologies (e.g. catchment-based solutions) can be used to meet WFD obligations compared to UWWTD obligations. The cost differential is likely to be greatest on larger sites, however catchment approaches at all scales show greater benefits due to their additional impact in a six capitals valuation.

An additional consideration linked to the type of obligation was that UWWTD is a statutory driver that stipulates end-of-pipe treatment by law, and as such the solution was not subject to cost benefit analysis by the EA before inclusion in the WINEP, whereas WFD drivers were.

For sites with both drivers, the EA's cost-benefit analysis of the WFD element was based on only the incremental cost between achieving the UWWTD limits and the WFD limits whereas the benefit achieved by both drivers was assumed.

This means that WFD schemes that would not be cost beneficial on their own became beneficial for YW's WINEP3. More expensive WFD schemes at other companies not subject to UWWTD drivers may have been rejected on cost benefit grounds and been excluded from Ofwat's modelled dataset (see Ofwat's Modelling Approach section below).

The final WINEP was confirmed on 31st March 2017 and contained 81 new phosphorous limits, with 11 limits driven from the Urban Waste Water Treatment Directive Sensitive Designations, 32 limits driven from the Water Framework Directive and 39 limits driven by both drivers. One site required no action at PR19 as it already met the standard.

The Scale and Challenge of YW's AMP7 Programme

The WINEP programme for Yorkshire Water was different to those for other companies in that:

- It had the largest total PE of sites with new phosphorus drivers in the industry. This meant that it had the largest scale driver of costs (Figure 1.1).

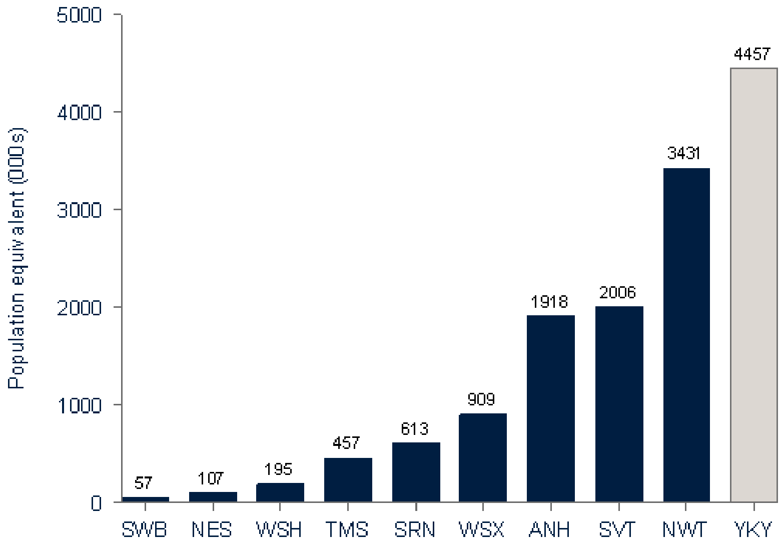

Figure 1.1 Population Equivalent impacted by new P permits for each company (in AMP7)

- YW had not had significant P-removal obligations in previous National Environment Programmes and hence did not have existing treatment in place. This meant that the level of improvement in P permits at YW sites, was larger than companies that already had permits in place (often going from no permit to an extremely tight permit). Companies with existing treatment in place may have been able to achieve improvements by minor modifications or optimisation of existing approaches or through catchment management at a significantly lower cost than if no treatment is currently in place. This is represented in Figure 1.2.

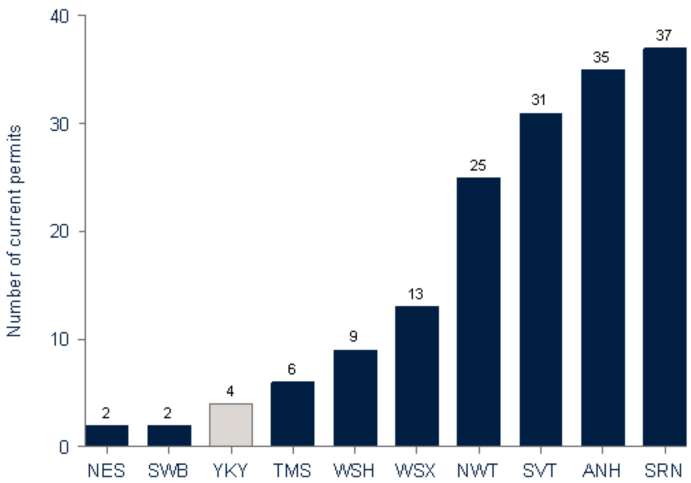

Figure 1.2 Number of Sites with new P Drivers that have Existing P Permits

- Approximately half of YW sites had both a U_IMP Driver and a WFD_IMP Driver. This was unique in the industry and the proportion was particularly large when viewed weighted by load (Figure 4). Many companies received UWWTD drivers in previous periods and were allowed enhancement funding to deliver improvements at the works. Further improvements to meet WFD drivers may have been achieved through catchment management and minor modifications of existing approaches. However, the requirement in the UWWTD that "*urban wastewater entering collecting systems shall before discharge be subject to secondary treatment or an equivalent treatment…"* meant the solutions and efficiency available to Yorkshire Water were limited by the need for end of pipe treatment. Figure 1.3 shows how YW's UWWTD obligations were proportionally much greater than the rest of the industry.

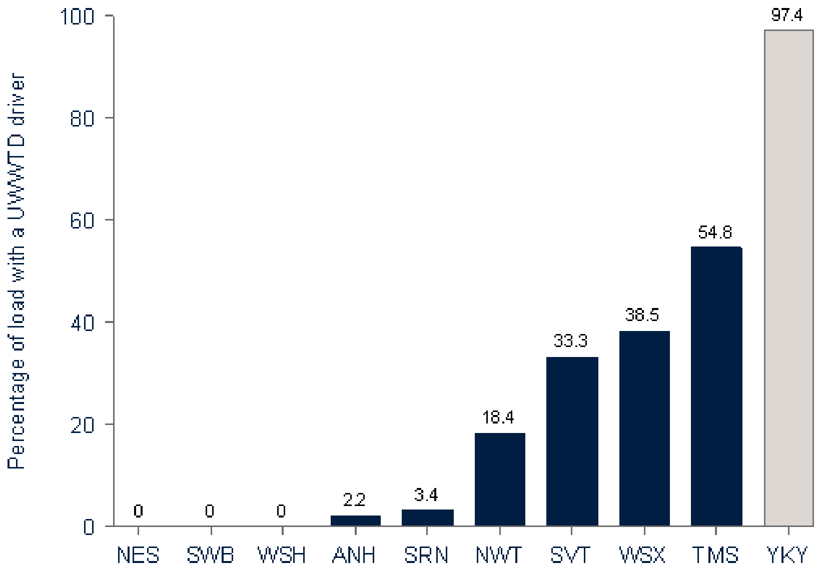

Figure 1.3 Proportion of AMP7 programme subject to new UWWTD obligations (by load)

In summary, YW had the industry's largest set of Phosphorus removal obligations in AMP7. As we had not previously had obligations under the UWWTD we are installing end-of-pipe solutions as mandated by the directive. This means that more efficient costs options (e.g. process optimisation or catchment management) are not available to YW as they are to other companies who have received funding in previous price reviews to achieve UWWTD phosphorus limits.

Phosphorus Modelling at PR19

The PR19 cost models for Phosphorus removal went through several iterations between the IAP stage and the CMA's final determination.

The final decision from the CMA was to adjust Ofwat's FD slightly and to use 8 models to estimate Yorkshire Water's efficient Totex costs within AMP7. These were triangulated to create the final allowance.

Model	Drivers	Model	Drivers
1	Population Equivalent with new P permits & No. of Sites with P-removal drivers	5	As 1 but excluding 4 UU large catchment interventions
2	Population Equivalent with new P permits & % sites with <=0.5 P permit	6	As 2 but excluding 4 UU large catchment interventions
3	Population Equivalent with new P permits & % sites with <=1 P permit	7	As 3 but excluding 4 UU large catchment interventions
4	Population Equivalent with new P permits & % sites with no current permit	8	As 4 but excluding 4 UU large catchment interventions

Table 1.2 Model specifications for AMP7 Totex Allowances

Outputs of the modelling & Final Determination

The CMA's final determination modelling outcome, following a WINEP in-the-round efficiency challenge for Yorkshire Water resulted in an AMP7 totex allowance of £549.8m (17/18 prices) in Wastewater Network Plus to deliver P-removal at 80 sites serving a population equivalent of c. 4,460,000.

1.3. The Need for a PR24 Adjustment

The challenge facing companies, and particularly Yorkshire Water in AMP8 is that there was no allowance made for the ongoing cost of operating the P removal process once the schemes are delivered.

Ofwat's approach is that the ongoing operating costs of enhancement schemes become part of base cost allowances in the next period. However, unless the interventions delivered by the enhancement programme impact the explanatory variables in the econometric Botex models then no allowance will be made to fund the ongoing compliance with the new obligations.

P-consent levels are neither directly included as cost drivers in the modelling suite, nor are they sufficiently captured by existing cost drivers. This is shown in Table 1.3 Correlation of load treated at P-consent levels ≤ 0.5mg/l with relevant cost drivers below, which shows the correlation of load treated at P-consent levels below or equal to 0.5m/l with the cost drivers included in the relevant sewage treatment (SWT) and wastewater network plus (WWN+) models. We note that correlation analysis alone cannot offer comprehensive evidence on whether a cost driver is appropriately captured by a set of models but can provide a starting point in the investigation.

Cost driver	Correlation coefficient
Load (log)	0.0753
Pumping capacity per sewer length (log)	0.0765
Load treated with ammonia consent ≤ 3mg/l	0.2198**
Load treated in size bands 1 to 3 (%)	-0.1411
Load treated in STWs ≥ 100,000 people (%)	0.1474
Weighted average treatment size (log)	0.0327
Urban rainfall per sewer length (log)	0.0626

Table 1.3 Correlation of load treated at P-consent levels ≤ 0.5mg/l with relevant cost drivers

Note: ** indicates statistical significance at the 5% level.
Source: Oxera analysis of PR24 Cost Assessment Master Dataset, Wholesale Wastewater Base Costs v4,

Only the correlation with cost driver load treated with ammonia consent ≤ 3mg/l is statistically significant, but it has a relatively low magnitude (0.22). All other correlation coefficients are statistically insignificant and close to 0[2]. Overall, the table shows that the correlation of P-removal activities with the cost drivers included by Ofwat is low.

Ofwat has recognised this in its recent Base Cost Modelling consultation[3] stating:

> *"We recognise that the additional ongoing cost associated with more stringent phosphorus removal programmes across the sector may not be fully captured in our proposed base cost models. We are exploring alternative options to ensure that our cost assessment approach funds efficient ongoing P-removal costs, which we welcome company views on:*
>
> - *We will continue to consider models with a P-driver (e.g. percentage of load with a P permit <= 0.5mg/l) fixed at the 2024-25 level. This will have the impact of funding the additional base expenditure associated with phosphorus removal enhancement schemes funded at PR19 and completed by the end of AMP7.*

[2] Note that, after Ofwat's ammonia-related complexity variable, the next strongest correlation is between P-removal activity and the economies of scale drivers ('load treated in size bands 1 to 3' and 'load treated in STWs ≥ 100,000 people'). Although statistically insignificant, the correlation suggests that large STWs may undertake more P-removal activity on average in the historical data.

[3] https://www.ofwat.gov.uk/wp-content/uploads/2023/04/Econometric_base_cost_models_for_PR24_final.pdf p41

- *We are considering whether we can calculate an accurate post-modelling adjustment that funds efficient ongoing opex associated with P-removal using data provided by companies in annual performance reports (APRs).*
- *The cost adjustment claim process."*

We are pleased that Ofwat has identified this gap and accept that the efficient ongoing costs allowance could be allowed for in multiple ways. Given this guidance, we include a cost adjustment claim as part of the Early Submission but would equally support an appropriate modelling, or post-modelling adjustment to ensure that efficient costs are recognised.

While the models' inability to reflect the costs associated with P-removal is a general modelling issue that could (in principle) affect all companies, YW in particular is materially affected by the omission of P-removal cost drivers. Figure 1.4 below shows how YW's P-removal activity is expected to change in AMP8 relative to the rest of the industry.

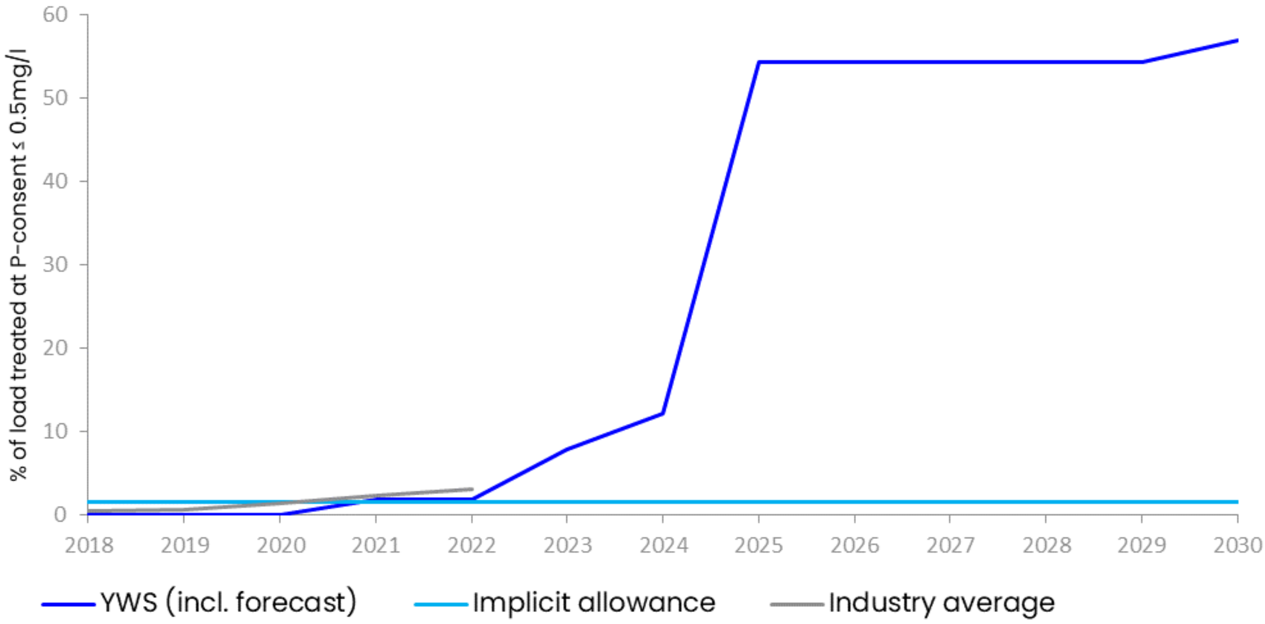

Figure 1.4 Historical and forecast P-removal activity

Note: The implicitly funded P-removal activity ('implicit allowance') is based on the five-year industry average for the years 2018 to 2022 as Ofwat tends to use the last five years of modelled data to determine the appropriate benchmark.
Source: Oxera analysis of PR24 Cost Assessment Master Dataset, Wholesale Wastewater Base Costs v4, and YWS forecast data.

The figure shows that historical P-removal activity across the industry is low. This means that estimating the cost of P-removal activities using econometric analysis on historical data is difficult, because P-removal activities only account for a small share of the relevant cost areas. Moreover, omitting P-removal activity in the models would mean that the implicitly funded level of P-removal activity in the models will likewise be low. In contrast, YW expects to rapidly increase the percentage of load treated at strict P-consent levels from 2022 to 2025, substantially above implicitly funded levels, requiring additional and more complex P-removal activities.

We discuss the calculation of implicit allowance later in this document.

1.4. Yorkshire Water's Efficient Cost Requirements

This cost adjustment claim is aimed at providing YW with adequate operating cost funding to operate the new P-removal sites. Construction of the new assets is underway, and we are working towards a compliance date of December 2024.

YW's processes, through using the totex hierarchy and having a rigorous design and feasibility process supported by a procurement process that is designed to find the most efficient costs possible through the market place, are implemented to ensure customers are protected as far as possible from unnecessary cost exposure. YW is confident that its costs are robust and efficient and with the customer protection mechanism in place described below, protect customers as much as possible

Each scheme is allocated a scheme sponsor whose role it is to manage and steer the scheme through the concept, optioneering, design and delivery processes to the point that the need, technical solution and the funding requirement is authorised in our corporate governance process. We have a framework of delivery partners who are incentivised to find further efficiencies where possible.

The final determination at PR19 for P-removal was significantly less than we had initially identified would be needed. Factors that we argued were important were recognised by both the CMA and Ofwat and included in final models, however, they were then triangulated with models that did not include them.

Our AMP7 programme has been re-evaluated to achieve compliance within our PR19 Totex allowances. Given the cost challenges outlined above, there are cases where the best value solution is not available given the additional AMP7 Totex cost. We have had to make trade-offs, often moving away from more expensive capital solutions (biological nutrient removal or nature-based solutions), to other less capital-intensive options that offer less value in the long-term as the annual operating costs are higher.

We recognise and welcome that Ofwat has recognised and sought to address the 'best-value' issue at PR24 but the issue with AMP7 allowances remains. We set out our approach to designing and optimising our PR19 programme below and understanding the operating cost impact that forms our CAC.

The table below summarises our planned approach to delivering the P programme by solution type:

Treatment Technology	No of permits
P-removal – Chem Precipitation	71
Biological Nutrient Removal	1
Nature Based Solution	4
Catchment Solution	2
Sewer Out	2
TOTAL	**80**

Table 1.4 Final YW Decisions on AMP7 Phosphorous Treatment Solutions

In order to identify the ongoing operating cost requirements, YW deploys a rigorous set of cost models across several categories. We hold and utilise models for the following key opex components:

- Chemical Use
- Power Use
- Business Rates
- Sludge Transport and Disposal
- Additional Manpower Requirements
- Proactive Maintenance Requirements

The table below summarises the calculated annual opex we require in in each key category to maintain P compliance at the required permit level:

Opex category	Annual requirement (£m)
Chemical Use	13.183
Power Use	4.792
Business Rates	2.187
Additional Manpower Requirements	0.186
Proactive Maintenance Requirements	2.701
Total annual WWN+ Operating Cost Requirement	**23.050**
Sludge Transport and Disposal	6.770
Total annual operating cost requirement	**29.819**

Table 1.5 Total Operating Costs of P Solutions split by Category

Costs in EDA inflated to 22/23 FYA

Design, costing and decision-making process

We undertake a robust assessment of costs, optioneering and efficiency through our end-to-end delivery process. Our Decision Making Framework (DMF) is embedded within this process and involves taking the need from the final WINEP and assessing all available options to achieve the best value outcome within cost constraints provided. Challenging the robustness of the cost based on the design and ensuring cost efficiency is built into the planning process. Figure 1.5 below shows our overall process from need through to authorisation to deliver the scheme.

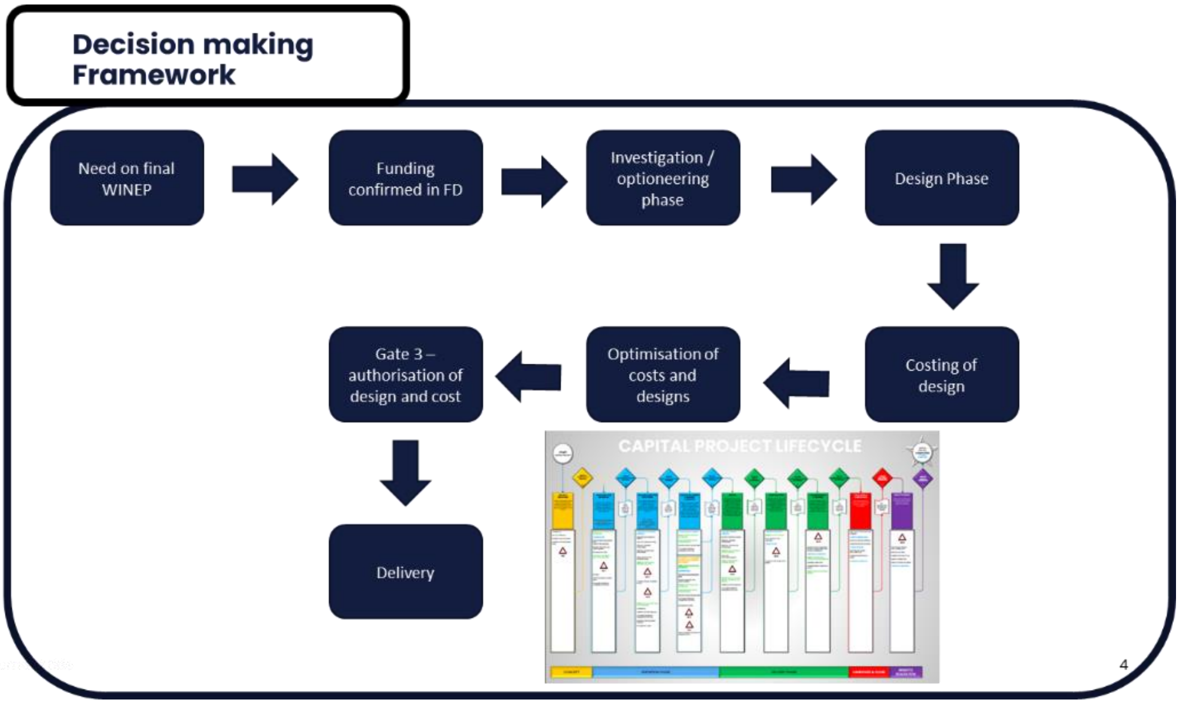

Figure 1.5 Decision Making Framework Process

Investigation and optioneering phase

All 80 limits requiring action were entered into the investigation and optioneering phase of our delivery process. We worked closely with our Strategic Planning Partner, Stantec, and the Environment Agency to assess the range of possible options to deliver our obligations for best value within our Totex constraints.

The decisions made at this stage on the solution type impact our ongoing operating costs and hence the value of the claim.

We deploy the totex hierarchy in all our decision making. Our philosophy, guided by ensuring a low carbon approach where possible and also providing best value for money to customers, is to find ways to minimise the construction of new assets to provide better value. The totex hierarchy we deploy is shown here in Figure 1.6.

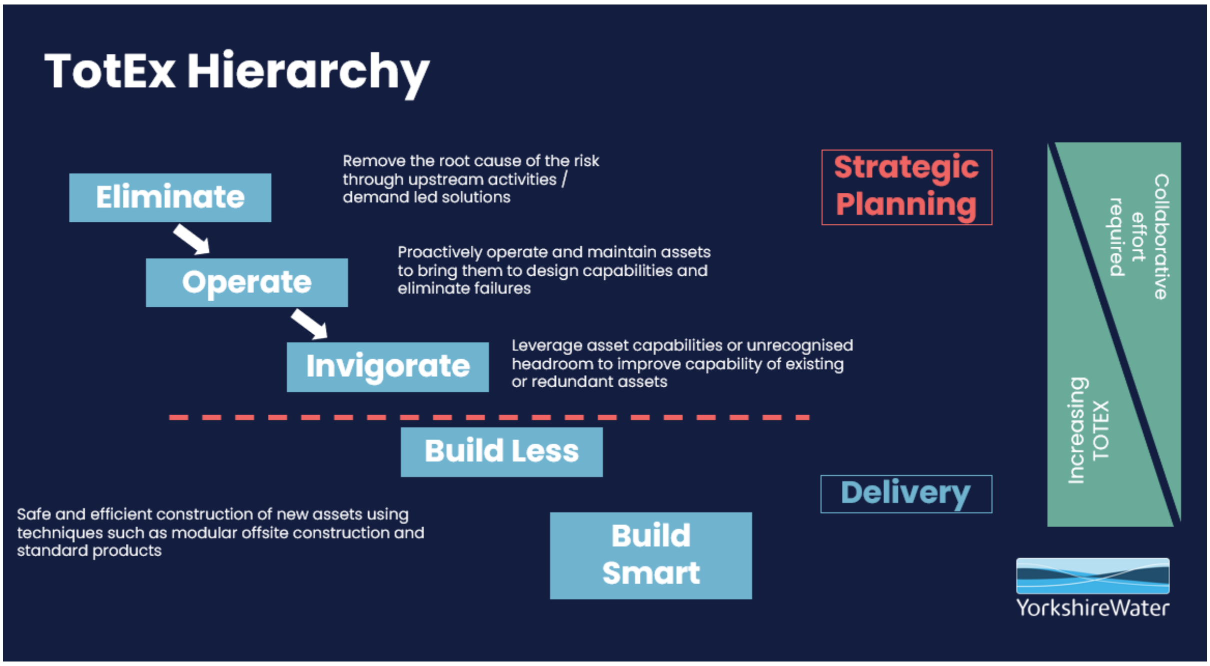

Figure 1.6 Totex Hierarchy

Using this hierarchical approach to totex the following intervention types have been assessed for AMP7 delivery:

Catchment Permit Trading – this is a minimise build approach which involves working with the Environment Agency to manage the overall river water quality objectives set out in the WFD by reviewing and amending permit limits (e.g., including dry weather flow sacrifice and permit trade), ultimately resulting in at least an equal benefit to the watercourse. This approach minimises construction of new assets and therefore additional operating costs in the future providing more sustainable, long-term solutions. We have been able to deploy this approach at a number of sites by optimising the requirement against flow leading to a less stringent limit required, therefore reducing opex requirement. This option is only available for WFD drivers.

Nature-Based Solutions – Where suitable land allows, and treatment load is relatively small, there is the option to install a nature-based solution such as a treatment wetland. Wetlands involve a slow rate natural process of removing P over a long period of time. A good example of this is our Clifton site near Doncaster – shown in Figure 1.7 below. The option has multi long-term sustainable benefits offering a low carbon solution, low operating costs, increased biodiversity and provides an amenity for the local community.

Figure 1.7 Clifton Wetlands – Low Carbon and Opex Solution

Sewering Out – where two wastewater treatment works are located in close proximity to each other there is the option to close the upstream site down and send (pump or gravitate) the influent to the next treatment site downstream. This can save large amounts of capex and opex by combining two requirements into one site, providing good value to customers and cost efficiency. The receiving wastewater treatment site will then be subject to the same options assessment as other sites. This option is available for both drivers.

P-Removal through Biological Processes – this is an alternative P-removal process which includes zoning off various parts of the process into aerated and non-aerated compartments (shown in Figure 1.7 below) and using chemicals but to a lesser extent than full chemical removal. The process can provide a better long-term value solution than standard chemical removal but is only cost effective where there is an existing Activated Sludge Process. The process is high capex however and whilst it often presents better long-term value may not be affordable within short-term Totex constraints. YW completed extensive cost assessment of this at PR19[4]. This option is available for both WFD and UWWTD drivers.

[4] https://www.yorkshirewater.com/media/txfoxuxx/appendix-8g-winep-technical-appendix.pdf

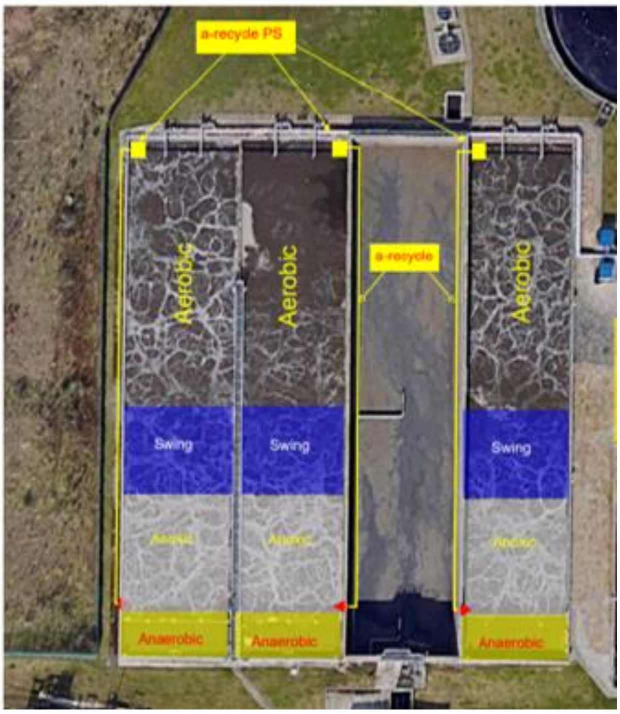

Figure 1.8 Biological Treatment Process Example

P-removal through chemical precipitation – this is the standard P-removal process which involves using a suitable chemical e.g. Ferric Sulphate to bind to the P and precipitate it out of the effluent. A tertiary solids capture unit may also be installed where required to capture the extra solids. Additional chemical may also be used to correct for water alkalinity. The process is relatively low in capex but high in opex and provides limited environmental benefit outside of removing the P from the final effluent. The option is available for all drivers.

Soneco –As an alternative to chemical dosing, an electro coagulation process made from specific metals can be used to treat the water. The process can be used for all drivers and reduces the overall need for chemical and therefore opex.

We use our DMF to assess the suitability of all options available at each site. The DMF considers costs and benefits in the short and long-term and incorporates our six capitals approach.

Table 1.6 below summarises all the optioneering we did for AMP7 delivery in this phase. It includes a comparison between the planned solutions at PR19 and what is now being delivered.

	Full Chemical Removal	Biological nutrient removal	Sewering Out	Wetland Option	Catchment Permit Trading	Soneco	Opex Savings from

							PR19 FBP
No of sites in PR19 (FD)	71	7	3	0	0	0	
No. sites assessed*	81	20	10	10	15	10	
AMP7 Solution	66	1	2	4	2	5	£4.1m

Table 1.6 Phosphorus Solutions Considered and Savings Identified

*Number of sites for which each solution type was considered (in design & feasibility stage)

Despite some non-best value decisions being required to deliver our programme within our AMP7 allowances this totex hierarchy led optioneering process has led us to find savings of £4.1m Opex p.a.

Design Phase

After the concept phase, the chosen outline solution was designed by our Strategic Planning Partner Stantec. Stantec base an outline design on a high-level indicative site layout to enable the delivery partner to confirm costs. Stantec undertake a buildability review looking at site layout, tanker access, following design guidance and standard designs from the Engineering Team e.g. dosing kiosks. Where necessary additional expertise was sourced to outline design more bespoke solutions such as EBPR, Soneco and Wetland interventions.

Costing

As designs become more detailed this allows us to get more detailed and accurate costs. This included both capital costs using our established UCD process and also our operating cost approach which aims to identify the operating cost impact of the designed solution.

Our Opex costs are completed for each scheme at the level shown in Table 1.5 with each key cost category being assessed using a range of methodologies at the best level of detail available at the time.

We have used our bottom-up costing tool within our decision-making framework system (EDA) where possible to estimate the costs. Where bottom-up outputs were not available we used expertise from our strategic planning partner Stantec to estimate the costs. The below sections describe more detail on each of the cost categories.

Chemicals

Chemical usage rates have been calculated using internal design guidance, specifically 'Chemical Dosing for P-removal design guidance'. These calculations consider; existing site technology type, site population equivalent (PE) and permitted dry weather flow (DWF). All estimates are based on theoretical per capita loading and molar dose ratios as defined in the guidance.

All solutions have been designed and costed to achieve compliance for a forecast 2035 population equivalent.

Our chemical unit prices were sourced from our chemical framework procurement process. The framework provides contractual guarantees on price to ensure costs are efficient and as part of the contract we use Ernst and Young annually to verify our rates are efficient.

Energy/Maintenance/Business Rates

For all sites, energy, maintenance and business rates requirements for the chemical dosing and tertiary solid capture were calculated by Stantec based on a mixture of bottom-up detail and top-down assessments where relevant to the cost type. All solutions have been designed and costed to achieve compliance for a forecast 2035 population equivalent.

The assets that are costed included dosing systems or 'package', mixing systems, safety showers and water booster package where available. Rateable assets include civils assets such as storage tanks. Maintenance is applied to M&E assets.

Key values for the assessment used are:

- **Energy / Power** – Assumed a 26p/kw hour for power consumption (KW requirements assume a 75% loading rate, a 60% average use factor, and 90% overall pump efficiency for M&E Assets)
- **Maintenance -** 2.44% of total M&E capex (where applicable) is applied as the annual rate for maintenance
- **Business Rates -** 0.04% of the total civils capex (where applicable) is applied as the annual rate for business rates

Labour

The labour estimated included an assumption on time based on an Optimiser role as well as a time-based assumption on a Senior Operator role, with cost rates based on YW bands and SAP rates. The time required per site per week includes travel time and is based on information from AMP6 delivered activity. The time and rates assumed were:

Role	Rate (£/hr cost to YW)	Time assumed in hours per site per week
Optimiser	70.38	0.5
Senior Operator	37.69	0.375

Table 1.7 Labour cost assumptions

Sludge

We have used a series of models to understand our sludge costs however these do not form part of this claim.

Assurance and corporate governance

The decision on the final designs and subsequent cost calculations were presented and authorised through our corporate governance process on Nov 22nd 2022 (Board Investment committee). This followed a process of internal YW quality assurance and external review from a Stantec subject matter expert.

Figure 1.9 below summarises our assurance process for costs

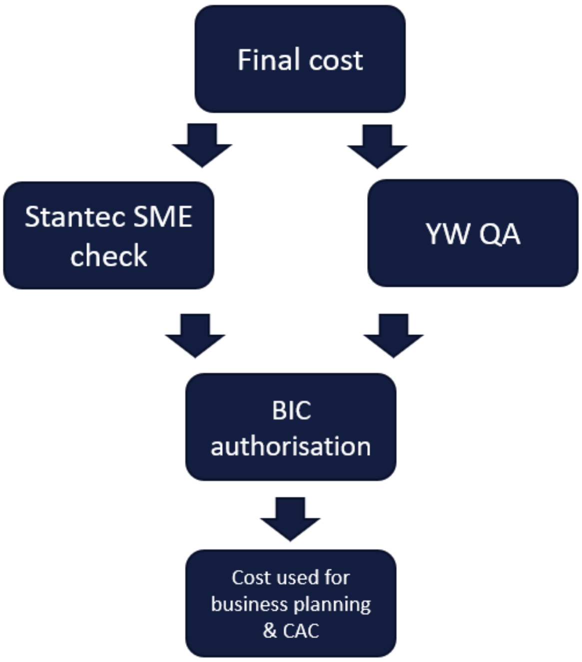

Figure 1.9 Cost and Solution QA and Assurance Process

These costs are now being reported in Table 7F of our APR submission, used for our programme planning and informing the size of this claim.

1.5. Calculating the Claim Value

As shown earlier in Figure 1.4 historical P-removal activity is very low across the industry at the tightest consent levels. Table 1.8 below shows the shares of load treated at P-consent levels below 0.5mg/l during the past five years and as forecast for AMP8.

	in %
YW's current P-removal activity	0.7
Implicitly funded level of P-removal activity based on outturn average	1.5
YW's forecast P-removal activity	54.2
Share of claim relating to meeting implicit allowance	1.5
Share of claim going beyond implicit allowance	98.5

Table 1.8 Calculation of share of claim beyond implicit allowance

Note: YW's current and the implicitly funded level of P-removal activity refer to 2018-2022 averages. Forecast share refers to YW's forecast value for 2026. P-removal activity is defined as the share of load treated at P-consent levels ≤ 0.5mg/l
Source: Oxera analysis of PR24 Cost Assessment Master Dataset, Wholesale Wastewater Base Costs v4.

The table shows that YW currently treats 0.7% of load at the strictest P-consent level of below 0.5mg/l, while the industry average of 1.5% is implicitly funded. However, YW will treat 54.2% of load at the most stringent P-consent levels in 2026. Consequently 1.5% of YW gross claim relates to meeting the implicit allowance and 98.5% goes beyond it.[5]

We have calculated the gross claim p.a. by our bottom-up estimate of OPEX costs relating to P-removal activities based. This reflects the estimated additional expenditure required by YW to meet the more stringent P-consent requirements. Table 1.9 below presents how a net claim value over 5 years can be calculated from this.

	in £ million
Gross claim p.a.	23.050
Net claim p.a.	**22.704**
Net claim over 5 years	**113.520**

Table 1.9 Calculation of Claim value

The gross claim p.a. reflects our bottom up build of costs as set out in Table 1.5 (however, some of this gross claim value (c. 1.5%, see Table 1.8) reflects costs associated with YW 'catching up' to the level of P-removal currently implicitly funded through the models. The net claim p.a. is calculated by multiplying the gross claim value (£23.1m) with the share of the claim going beyond the implicit allowance (98.5%). On the basis of this analysis, the net claim amounts to c. £22.7m p.a., or £113.5m over a five-year period.[6]

[5] The exact calculation is as follows: $\frac{average\ share - current\ share}{forecast\ share - current\ share} = \frac{1.5 - 0.7\%}{54.8\% - 0.7\%} = 1.5\%$

[6] Our populated data tables show the gross value, the implicit allowance, and the net value of the claim by year. They also show the historical expenditure per year.

We will continue to revise the costs to reflect any changes in chemical and energy prices and any final changes to solution type and update for the final CAC submission in October.

1.6. Economic Benchmarking – Empirical Analysis

Section 1.4 sets out in detail the approach we have taken to designing our solutions and understanding the ongoing operating costs. However, in order to support this, we have worked with our economic consultancy partner Oxera to develop econometric evidence on the efficiency of our costs.

Oxera has taken two approaches to assess what could be considered an industry level efficient cost.

- Firstly, it has used the data submitted by companies in APR table 7F to assess an efficient unit rate for the ongoing operating costs associated with additional treatment of phosphorus in the AMP7 WINEP.[7]
- Secondly, it has explored the impact of including a composite complexity variable involving P-removal in the base cost modelling. It has completed further analysis to confirm its assumptions in the weighting of P-removal in the complexity variable.

These are described in detail in Appendix 1 and the calculations will be made available in the accompanying datasheets can be provided upon request.

	Net claim value (£m p.a.)
Analysis based on APR tables 7F	20.4-26.4
Ofwat proposed models with add composite treatment complexity variable	42.2
YW' bottom-up estimate	23.0

Table 1.10 Summary Table of Oxera Model Findings

Source: Oxera analysis.

[7] It is not clear whether APR Table 7F contains elements of Bioresources costs for each company. The output of this analysis provides a range based on different assumptions regarding whether bioresources expenditure is included in the cost data.

Oxera's analysis considers the reasonable range for a cost adjustment claim based on P-removal to be in range of **£20.4m to £42.2m p.a**. YW's bottom-up estimate of **£23.0m p.a** lies within this range**.**

We anticipate updating this analysis to reflect the latest APR data prior to our final submission and recommend that Ofwat ensures that the definition of table 7F is clear on whether it includes the bioresource operating cost impact of the investments.

1.7. Symmetrical Adjustments

In theory, the cost adjustment claim can be symmetrical as companies could undertake future P-removal activities below the implicitly funded historical average. However, forecast data indicates that all companies expect to significantly increase their P-removal activities in the coming years, due to tightening P-consent levels. In practice, we do not expect many companies to be affected by negative cost adjustments due to this claim.

1.8. Customer Protection

Whilst we are investing to complete our construction at all 80 sites by December 2024, we propose a protection mechanism for this cost adjustment claim to protect customers in the event that any schemes are delivered late.

We propose to use the reported values in Table 7F of the APR which contains a value for operating expenditure 'after 2024-25' but excluding any sludge costs.[8] See figure 1.10 below.

[8] We note that our previous submission of Table 7F contained sludge operating costs relate to the scheme. It was not clear in the RAG guidance whether this was the correct assumption or whether other companies reported these costs. This protection mechanism will be based on costs in table 7F *excluding* bioresources costs. We have sought clarification on this and if Ofwat confirms bioresources costs should be excluded then then Table 7F can be used as the basis of the protection mechanism.

Pro forma 7F

Yorkshire Water

Wastewater network+ - WINEP phosphorus removal scheme cc

B	C	D	L	M	N	O	P	Q	R	S
				Operating expenditure						
	Units	DPs		2019-20	2020-21	2021-22	2022-23	2023-24	2024-225	After 2024-25
Ackworth WwTW	£m	3		0.000	0.000	0.000	0.000	0.011	0.092	0.092

Figure 1.10 APR Table 7F

We propose a mechanism where we would return a proportion of the annual operating costs associated with each late delivered scheme based on the number of months late delivery (rounded up to the nearest month). Where 'late' is defined as not achieving the compliance date (December 2024 or March 2025).

For example if Ackworth were delivered 6.5 months late we would return **7**/12 x £0.092m = £0.0536m. If it were delivered 15 months late we would return **15**/12 x £0.092m = £0.115m

We will expand on this further in our final plan and would welcome engagement with Ofwat on the suitabiltiy of this mechanism before final determination. We would propose that the most up to date APR table 7F available is used to set the rates (there will be two further iterations of this table before final determination).

1.9. Data Table Commentary

	Title	Commentary
CWW18.1	**Description of cost adjustment claim**	The base cost impact of YW's AMP7 Phosphorus Removal Programme unfunded through base modelling
CWW18.2	**Type of cost adjustment claim**	We have assigned this to 'new legal requirements' as the claim is for the costs to maintain compliance with new legal requirements not in the historic dataset.
CWW18.3	**Symmetrical or non-symmetrical**	This is a forward-looking claim and therefore non-symmetrical.
CWW18.4	**Reference to business plan supporting evidence**	Refers to this document as this is the Early submission.
CWW18.5	**Total Gross Value of Claim**	We populate the gross value of the claim to align our costed ongoing operating costs excluding Sludge. We do not populate claim values for the period 2022-25 as we assume that any operating costs in this period are allowed for through the PR19 Totex allowance.
CWW18.6	**Implicit Allowance**	This has been calculated as set out in Section 1.5 above
CWW18.7	**Total Net Value of Claim**	Calculated from above two lines
CWW18.8	**Historic Base Expenditure**	The investment to address these new obligations has only begun in AMP7 with the first operating expenditure seen in 2021/22 so we have not included historic base expenditure for years prior to this. A small value (as reported in APR table 7F Column O has been reported in 2021/22) as the first small schemes with early compliance dates have been delivered.
CWW18.9	**Totex for the control**	We are not required to populate Totex value but include a WWN+ value
CWW18.10	**Materiality**	N/A We note that the size of the claim is significantly higher than 1% of WWN+ Totex historically.

Table 1.11 Data Table CWW18 - Cost Adjustment Claim

2 – Combined Sewers

2.1. Executive Summary

This document sets out the case for an upward adjustment of **£15.5m p.a**. (**£77.5m over the 2025-2030 period)** of costs for operating and maintaining a wastewater (WW) network with a materially higher proportion of combined sewers than the industry average (Figure 2.1).

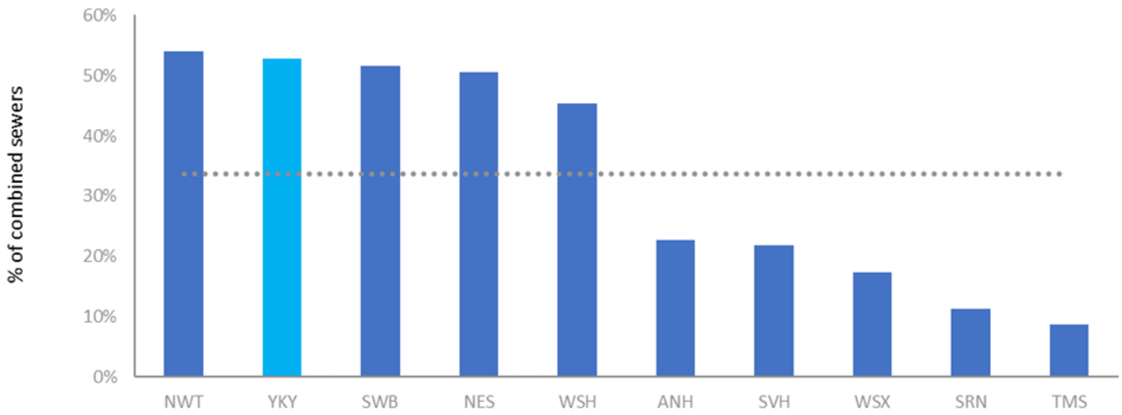

Figure 2.1 Industry proportion of combined sewers (legacy assets)

Combined sewers carry both foul and surface water and hence are more susceptible to causing sewer flooding and overflow spills than separated systems. We believe this drives significant differences between the level of performance companies are achieving[9] and following the decision to set common internal sewer flooding performance commitment levels, materially impacts the costs that impacted companies are incurring as they implement operational strategies to minimise penalties.

Cost Adjustment Claims (CACs) are in place to capture company specific factors not reflected in Ofwat's econometric base models. We believe that there are a variety of factors that impact our Internal Sewer Flooding (ISF) performance that may have led to this CAC to be larger but the *Percentage of Combined Sewers* is the factor that is both supported by economic and engineering rationale and by robust high-quality data available in Ofwat's PR24 dataset.

The value of this claim is driven by the difference between the inclusion and exclusion of this driver in Ofwat's base econometric models. This calculated value does not provide YW with sufficient allowance to overcome the differences in operating circumstances that impact on performance levels (current relative performance is not included in the models)

[9] We are currently developing an evidence base that demonstrates that the current performance differences (not reflected in the cost models) are driven by a combination of exogenous factors and that it is appropriate to

but it describes the cost impact of this factor given the current performance differences (excluding penalty payments).

Table 2.1 below points to the locations in the document where we address Ofwat's cost adjustment claim assessment criteria.

Cost Adjustment Claim Assessment Criteria	Sections
Need for adjustment	2.2, 2.3, 2.4, 2.7
Cost efficiency	2.5, 2.6
Need for investment	2.3,
Best option for customers	n/a
Customer protection	n/a

Table 2.1 References in Document to Ofwat's Cost Adjustment Claim Criteria.

2.2. Introduction

Yorkshire Water has both overall poorer performance and higher costs than the industry average in its wastewater networks. The performance (and therefore cost) issues are not however spread evenly across our region and are primarily focused in the far west as shown in Figure 2.2.

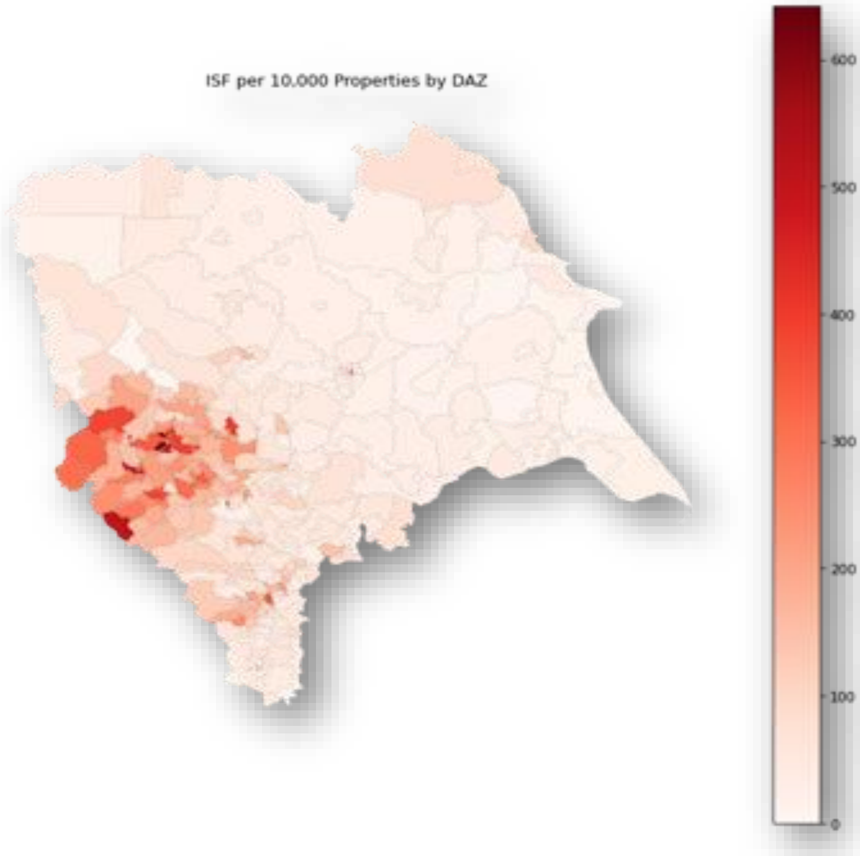

Figure 2.2 Geographical representation of Internal Sewer Flooding per 10,000 properties in individual Drainage Area Zones

Our analysis shows that the cost of operating a sewer network within a fixed performance envelope is directly impacted by a variety of exogenous factors that have historically not been captured in Ofwat's econometric modelling. These include, but may not be limited to:

- the prevalence of **combined sewers** – sewerage and surface water entering the same system.
- the propensity of the area to experience blockages (e.g. **food service establishments** adding fats, oils and greases to the sewer network)
- the prevalence of **cellared properties** impacting internal sewer flooding)
- the **age and material of the network** (exogenous in the short and medium term) increasing the propensity of a sewer to block (due to a combination of minor imperfections and solids from the toilet naturally depositing on the invert) and collapse.
- heavy rainfall in urban areas – meaning more surface water requiring removal.

These factors work in tandem to materially impact company cost and performance in sewage networks (and at the receiving STW assets.). An event (for example an internal sewer flooding) is often the culmination of factors – an example causal flow is set out below.

- A rainfall event meaning there is water landing on roofs and roads that enter the sewerage system.
- A combined sewer which means that sewerage and rainwater are carried into the same system.
- A partial blockage of the sewer due to the natural deposition of solids (e.g. wipes) that catches on slight gap between pipes (e.g. 2mm) that leads to further solids collecting and when combined with rainfall leads to an escape.
- A property with a cellar which receives the escaped diluted sewerage.

We believe that Yorkshire Water is impacted by all of the above factors in a way that negatively impacts both our costs and performance in sewerage networks. See Figure 2.3 below.

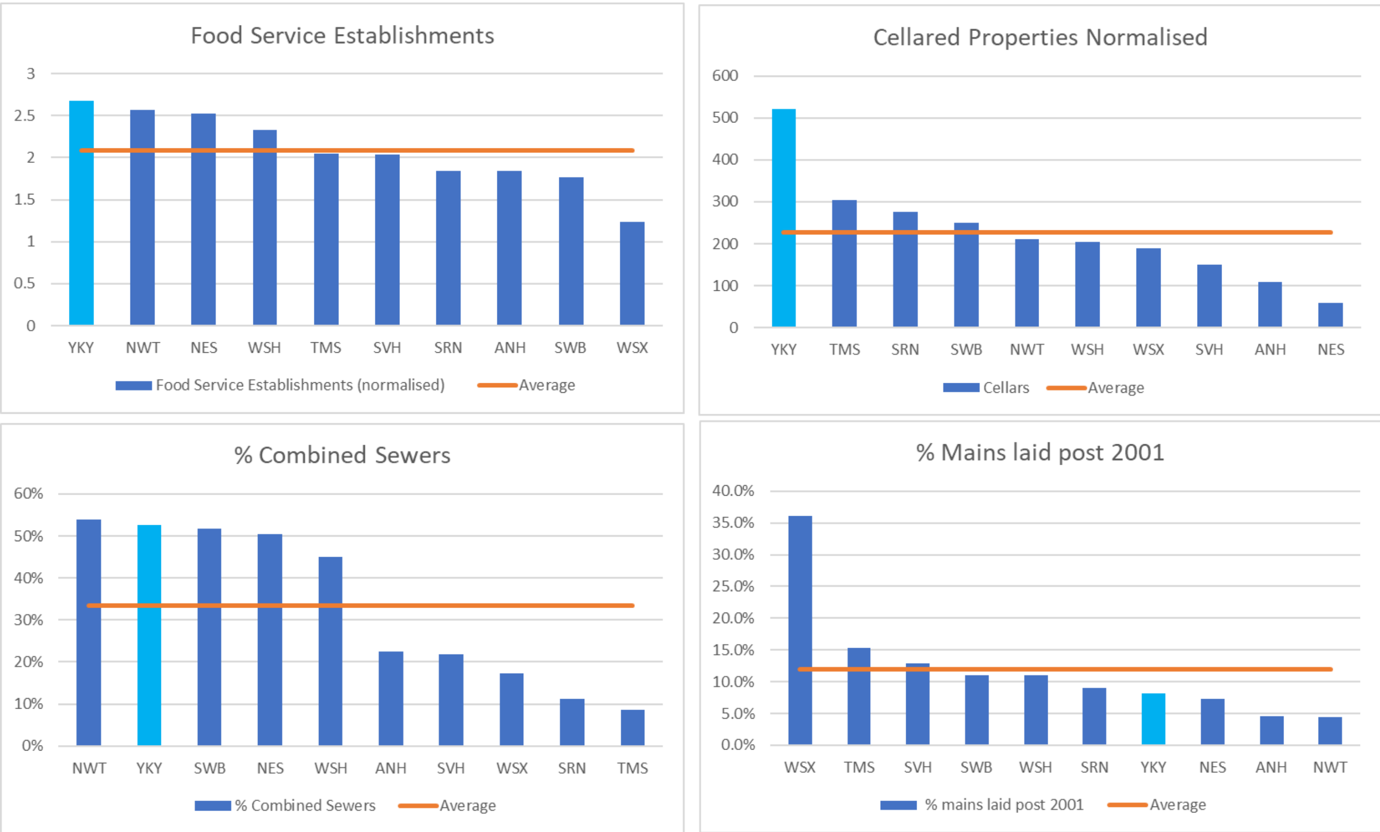

Figure 2.3 Industry comparison of key factors influencing network performance

We believe that all of the above factors in combination lead to the overall higher costs and lower relative performance experienced by Yorkshire Water in managing its network performance. For the purpose of this cost adjustment claim, we have currently focused on *percentage combined sewers,* because: (i) it is an operationally relevant driver of expenditure that can readily be incorporated into Ofwat's cost models; (ii) it performs well in such models from a statistical perspective; and (iii) the data is readily available in Ofwat's PR24 cost modelling dataset.

We are also developing an evidence base that demonstrates that the current performance differences in internal sewer flooding (not reflected in the cost models) are driven by multiple combination of exogenous factors and that it is appropriate to adjust PC targets to reflect exogenous factors where it is in customer interest to do so.

2.3. Combined Sewers – The Basis of our Claim

Many sewer systems were designed to carry stormwater and wastewater in separate pipes. However, in older towns & cities, combined sewers were commonly installed. This practice was stopped for new development post-World War 2.

A key challenge associated with combined sewers compared with separated sewers is that when it rains stormwater and wastewater flow into the combined sewer system simultaneously. In heavy rainfall events, this can lead to the system exceeding its designed capacity (hydraulic flooding), but more commonly the sewer does not have the capacity to convey the surface water from smaller rainfall events when there is a blockage (which does not have to fully block the pipe) or partial collapse. This event leads to flows backing up.

Depending on the location of these events, it can cause internal and external sewer flooding, property damage, and pose a risk to public health and the environment.

The combined sewers, when built, were not designed to a consistent rainfall return period unlike newer developments which utilise drainage models to inform their design.

To manage hydraulic overload in the combined sewer network, historically pre-privatisation storm overflows were built to protect the main sewer network from flooding. Typically, since privatisation, new storm overflows have not been built and additional infrastructure, such as storage tanks, has been required to temporarily store and divert excess flows, increasing the complexity and cost of the sewer network.

A further challenge is that the age and location of the combined sewers that receive wastewater and surface water in and around properties leads to more flooding. For example, the formation of more partial or full blockages leading to flooding. Proportionally flooding occurs significantly more from combined sewers compared with fouls sewers, compared with our combined sewer and foul sewer percentage spilt.

The below diagrams (Figure 2.4 and Figure 2.5) show analysis across Yorkshire Water's Drainage Area Zones (DAZ) on the link between ISF performance and percentage combined sewers. They demonstrate that we do observe a correlation between these factors.

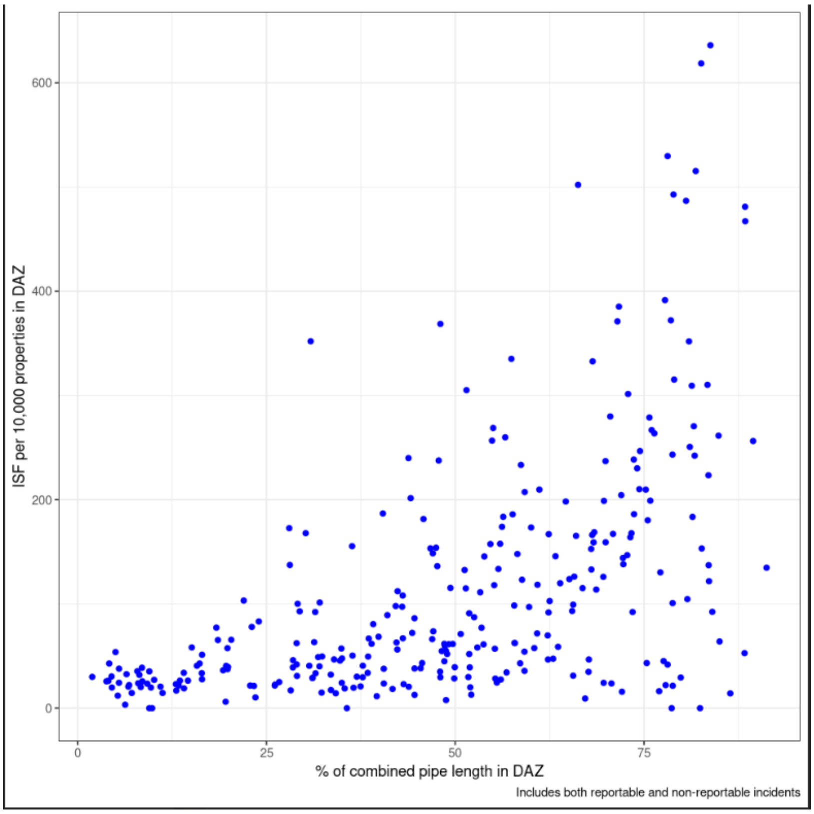

Figure 2.4 Combined Sewers v Internal Sewer Flooding in each YW Drainage Area Zone

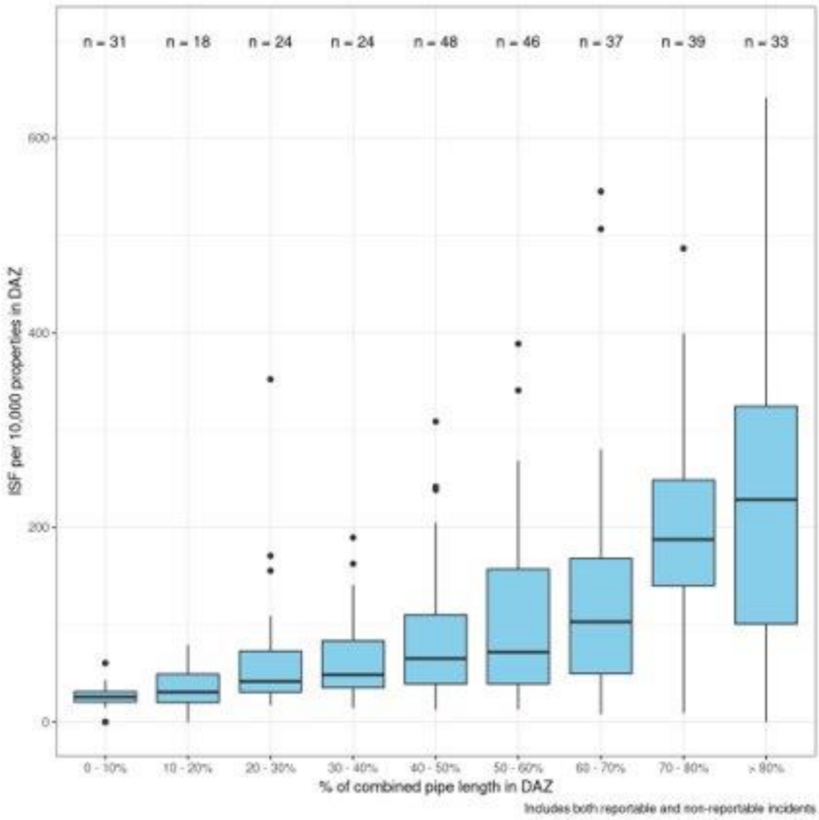

Figure 2.5 YW Combined Sewers v Internal Sewer Flooding Further Analysis

Several companies submitted models that control for combined sewers as a cost driver in the PR24 modelling consultation. However, Ofwat assessed that its inclusion could 'perversely incentivise companies not to separate sewers into surface water and foul'.[10] Therefore, Ofwat prefers to use another cost driver, namely urban rainfall, and argues that it captures a similar impact while qualifying it as being more exogenous in nature.

Ofwat's arguments for exclusion of combined sewers are incorrect as (i.) Companies cannot influence their asset base in the short run. (ii.) Urban rainfall is not a substitute driver for combined sewers to explain sewage flooding, storm overflow performance and costs. Each driver captures a different characteristic (i.e. the inclusion of urban rainfall in the cost models does not preclude the inclusion of combined sewers as an additional driver).

On the first point, Ofwat uses 'asset-based' cost drivers across its modelling suite, where companies have some control of the driver in the long run but not in the short run, including:

- the length of the water network in Ofwat's TWD models;
- the length of the sewer network in Ofwat's SWC and WNPW models.

We consider Ofwat's argument that companies may be incentivised to invest in combined sewers to receive higher cost allowances to be unrealistic. In the current context, combined sewers are associated with higher costs, yet these high costs are not reflected when setting cost allowances. Therefore, if combined sewers were indeed endogenous in the short run, companies would have had strong incentives to reduce the percentage of combined sewers of their asset base in order to perform better in the cost assessment models.

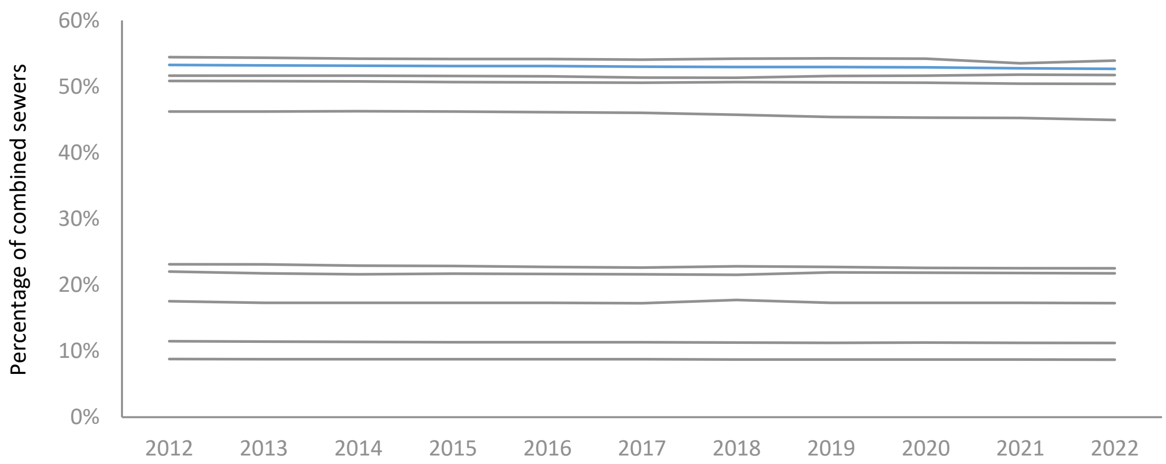

Figure 2.6 below shows how the proportion of combined sewers has evolved in the modelling period (2012–22).

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[10] 'Econometric base cost models for PR24' Ofwat. April 2023. p. 45.

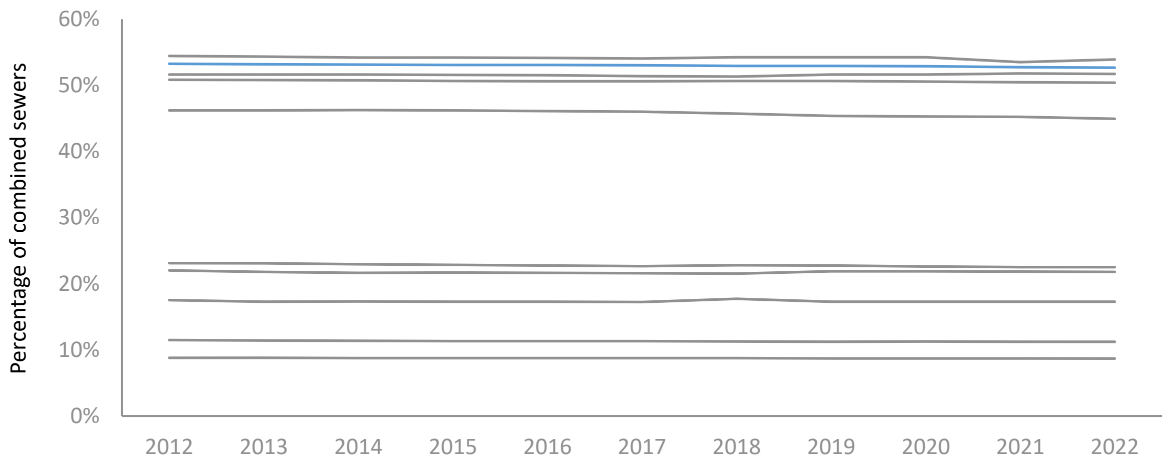


Figure 2.6 Evolution of the percentage of combined sewers over time

Note: YWS is highlighted in blue.

Source: Oxera analysis.

The evolution of the percentage of combined sewers in the last eleven years of available data is very small, with 8 of the 10 wastewater companies showing a change smaller than one percentage point in this ten-year period. Therefore, the extent to which companies will have any substantial control (and, by implication, the extent to which the models may lead to perverse incentives) is limited.[11]

The stability of combined sewers levels is not a choice for companies as replacing combined sewers with separate systems piecemeal is not an option. Large proportions of a network would need redesigning and replacing at once or in substantial stages – over multiple AMPs. If we have a collapsed combined sewer, it cannot just be replaced with a separated sewer, it needs to match with the surrounding sewers, which are likely combined.

The new obligations and performance commitment related to spill frequency provide companies with further incentives not to increase the lengths of combined sewers. Companies are investing significantly to keep water out of the network as a primary option (through SUDs etc.) rather than extending the combined sewer network and creating additional challenges to downstream compliance.

We typically invest in smaller lengths of the higher risk sewers and as we are not redesigning whole sewerage systems, it would also not be economic or in customers interests for us to do so.

[11] Note that we are exploring alternative methods of assessing the hypothesised endogeneity of combined sewers, such as formal statistical tests.

On the second point, Ofwat argues that the inclusion of other cost drivers, such as urban rainfall, has a similar impact to the inclusion of percentage of combined sewers. [12] The rationale behind Ofwat's argument is not clear, but we consider that Ofwat may have applied the following logic.

1. Combined sewers are more prone to sewer flooding. As such, the costs associated with having combined sewers are typically related to dealing with sewer flooding.
2. Urban rainfall is also intended to capture (among other things) the costs relating to sewer flooding.
3. As there is already a cost driver that captures a characteristic that leads to increased sewer flooding (urban rainfall), there is no need to include another cost driver that also captures costs associated with increased sewer flooding (combined sewers).

This line of reasoning is incorrect. The observation that urban rainfall increases sewer flooding says nothing about whether combined sewers also increase sewer flooding — the two cost drivers are not intrinsically related to each other, nor can they be treated as proxies or substitutes. Two companies that operate in a region with similar urban rainfall may experience different levels of sewer flooding depending on the composition of their assets (e.g. the number of combined sewers). Similarly, two companies that operate a similar composition of assets may experience different levels of sewer flooding depending on the level of urban rainfall. We note that, Ofwat controlled for both population density and STW size in its bioresources models at PR19, despite the fact that both cost drivers were intended to capture different aspects of the cost-impact of STW-level economies of scale.[13]

We also noted in our base cost consultation response Ofwat's comment that the 'variable does not take into account that the volume of rainfall may differ within a company's operating area'. This is crucial in our understanding of the risks of escapes in our region. As seen previously in Figure 2.2 it is the west of the region where we experience the greatest service issues and this is where we have significantly higher daily rainfall. The east of our region performs relatively well but is much more sparsely populated and much drier.

We believe that Ofwat's urban rainfall driver could be improved to be more granular to capture where the rainfall occurs and to effectively account for the size of surface connected to each sewer and hence the additional flow carried.

[12] 'Econometric base cost models for PR24' Ofwat. April 2023. p. 45.

[13] See Ofwat (2019), 'PR19 final determinations: Securing cost efficiency technical appendix', December, Table A2.2. Note that Ofwat has presented similar models as part of the PR24 modelling consultation. See Ofwat (2023), 'Econometric base cost models for PR24', April, Table 7.15.

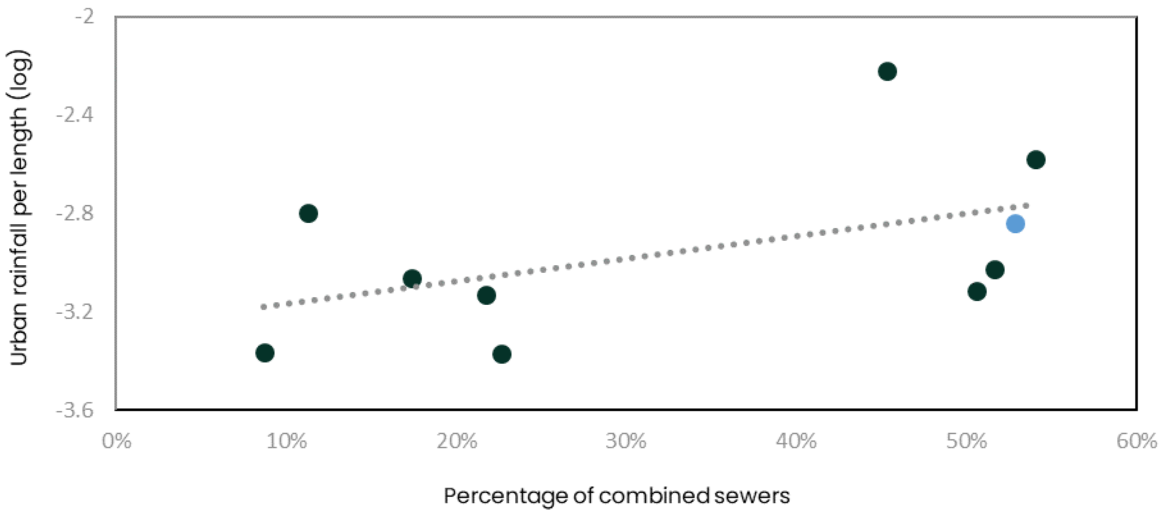


Figure 2.7 below shows the correlation between urban rainfall and combined sewers in the last five years.

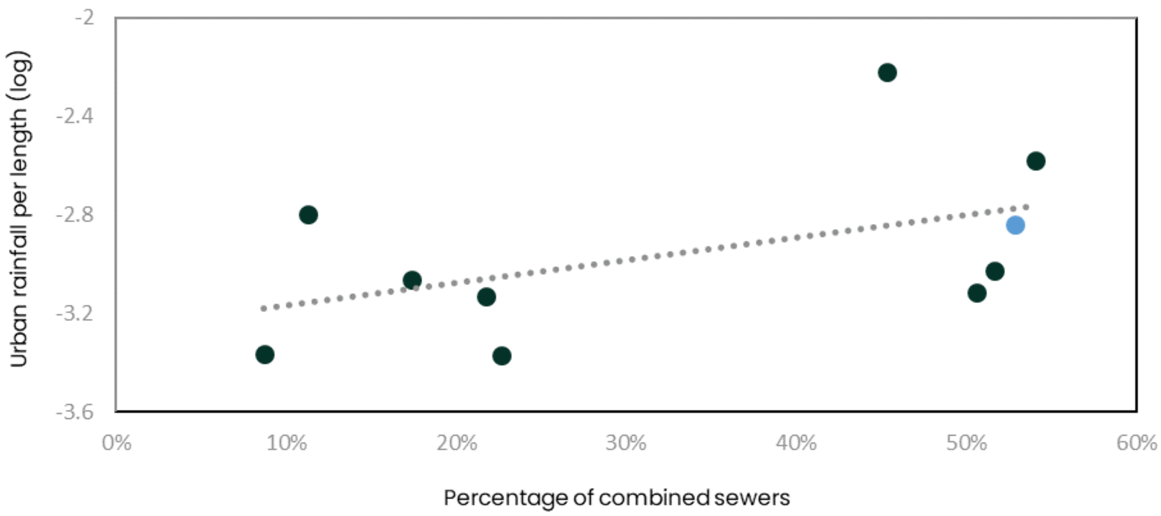


Figure 2.7 Relationship between percentage of combined sewers and urban rainfall

Note: The dots represent each company's average for the last five years of data. YWS is shown in blue. The trendline is shown in a dotted grey line.
Source: Oxera analysis.

The chart shows that urban rainfall and combined sewers should not be seen as substitute cost drivers. Although there is a correlation between the two drivers, urban rainfall does not perfectly capture all of the differences between companies with respect to combined sewers (in other words, the correlation is 'noisy' and imprecise, even ignoring the limitations of a simple correlation analysis). Therefore, the omission of one driver could lead to biased estimations.

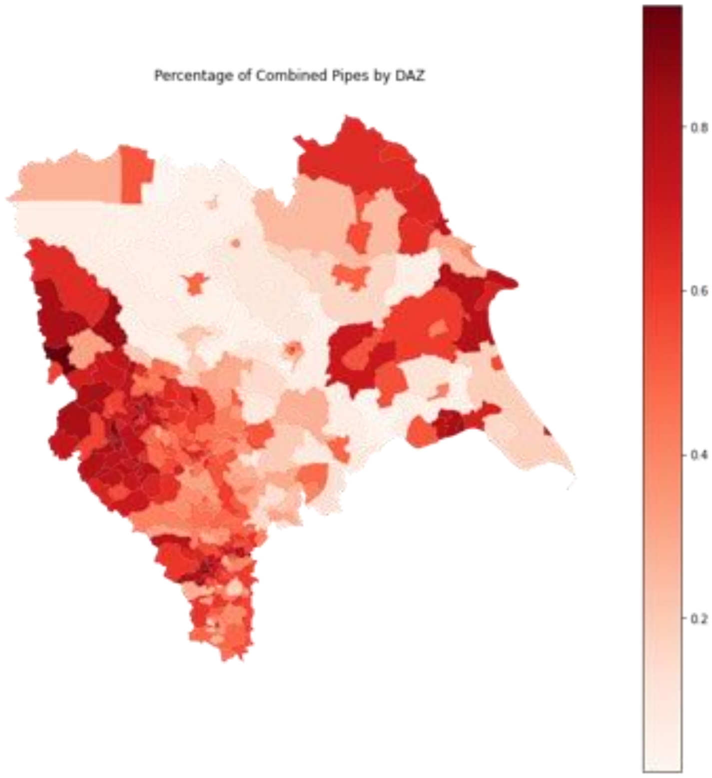


Figure 2.8 Percentage of Combined Pipes by DAZ

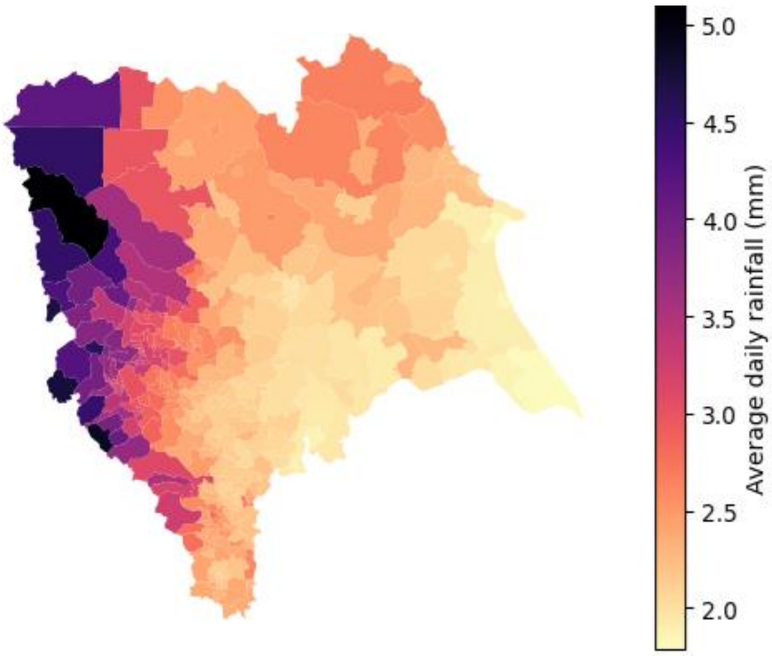


Figure 2.9 Rainfall by DAZ (01.01.2020-31.03.2023)

Visually this can be seen in Figure 2.8 and Figure 2.9 above where it is the combination of combined sewers and rainfall location within the region that drive the service issues represented in Figure 2.2.

2.4. Why is an adjustment required?

Figure 2.10 shows the percentage of combined sewers for each of the companies offering the wholesale wastewater service. YWS stands out second in the industry with c. 53% of combined sewers, behind NWT with 54%. In contrast, the industry average is c. 34%. This implies that YWS's percentage of combined sewers is around 20 percentage points above the average.

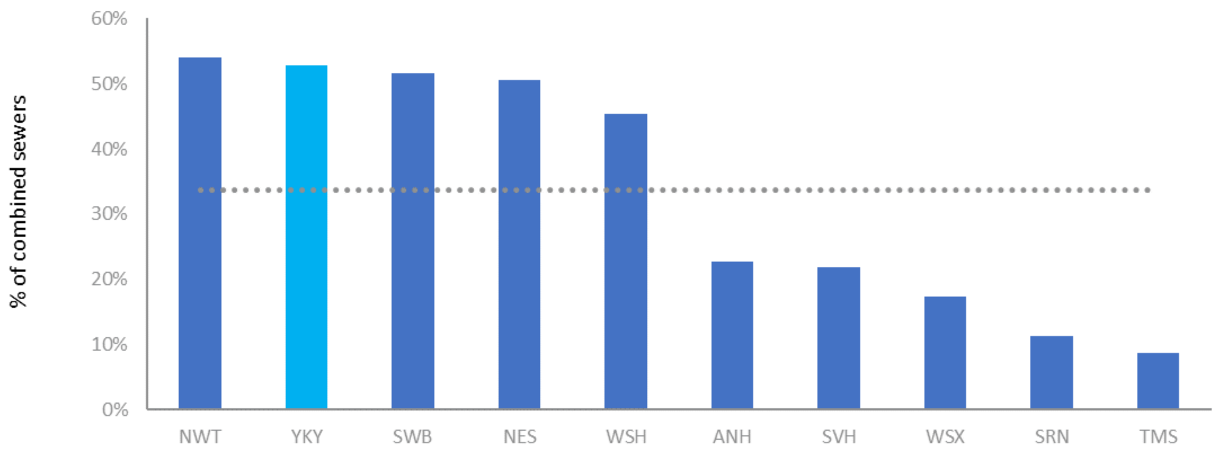


Figure 2.10 Industry proportion of combined sewers (legacy assets) Note: The chart shows the average percentage of combined sewers for each company in the last five years (2018–22). The industry average is shown in a dotted grey line.
Source: Oxera analysis.

We have used legacy assets to develop these percentage values. We do not have industry data to estimate the splits between combined, foul and surface water for adopted assets and hence we believe the most appropriate assumption is to assume the splits across legacy assets are proportional across the whole sewer asset base.

We believe the combination of a nationally available, accepted data set, industry level analysis and internal YW evidence alongside the economic rationale set out in section 2.6 mean that *% Combined Sewers* is the most appropriate factor to include in a Cost Adjustment Claim at this stage.

2.5. Cost Efficiency

Yorkshire water has optimised and invested significantly in recent years in order to maintain and improve internal sewer flooding. We are confident that, whilst we can continue to improve, we are not doing anything substantially different to the rest of the industry. It is the exogenous factors discussed above that explain our cost (and performance) positions.

We describe below some of the initiatives and investment we have undertaken to drive service improvements in recent years.

As part of our plan to improve sewer flooding performance from AMP6 to AMP7, we developed processes to reduce internal flooding other causes in discrete, higher risk zones across our region (e.g. targeting cellared properties for internal sewer flooding) as well as significantly increasing proactive sewer network investigation CCTV and increasing repair programmes of work supported by the introduction of larger scale defects rectification programmes for more complex solutions.

The Company insourced all non-civils work into the business in May 2019 and also at that time purchased additional vans, CCTV units and tankers; this allowed us to spend longer investigating individual jobs, therefore providing a better-quality service with more detailed investigations meaning improved raising of follow-on work, which in turn leads to less re-work.

During AMP7 we have engaged with multiple WASCs including Northumbrian Water, United Utilities and Severn Trent to identify commonalities in driving improvements in operational efficiency; learning that we are implementing many similar initiatives.

Key activities implemented throughout AMP7[14] include:

- Elimination at source:
    - Increased proactive programme of work (Sewer Maintenance Programme, SMP), including improved targeting of this programme to prevent initial flooding incidents occurring
    - Installation of circa 40,000 Customer Sewer Alarms by 2025 (22,000 already installed by May 2023), to provide alerts on the formation of blockages which can then be resolved prior to any impacting flooding incidents
    - Dedicated customer campaigns and focus on education via the network protection team (including for example visiting all Food Service Establishments (FSEs) in Yorkshire's high-risk areas)
- Enhanced initial response:
    - Focus on initial action following notification of a flooding incident, response times to customers have improved significantly.
    - Restructuring our customer field services flooding teams to give more dedicated focus where required
    - Improved tracking of key metrics including process reviews and competency levels.
- Reduction in repeat incidents:
    - Dedicated hubs supported by dynamic data to allow increased scrutiny of incidents and quicker resolution

[14] See YW's APR assurance documentation on Sewer Flooding (2020-2023)

- Escape Report Assurance process implemented which again improves the length of time it takes to resolve incidents and therefore minimised repeats
- Management information & governance
    - Escape Optimisation Engineers giving training roadshows for operational colleagues, to improve competence around sewer flooding and data capture
    - Continued improvement of regular reporting processes from the Sewer Flooding Team and Data Science to ensure standardised information to every level of the business from practitioner to director level.

Overall, the improvements made over the last three years have been delivered through sustained, coordinated efforts across the business and with our service partner, Avove. We continue to drive additional improvements through further optimisation of all the above, along with our ongoing transformational approach (Wastewater Networks 2.0) and further reduction of private demand, to enable reinvestment/targeting of resources to proactive activities and improving first time response.

2.6. Cost Efficiency – Empirical analysis

As Ofwat's base modelling consultation dataset contains data on combined sewers, the net value of the CAC can be estimated by comparing YW's cost allowance under Ofwat's PR24 models to YW's cost allowance under models that control for combined sewers. The most straightforward approach is to compute the implicit allowance as YW's allowance under Ofwat's PR24 models, and the gross value of the claim as YW's allowance under alternative models that account for combined sewers.

The table below shows how Ofwat's SWC models perform when combined sewers is included as an additional cost driver.

	SWC1	SWC2	SWC3	SWC4	SWC5	SWC6
Dependent variable						
Sewer length (log)	0.875***	0.973***	0.952***	0.888***	0.960***	0.941***
	(0)	(0)	(0)	(0)	(0)	(0)
Pumping capacity per length (log)	0.432***	0.714***	0.669***	0.423***	0.672***	0.625***
	(0.000841)	(1.46e-06)	(1.13e-06)	(0.00711)	(0.000110)	(0.000211)
Density (log)	1.050***			0.993***		
	(3.93e-06)			(0.000116)		
WAD MSOA to LAD population (log)		0.260***			0.277***	
		(0.00463)			(0.000573)	

WAD MSOA population (log)			0.424***			0.445***
			(0.000398)			(6.61e-05)
Urban rainfall per length (log)				0.0983***	0.134***	0.130***
				(0.000962)	(0.00176)	(0.00225)
Percentage of combined sewers	0.335***	0.580***	0.609***	0.239*	0.451*	0.483*
	(0.00179)	(0.00275)	(0.00140)	(0.0762)	(0.0786)	(0.0532)
Constant	-8.903***	-8.131***	-9.374***	-8.507***	-7.652***	-8.962***
	(0)	(0)	(0)	(0)	(9.40e-09)	(4.72e-09)
Model fit	0.924	0.912	0.915	0.922	0.920	0.921
VIF	3.072	2.313	2.358	3.074	2.359	2.393
Observations	110	110	110	110	110	110

Table 2.2 PR24 models for sewage collection with the introduction of combined sewers and associated efficient allowances

Note: ***, **, * indicate statistical significance at the 0.01, 0.05 and 0.1 levels. The VIF has been computed using OLS with the same specification.

Source: Oxera analysis.

The inclusion of combined sewers increases the model fit in all six SWC specifications, with the improvement ranging from 0.3 percentage points to 2.6 percentage points. Moreover, the coefficient on combined sewers is positive in all specifications, statistically significant at the 1% level in models SWC1–SWC3, and statistically significant at the 10% level in models SWC4–SWC6.

Note that models SWC4–SWC6 include urban rainfall, which Ofwat argued captured a similar effect in the models. Nevertheless, the coefficient on combined sewers is still statistically significant in all three of the models. Moreover, the VIF statistic (Ofwat's preferred measure of multicollinearity) for these models is always below three (and materially below Ofwat's threshold of 10), pointing to little collinearity among the independent variables. As such, the empirical evidence suggests that combined sewers and urban rainfall capture different operational characteristics.

The table below shows the equivalent analysis for Ofwat's network plus (WWN+) models.

	WWN+1	WWN+ 2	WWN+ 3	WWN+ 4	WWN+ 5	WWN+ 6	WWN+7	WWN+8
Dependent variable								
Load (log)	0.723***	0.819***	0.833***	0.775***	0.706***	0.802***	0.820***	0.764***
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Pumping capacity per	0.462***	0.491***	0.478***	0.392***	0.430***	0.461***	0.446***	0.350***
	(0)	(0)	(0)	(0)	(5.24e-09)	(0)	(0)	(5.72e-09)

length (log)								
pctbands13		0.0226***				0.0231***		
		(2.52e-05)				(0.000237)		
pctnh3below3mg	0.00473***	0.00435***	0.00453***	0.00493***	0.00496***	0.00466***	0.00481***	0.00521***
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Percentage of load treated at works with a population equivalent >=100,000			-0.0044***				-0.0046***	
			(6.01e-07)				(2.87e-05)	
WATS (log)				-0.0773***				-0.0862***
				(2.19e-07)				(2.34e-05)
Urban rainfall per length (log)					0.0589**	0.0545***	0.0605**	0.0671**
					(0.0190)	(0.00982)	(0.0261)	(0.0218)
Percentage of combined sewers	0.366***	0.395***	0.461***	0.344***	0.289***	0.322***	0.386***	0.255***
	(0.000263)	(9.50e-06)	(2.08e-10)	(2.37e-05)	(0.00157)	(2.18e-06)	(8.14e-07)	(0.00120)
Constant	-4.106***	-5.427***	-5.300***	-3.991***	-3.690***	-5.026***	-4.917***	-3.525***
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Model fit	0.960	0.967	0.967	0.966	0.960	0.967	0.968	0.968
VIF	4.669	6.131	6.722	4.855	5.035	6.429	6.882	5.114
Observations	110	110	110	110	110	110	110	110

Table 2.3 PR24 models for wholesale wastewater network plus with the introduction of combined sewers and associated efficient allowances

Note: ***, **, * indicate statistical significance at the 0.01, 0.05 and 0.1 levels. The VIF has been computed using OLS with the same specification.
Source: Oxera analysis.

Including combined sewers as a cost driver in the WWN+ models generally leads to an improvement in model quality. First, its inclusion increases the model fit across specifications. Moreover, the coefficient is highly significant in all of the models: the coefficient is significant at the 1% level in the eight models.

This is also the case in the models that already account for urban rainfall (WWN+5 – WWN+8).

Similarly, the VIF statistic is still materially below Ofwat's threshold of 10. This suggests that urban rainfall should not be considered as a substitute to combined sewers. There is no compelling evidence to suggest that either combined sewers is endogenous or that it is not a relevant driver of costs in additional to rainfall.

The table below shows how YW's allowance under models with and without combined sewers as a cost driver.

	PR24 models (£m p.a.)	PR24 models with combined sewers (£m p.a.)	Difference (£m p.a.)
YWS's estimated allowances	328	344	**15.5**

Table 2.4 YW's yearly average estimated allowances for AMP8

Note: Allowances are presented in 2022/23 prices. The allowances estimated using the PR24 models with the inclusion of combined sewers constitutes the gross value of the claim. We subtract allowances associated with the PR24 models and the difference of £15.5m corresponds to the net value of the claim.
Source: Oxera analysis.

Ofwat's PR24 consultation models predict YW's cost allowance to be c. £328m p.a. in AMP8. The inclusion of combined sewers in the SWC and WWN+ models increases YW's predicted allowance to c. £344m p.a., an average increase of c. £15.5m p.a. Therefore, the analysis indicates that the net value of the CAC relating to combined sewers is c. £15.5m p.a.

2.7. Claim Value and Materiality

Combined sewers is a material driver of expenditure that Ofwat has omitted from its PR24 consultation models. The driver is sufficiently exogenous in the short-term to pass Ofwat's exogeneity criterion, and its inclusion in the cost assessment models leads to an improvement in the statistical quality of the models across a range of metrics. As such, Ofwat should consider including combined sewers in its cost assessment models at PR24.

On the basis of the current evidence, we estimate the net value of the CAC to be c**. £15.5m** p.a. in AMP8, or **£77.5m** over the full AMP. This will clearly meet Ofwat's materiality criteria for WWN+ which was £25m for the whole period at PR19.

2.8. Symmetrical Adjustments

As this CAC relates to an omission in Ofwat's cost models, we consider an appropriate solution is for Ofwat to amend its PR24 models to account for combined sewers.

The table below shows the impact of including combined sewers in Ofwat's models on companies' allowances on an outturn basis, based on cost predictions in the last five years (2018–22).

	Gross value of the claim	Implicit allowance	Net value of the claim
ANH	£1,781m	£1,798m	-£18m
NES	£838m	£824m	£15m
NWT	£2,347m	£2,191m	£156m
SRN	£1,645m	£1,668m	-£23m
SVH	£2,248m	£2,297m	-£49m
SWB	£706m	£698m	£8m
TMS	£3,458m	£3,575m	-£117m
WSH	£1,098m	£1,080m	£18m
WSX	£854m	£919m	-£64m
YKY	£1,639m	£1,562m	£77m

Table 2.5 Symmetrical Adjustments by Company due to this claim

Note: The values are presented in 2022/23 prices. Source: Oxera analysis

2.9. Customer Protection

This claim is not a discrete piece of activity rather an adjustment to the cost modelling so it is therefore not applicable for a customer protection mechanism beyond the existing process of setting appropriate stretching performance commitments and ODIs.

2.10. Data Table Commentary

	Title	Commentary
CWW18.1	Description of cost adjustment claim	This claim is due to the non-inclusion of a combined sewers variable in the base cost modelling.
CWW18.2	Type of cost adjustment claim	This claim is related to a regional operating circumstance.
CWW18.3	Symmetrical or non-symmetrical	Symmetrical
CWW18.4	Reference to business plan supporting evidence	Refers to this document as this is the Early submission.
CWW18.5	Total Gross Value of Claim	We have used totals identified through the modelling and split these costs across the SWC value chain using the average splits across YW's last 7 APRs
CWW18.6	Implicit Allowance	We have not included an implicit allowance as the value of the claim has been derived from the difference between models including and excluding the % combined sewer driver so already excludes implicit allowance.
CWW18.7	Total Net Value of Claim	Calculated from above two lines
CWW18.8	Historic Base Expenditure	We have used our modelling to estimate historic implicit combined sewer allowances from 2012-2022. See Appendix 2. We have used the net values from this to populate the 'historic total expenditure' in the CWW18 data table and split the costs across the value chain using a) the in-year value chain split as reported in APR or b) the average value chain split for 2016-2022 if a is not available (or is a forecast cost).
CWW18.9	Totex for the control	We are not required to populate Totex value but identify that the claim sits in the WWN+ price control.
CWW18.10	Materiality	N/A We note that the size of the claim is significantly higher than 1% of WWN+ Totex historically.

Table 2.6 CWW18 - Cost Adjustment Claim 2 Commentary

3 – Capital Maintenance Challenges

We have highlighted throughout the PR19 and PR24 engagement processes that we do not believe the current base cost modelling approach appropriately allows for companies to maintain assets into the long-term, particularly when combined with policy decisions on performance targets, efficiency assumptions and investor returns.

We provide narrative developed with Oxera in Appendix 3 which sets out our concerns with the current approach to base modelling, and the need for a change in approach to capital maintenance.

We believe a wider conversation is required between Ofwat and the industry to address the concerns on long-term asset maintenance, the risks to service and how to give efficient allowances to companies. The current cost adjustment claim guidance and approach does not allow for the full scope of this discussion to take place.

That said, in building our plan, we have identified several areas where an increase in base cost allowances is required to maintain long-term sustainable service and drive incremental improvements. This is particularly notable in the areas of network capital maintenance and metering.

We do not include cost adjustment claims for these areas at this stage as we are still developing our strategies for the activity whilst trying to align the affordability and deliverability of our plan in-the-round.

At this stage the uncertainty around the scale of investment we will be proposing in our plan and the most efficient solution (e.g. we are exploring market options for delivering our metering strategy) means that we cannot provide the evidence required to meet Ofwat's CAC requirements for the early submission. Once final programme decisions are made, we may still include claims for these areas alongside our final plan.

We recognise that Ofwat has stated it will treat CACs not captured as part of this process with caution, but as these claims would be forward looking and activity-based we do not anticipate that they would be symmetrical and impact on other companies' allowances.

4 – Inflationary Pressures

We noted in our base cost consultation response that Ofwat has not demonstrated that its cost models fully account for the extreme inflationary pressures that the industry has experienced early in AMP7 on both energy costs and to a lesser, but still material extent, chemicals and material costs.

Companies have been only partially protected from this inflation during AMP7 through indexation to CPIH and the totex sharing mechanism; however, input price inflation has materially departed from CPIH in the last few years, and is expected to follow different trends in AMP8. We believe that the best way to protect companies and customers from fluctuations in energy prices going forward is through a true-up mechanism and intend to propose this in our plan. However, any true-up is only fair if the implicit modelled cost of energy reflects the prices at the time of the determination and we do not believe that the models currently do this (they have been primarily built on data from a period prior to the high input price inflation diluting its true effect).

Based on this we believe that Ofwat's cost models may materially underfund companies at final determination on the basis of real input prices. We attach a discussion paper developed by KPMG with a consortium of companies demonstrating options to address this issue.

Our concern is that the recent high input prices facing the industry could be 'averaged out' with unrepresentative data, such that the implicitly funded input prices are lower than the prices that companies face in the last year of outturn data (from which RPEs and any associated uncertainty mechanisms would be applied).

We note that this may be partially mitigated by the benchmarking approach used to set the catchup efficiency e.g. if Ofwat continues to use the last five years of outturn data to estimate the cost benchmark, then the cost models could 'fund' companies on the basis of the average real input prices faced by companies in that period (rather than the whole modelled period).

However, this may still manifest as a material underfunding of company allowances. An example of how this manifests is seen in the below table below that shows the evolution of real electricity input prices in the modelling period.

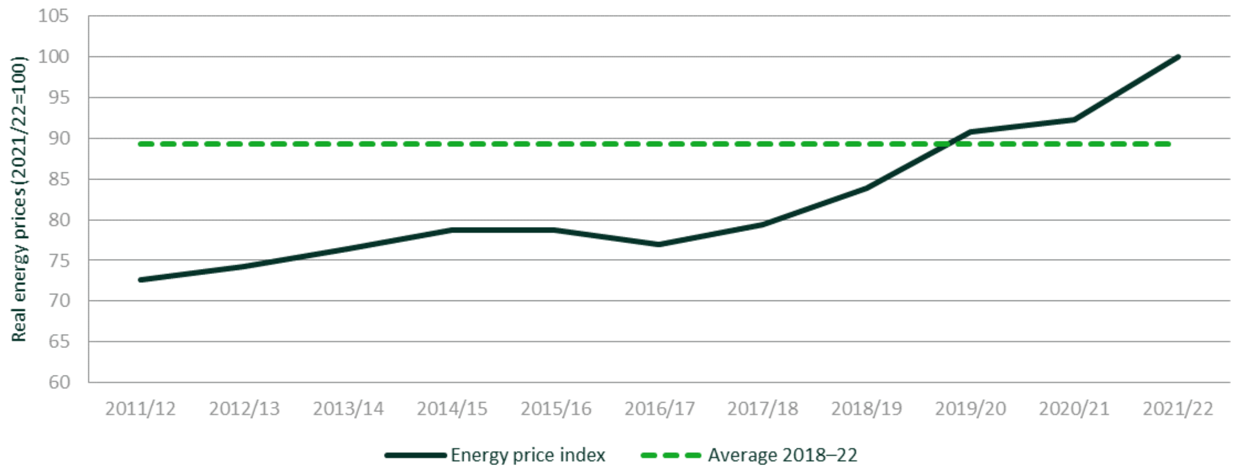


Figure 4.1 Evolution of energy prices in the modelling period

Source: Oxera analysis.

The chart shows that real energy prices have been increasing over the modelling period. Moreover, the average energy price in the last five years of outturn data is c. 10% below the actual real energy price faced by companies in 2021/22. Therefore, if Ofwat were to apply an RPE/adjustment mechanism from 2021/22, it would first have to uplift allowances to reflect the energy prices faced by companies in 2021/22.

Note that energy prices are presented as an example, but the same issue applies to all input prices.

However, as companies are strongly incentivised to spend within their allowances (while meeting service performance commitments), the assumption that actual Totex spend will fully capture the impact of these inputs may be flawed. The overall Totex approach is likely to incentivise companies to divert expenditure away from more expensive, long-term solutions to meet these short-term cost pressures rather than overspending to the level of input price pressures experienced.

We therefore recommend that as a minimum Ofwat should ensure that the 'funded' energy cost should be accounted for when setting the Totex allowance but more appropriately the exogenous factors of input prices should be accounted as a modelling or post-modelling adjustment.

We have not proposed a Cost Adjustment Claim in this area at this stage because of the uncertainty in calculating an appropriate claim value due to our uncertainty of Ofwat's approach to benchmarking combined with the highly volatile and uncertain input prices over the 2022-2024 period.

In addition, this is clearly an issue that impacts all companies rather than YW alone and we feel it is more appropriate for Ofwat to treat it as such.

Appendix 1 – Phosphorus Removal Empirical Analysis (Oxera)

A direct method to calculate the CAC would be to include a cost driver reflecting P-removal activities in Ofwat's PR24 consultation models. However, as Ofwat noted in the consultation, cost drivers that can account for P-removal activity do not perform well in the cost models—the cost drivers are typically statistically insignificant. As indicated above, this is likely due to the lack of historical variation in P-removal activity across the industry.[15]

Given the limitations of the current base modelling dataset, we consider alternative sources of evidence to estimate the P-removal CAC as follows.

- STW-level modelling based on APR tables 7F. Companies are required to report data at the treatment-plant level regarding the expected incremental costs (OPEX and CAPEX) associated with increasing P-removal activity for affected treatment plants. This data can be used to estimate the relationship between costs and P-removal activity at the treatment-plant level, which can then be aggregated to a company-level adjustment.
- STW-level modelling based on APR tables 7B. Companies are required to report data at the treatment-plant level relating to costs, scale (load) and treatment complexity for large treatment plants. This dataset can be used to estimate the relationship between costs and treatment complexity. Unlike the dataset in point one above (which only captures STWs that are experiencing increases in P-removal activity), this dataset can also be used to estimate the relative costs of P-removal and ammonia-removal (and other complexity measures).
- Company-level modelling. The insights from modelling option two can also be used to construct a composite complexity variable, defined as the weighted sum of P-removal and ammonia-removal complexity, where the weights are determined through the relative cost impact of different complexity variables.

These three methods are discussed in more detail in the sub-sections below.

STW-level modelling based on APR tables 7F

In Table 7F of companies' APRs, companies are required to report cost, load and treatment complexity data for treatment works that are experiencing an increase in P-removal activity.[16] Therefore, this dataset can be used to model the relationship between anticipated expenditure and anticipated P-removal activity.

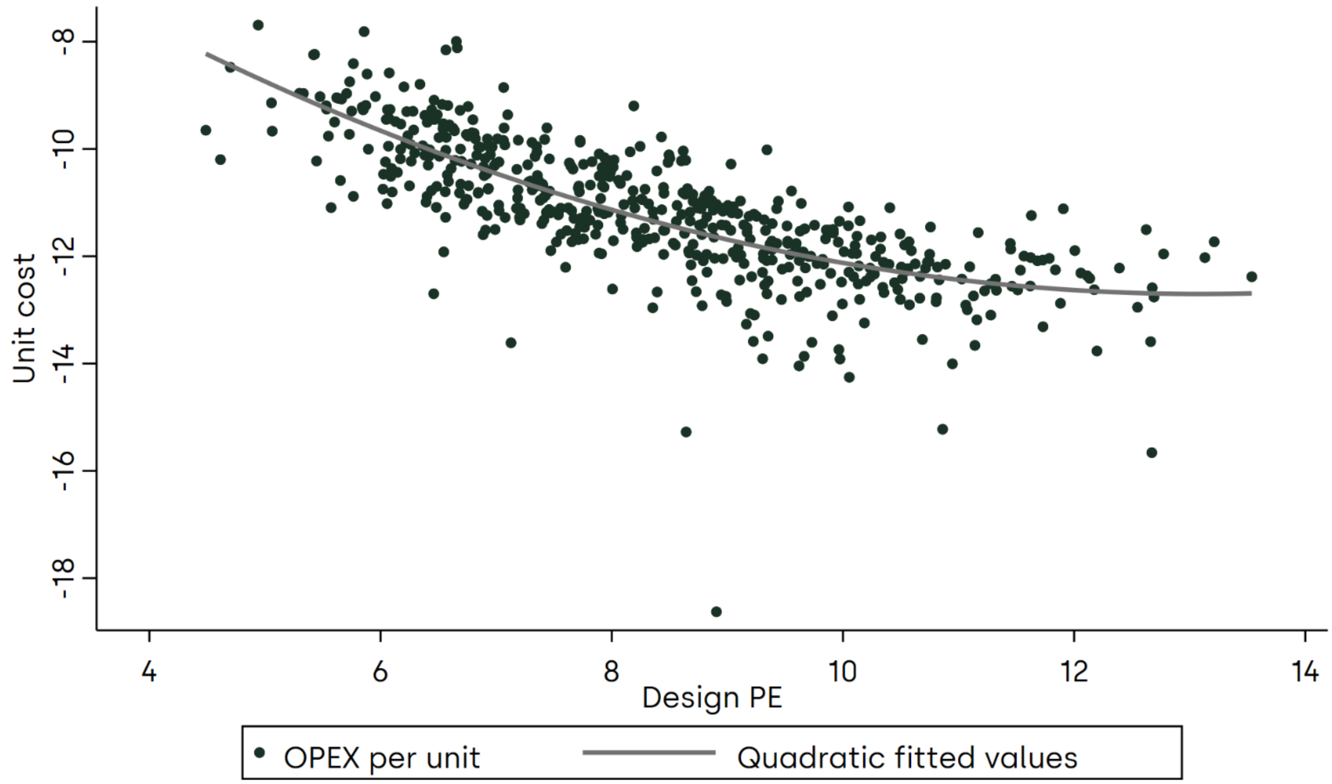
[15] The inability of the models to account for P-removal activity is an empirical problem based on the limitations of the current dataset. These limitations of the dataset may be mitigated once new outturn and business plan data become available at the PR24 determination.

[16] See table 7F in companies' Annual Performance Reports.

To estimate the cost of P-removal for time periods relevant for PR24, we restrict the dataset used in our modelling to the year 2026, the year in which all of the treatment plants are scheduled to have started P-removal activities.[17] In addition, we only include the 535 observations that are associated with positive value for OPEX, and exclude 433 observations that reflect zero or negative OPEX.

Figure A1.1 shows a scatter plot of the unit cost by STW against the size of the STW, as measured by design population equivalent (PE).[18]

Figure A1.1 Economies of scale at the STW level



Note: Unit cost in £ / design PE. Both variables are plotted as natural logarithms.
Source: Oxera analysis of Aggregated APR Table 7F v1.

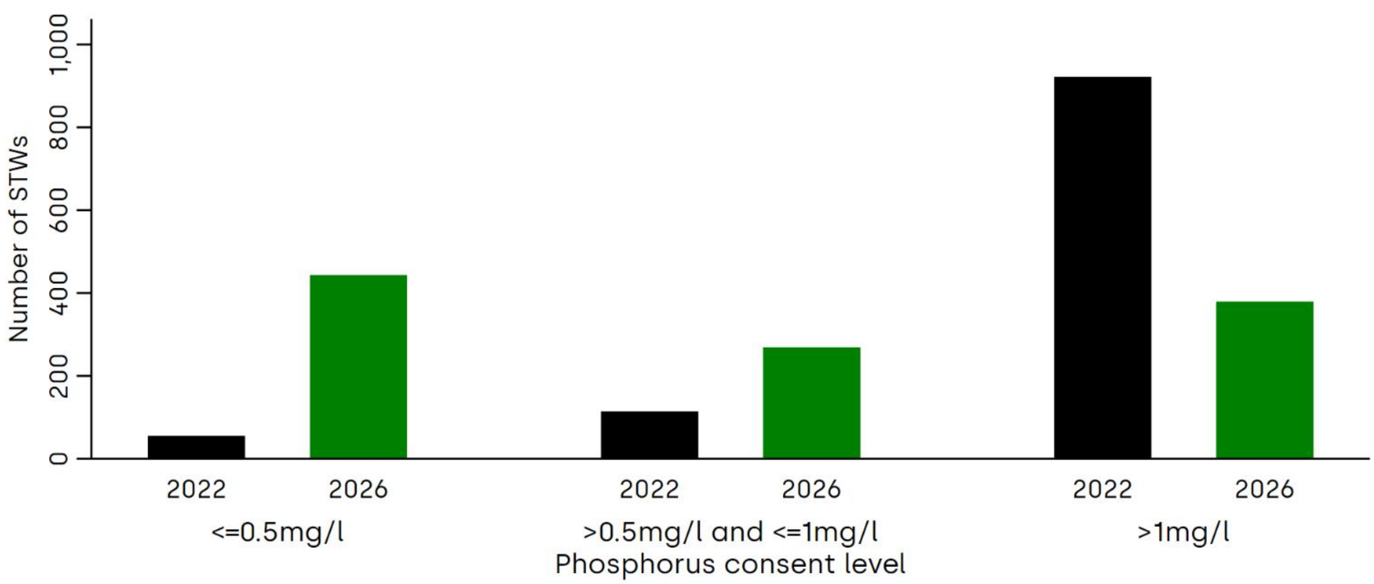
The figure suggests that the unit costs decrease with the size of the plant, implying positive economies of scale. The grey line, reflecting quadratic fitted values, indicates that the economies of

[17] We assume that P-removal activities start in the year of the completion date indicated in the table.
[18] For ease of interpretation, we have modelled the logarithm of the unit costs as a function of the STW size.

scale are decreasing with the size of the plant.[19] We therefore include a linear and a quadratic term of design PE control variables in our models.

We furthermore group STWs into bands of consent levels, based on the current categorisation by Ofwat.[20] Figure A1.2 below presents the distribution of STWs by (projected) phosphorus consent levels in 2022 and in 2026.

Figure A1.2 Distribution of STWs based on phosphorus consent level (comparison 2022 and 2026)



Note: The category >1mg/l includes STW that have no permit.
Source: Oxera analysis of Aggregated APR Tables 7F v1.

[19] This is shown by the fact that the function is convex.

[20] For P-consent, these bands are: below 0.5mg/l, between 0.5mg/l and 1mg/l and above 1mg/l. We include no permit in the category of above 1mg/l. The lower bounds are always exclusive, e.g. > 1mg/l, and the upper bounds are always inclusive, e.g. ≤ 3mg/l. This categorisation is used, for example, in the PR24 Cost Assessment Master Dataset, Wholesale Wastewater Base Costs v4, published in April 2023.

The figure illustrates the shift in P-consent levels, with the number of STWs included in the most stringent category of below 0.5mg/l increasing from 55 to 443, while the number of STWs included in the least-stringent category falls from 922 to 379.[21]

We model unit costs as a function of phosphorus consent levels, controlling for economies of scale. To be able to calculate a CAC from our estimates, our analysis focuses on the comparison of STWs with P-consent levels below 0.5mg/l with STWs with P-consent levels above 0.5mg/l. We use design population equivalent (PE) as the relevant scale variable, which reflects the treatment capacity of STWs in population equivalent load.

The table below shows the results from regressing P-removal unit opex on P-consent level and economies of scale control variables.

Table A1.1 Results from regressing unit costs (P-removal opex/design PE) on P-consent levels and economies of scale control variables

	STW
Design PE	-1.799***
Design PE squared	0.071**
Phosphorus consent ≤ 0.5mg/l	0.414***
Observations	535
Model fit	0.611

Note: All continuous variables enter as natural logarithms. The variables for phosphorus consent is a dummy that takes the value 1, if the P-consent level is above 0.5mg/l, or 0 otherwise. ***, **, * indicate statistical significance at the 1%, 5% and 10% level, respectively, based on standard errors clustered at the company level.
Source: Oxera analysis of Aggregated APR Table 7F v1.

The result indicates that P-consent levels below 0.5mg/l are associated with unit costs that are c. 51.3% higher than unit costs for STWs with less stringent consent levels.[22] This relationship is statistically significant at the 1% level. In addition, the economies of scale control variables have the expected sign, and are statistically significant.

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[21] These numbers only refer to STWs included in the APR tables 7F dataset.

[22] This is calculated from the coefficient (β_1) for phosphorus consent levels below 0.5mg/l (x_1), as follows: $\Delta \log(unit\ cost) = \beta_1 \Delta x_1 \iff \Delta unit\ cost = \exp(\beta_1 \Delta x_1) - 1 \Rightarrow 51.3\% \cong \exp(0.414 * 1) - 1.$

We calculate the gross claim p.a. by predicting YWS's OPEX relating to P-removal activities based on model STW presented above, for the years 2022 and 2026, and then subtract the value for 2022 from the value for 2026. This reflects the estimated additional expenditure required by YWS to meet the more stringent P-consent requirements. Table A1.2 below presents how a net claim value over 5 years can be calculated from this.

Table A1.2 Calculation of Implied Claim value

	Value in £m
Gross claim p.a.	26.9
Net claim p.a	26.4
Net claim over AMP8	132.2

Source: Oxera analysis.

The gross claim p.a. reflects the difference in predicted costs from model STW outlined above. However, some of this gross claim value (c. 1.5%) reflects costs associated with YWS 'catching up' to the level of P-removal that is currently implicitly funded through the models. The net claim p.a. is calculated by multiplying the gross claim value (£26.9m) with the share of the claim going beyond the implicit allowance (98.5%). On the basis of this analysis, the net claim amounts to c. £26.4m p.a., or £132.2m over a five-year period.[23]

We understand that YWS has included costs relating to sludge transport and disposal amounting to £6.4m p.a. in its APR 7F table. The estimate of a claim value of £26.4m p.a. above rests on the assumption that all companies have submitted costs attributable only to the WWN+ cost area.

If we assume that all companies allocated some sludge transport and disposal costs to the relevant P-removal OPEX, and that the proportion of the OPEX included in the APR 7F tables resulting from this is the same for all companies, a conservative lower bound for the claim value can be estimated. We understand that YWS's bottom up estimate of the average OPEX p.a. relating to P-removal in PR24 is £21.9m, or 77.3% of the submitted costs of £28.4m p.a. Multiplying the upper bound claim value of £26.4m p.a. by this factor results in a lower bound claim value of £20.4m p.a., corresponding to a claim value of £102.0m over AMP8.

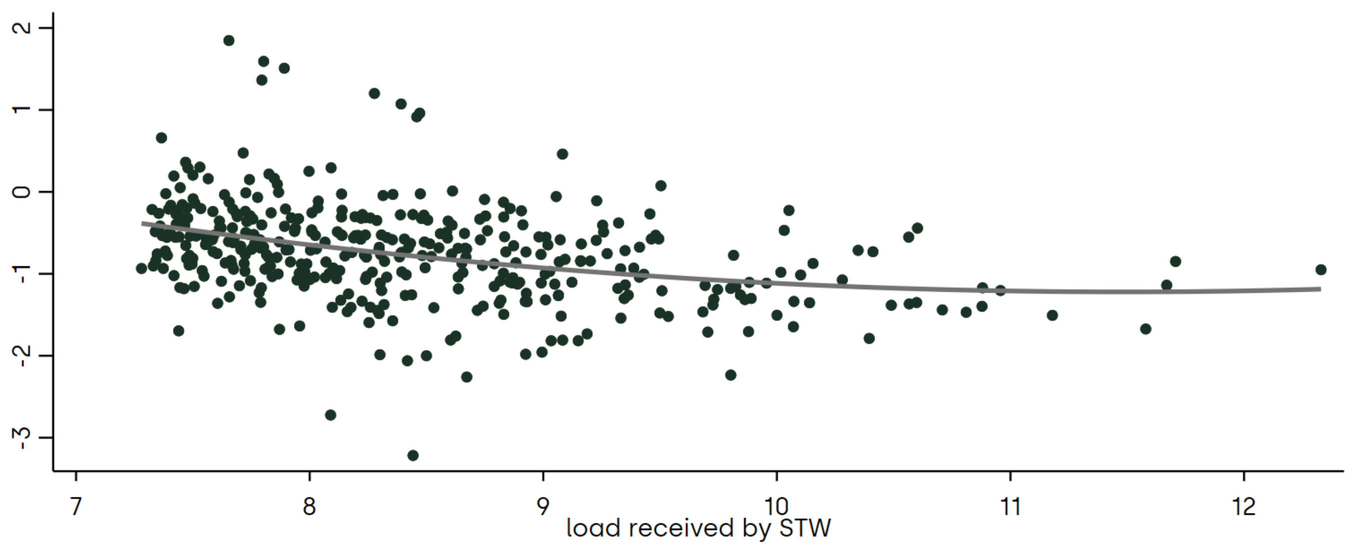
[23] Our populated data tables show the gross value, the implicit allowance and the net value of the claim by year.

STW-level modelling based on APR tables 7B

To account for treatment complexity in a single composite variable, it is necessary to make assumptions about the relative cost of the treatment activities. In this section, we analyse the relative cost of P-removal and ammonia removal (N-removal) activities at the STW level. As part of this analysis, we regress unit costs on consent levels and economies of scale control variables. The results allow us to construct a composite complexity variable, based on P-consent and ammonia (N-consent) levels.

As the basis for our analysis, we have compiled a dataset of large STW, including STW-level costs and pollutant consent levels, from section 7B of all wastewater companies' APR tables.[24] The figure below shows a scatter plot of the unit cost by STW against the size of the STW, as measured by the load received.[25]

Figure A1.3 Economies of scale



Note: Unit cost in £/kg BOD5/day. Load received in kg BOD5/day. Grey line reflects a fitted quadratic function.
Source: Oxera analysis of section 7B of 2021-22 Annual performance report tables.

[24] 2021-22 Annual performance report tables.

[25] For ease of interpretation, we have modelled the logarithm of the unit costs as a function of the STW size.

The figure suggests that the unit cost decreases with the size of the plant, implying positive economies of scale. The grey line reflects the fitted values of a regression of unit costs on load received, as well as squared load received. It indicates that the economies of scale are decreasing with the size of the plant.[26] As in the previous section, we therefore include a linear and a quadratic term of load received as control variables in our models.[27]

We use other direct expenditure, and total expenditure, as measures to calculate the relevant unit cost, which we estimate in our models. Although we would generally expect the cost of P-removal activities to be accounted for under other direct expenditure, we also use total expenditure, since this measure is more closely aligned with Ofwat's definition of modelled base costs. In addition, this approach may help to prevent potential issues arising from cost misallocation.

Moreover, we estimate models excluding and including company-specific effects.[28] While company-specific effects can potentially capture some of the effect of varying consent levels, they also capture company-level inefficiencies and other unobserved factors that affect unit costs. This allows for more precise estimates of the unit costs, thereby potentially improving statistical power.[29]

We explore three different specifications, as follows.

- STW1 reflects a regression of unit costs, measured by other direct expenditure, on a dummy variable for P-consent below 0.5mg/l, a dummy variable for N-consent below 3.0mg/l, and controls for economies of scale.
- STW2 is equivalent to STW1, but also controls for company-specific effects.
- STW3 is equivalent to STW1, but uses total expenditure as the dependent variable.
- STW4 is equivalent to STW3, but also controls for company-specific effects.

Table A1.3 presents the results of the models described above.

[26] This is shown by the fact that the function is convex.

[27] Note that Ofwat has proposed controlling for the proportion of load treated at different size bands in the PR24 modelling consultation. There is no equivalent measure of economies of scale when models are estimated at the STW level. See Ofwat (2023), 'Econometric base cost models for PR24', April, appendix A4.

[28] Here, company-specific effects are modelled by including company-specific dummy variables (e.g. a dummy variable equal to 1 if the STW belongs to Yorkshire Water and 0 otherwise, another dummy variable equal to 1 if the STW belongs to Anglian Water and 0 otherwise, etc.).

[29] Some companies have higher average consent levels for certain pollutants than others, the variables are thus correlated.

Table A1.3 Results from regressing unit costs on p- and a-consent levels

	STW1	STW2	STW3	STW4
Dependent variable (expenditure)	Other direct	Other direct	Total	Total
Load received by STW	-1.036***	-1.032***	-1.028***	-0.917***
Load received by STW squared	0.0460**	0.0431***	0.0436**	0.0370**
Phosphorus consent ≤ 0.5 mg/l	0.0861	0.177*	0.150**	0.181**
Ammonia consent ≤ 3mg/l	0.176***	0.0772	0.108*	0.0658
Company-specific effects	No	Yes	No	Yes
Observations	397	397	397	397
Model fit	0.129	0.254	0.147	0.278

Note: All continuous variables enter as natural logarithms. The variables included under 'phosphorus consent' and 'ammonia consent' are dummy variables that either take the value of 1, if the consent level falls into the specified range, or 0 if it does not; STWs without a permit for the relevant pollutant are included in the highest consent level. ***, **, * indicate statistical significance at the 1%, 5% and 10% level, respectively, based on robust standard errors.
Source: Oxera analysis of section 7B of 2021-22 Annual performance report tables.

The coefficients associated with strict P-consent and N-consent levels in all models are positive, indicating that strict levels are associated with higher costs. The coefficient associated with P-removal is statistically significant in models STW2, STW3 and STW4, at the 10% level in STW2 and the 5% level in the other two models. The coefficient associated with N-removal is statistically significant in models STW1 and STW3, at the 1% level and the 10%-level, respectively. We also note that the economies of scale control variables have the expected sign, and are statistically significant.

To derive estimates of the relative cost of P- and N-removal, we calculate the ratio of the coefficient associated with P-removal over the coefficient associated with N-removal.[30] This ratio is 0.59 based on model STW1, 2.41 based on model STW2, 1.42 based on model STW3 and 2.92 based on model STW4.

In summary, the results in above table A1.3 show that P-removal activities are generally associated with higher unit costs, and that these associations are generally statistically significant. However, based on this dataset, we are unable to precisely estimate the relative cost of phosphorus- and ammonia-removal. The estimates range from P-removal being approximately 0.59 as expensive (STW1) to 2.92-times more expensive (STW4) than ammonia-removal. As a conservative estimate,

[30] Note that we first transform logarithmic unit costs into unit costs in levels. All values are approximations.

we currently assume P-removal to be half as expensive when generating the composite complexity variable in the following section.

Company-level modelling

This section describes the impact of including a composite treatment complexity variable in Ofwat's consultation models, instead of a P-removal variable which is solely based on P-removal, and calculates a claim value based on these results. The composite complexity variable is defined as the sum of the percentage of load treated at P-consent levels below 0.5mg/l divided by two, and the percentage of load treated at N-consent levels below 3mg/l. This reflects the assumption that P-removal is half as expensive as N-removal for the relevant consent levels (as a conservative assumptions based on current data and modelling).

The tables below show the regression results for the sewage treatment (SWT) models and network plus (WWN+) models.

Table A1.4 SWT models including composite complexity variable

	SWT1	SWT2	SWT3
Load (log)	0.644***	0.717***	0.783***
Composite treatment complexity	0.006***	0.006***	0.006***
Load treated in size bands 1 to 3 (%)	0.029		
Load treated in STWs ≥ 100,000 people (%)		-0.008***	
Weighted average treatment size (log)			-0.244***
Constant	-3.628***	-3.997***	-2.923***
R-squared	0.854	0.868	0.912
RESET test	0.036	0.209	0.804

Source: Oxera analysis of PR24 Cost Assessment Master Dataset, Wholesale Wastewater Base Costs v4.

Table A1.5 WWN+1-4 models including composite complexity variable

	WWN+1	WWN+2	WWN+3	WWN+4
Load (log)	0.639***	0.720***	0.680***	0.709***
Pumping capacity per sewer length (log)	0.360***	0.373***	0.351***	0.287***
Composite treatment complexity	0.005***	0.005***	0.005***	0.006***
Load treated in size bands 1 to 3 (%)		0.024*		
Load treated in STWs ≥ 100,000 people (%)			-0.002	
Weighted average treatment size (log)				-0.095**
Urban rainfall per sewer length (log)				
Constant	-2.888***	-4.013***	-3.291***	-2.837***
R-squared	0.947	0.952	0.948	0.956
RESET test	0.493	0.394	0.609	0.828

Source: Oxera analysis of PR24 Cost Assessment Master Dataset, Wholesale Wastewater Base Costs v4.

Table A1.6 WWN+5-8 models including composite complexity variable

	WWN+5	WWN+6	WWN+7	WWN+8
Load (log)	0.644***	0.725***	0.701***	0.718***
Pumping capacity per sewer length (log)	0.350***	0.364***	0.341***	0.270***
Composite treatment complexity	0.005***	0.005***	0.005***	0.006***
Load treated in size bands 1 to 3 (%)		0.023**		
Load treated in STWs ≥ 100,000 people (%)			-0.003*	
Weighted average treatment size (log)				-0.098***
Urban rainfall per sewer length (log)	0.074**	0.076**	0.079**	0.087**
Constant	-2.730***	-3.851***	-3.277***	-2.664***
R-squared	0.953	0.958	0.956	0.964
RESET test	0.168	0.107	0.008	0.23

Source: Oxera analysis of PR24 Cost Assessment Master Dataset, Wholesale Wastewater Base Costs v4.

The tables show that the magnitude of coefficients associated with the composite complexity variable is almost the same as the coefficients associated with the N-consent level variable in

Ofwat's models. Variables associated with other cost drivers also do not change materially. There are also no material changes in the model fits (R-squared), and the p-values from the RESET tests.

Table A1.7 WWN+5-8 models including composite complexity variable

	SWT	WWN+	Triangulated
Ofwat proposed models (£m)	851.7	1680.9	
Models incl. composite complexity variable (£m)	1009.6	1945.2	
Claim value (£m)	157.9	264.3	211.1

Note: All values in 2023 prices.
Source: Oxera analysis of PR24 Cost Assessment Master Dataset, Wholesale Wastewater Base Costs v4.

Based on YWS's forecast of its cost drivers, we calculated its predicted costs for AMP8 using Ofwat's proposed models, as well as the adjusted models, including a composite treatment complexity variable described above. From the difference in predicted costs, we calculate a claim value of £211.1m over AMP8, corresponding to £42.2m p.a.

Conclusion

The empirical evidence presented in this note confirms that P-removal activities are associated with higher operational costs, and that these are insufficiently captured in Ofwat's current models. We therefore use forecast data on OPEX associated with P-removal activities on the one hand, and Ofwat's proposed models with an added composite treatment complexity variable on the other hand to estimate the efficient costs associated with stricter P-consent levels.

This allows us to estimate the claim values based on these two approaches. These are shown in Table A1.8 below.

Table A1.8 Claim value based on calculation method (£m p.a.)

	Net claim value
Analysis based on APR tables 7F	20.4–26.4
Ofwat proposed models with add composite treatment complexity variable	42.2

	Net claim value
Analysis based on APR tables 7F	20.4–26.4
YWS' bottom-up estimate	23.0

Source: Oxera analysis.

We consider the reasonable range for a cost adjustment claim based on P-removal to be in range of £20.4m to £42.2m p.a. This compares to YWS' bottom-up estimate of £23.0m p.a.

Appendix 2 – Combined Sewers claim values (historic and forecast)

The table below shows the model outputs including and excluding the % combined sewers variable and the net CAC value for combined sewers. We consider that this claim relates entirely to the SWC value chain, although the specific aspect of the value chain (i.e. foul, surface water drainage or highway drainage) is not indicated by the modelling. We have used the net values from 2012-2022 to populate the 'historic total expenditure' in the CWW18 data table and split the costs across the value chain using a) the in-year value chain split as reported in APR or b) the average value chain split for 2016-2022 if a is not available (or is a forecast cost)

	Model output including %CS	Model output excluding % CS	Net value of the claim
2012	£281m	£267m	£13.7m
2013	£286m	£274m	£12.4m
2014	£302m	£289m	£12.5m
2015	£304m	£291m	£13.0m
2016	£307m	£295m	£12.6m
2017	£310m	£296m	£14.3m
2018	£308m	£295m	£13.7m
2019	£308m	£294m	£14.4m
2020	£329m	£316m	£13.1m
2021	£335m	£320m	£14.9m
2022	£359m	£338m	£20.8m
2023	£334m	£319m	£15.1m
2024	£337m	£321m	£15.2m
2025	£338m	£323m	£15.3m
2026	£340m	£325m	£15.4m
2027	£342m	£327m	£15.4m
2028	£344m	£328m	£15.5m
2029	£346m	£330m	£15.6m
2030	£348m	£332m	£15.6m

Note: The values are presented in 2022/23 prices.
Source: Oxera analysis.

Appendix 3 – Oxera Capital Maintenance Analysis

Companies are expected to maintain or improve the health of their assets in order to meet long-term consumer needs regarding supply interruptions, leakage, sewer flooding and other obligations. Maintenance expenditure is included in Ofwat's modelled base costs definition, and is therefore funded through its BOTEX models.

However, Ofwat's analysis of maintenance expenditure has several limitations.

First, Ofwat does not account for maintenance activity (e.g. renewing lengths of mains) in its cost models. Given the lack of maintenance drivers, the models will fund companies to deliver the historical average maintenance activity in a benchmarking period. For example, at PR19, Ofwat benchmarked companies' performance in the period 2015–19, in which time the industry-average mains renewal rate was c. 0.3% p.a. Therefore, companies were only funded to deliver (on average) a mains renewal rate of 0.3% p.a. in AMP7.

Second, Ofwat does not provide a separate allowance for maintenance activity. Rather, companies are set a BOTEX or TOTEX allowance on the basis of Ofwat's cost modelling, and are then permitted to spend the expenditure allowances on activities that they deem appropriate during a regulatory period (subject to some limitations and expectations). Therefore, while companies may have been funded to deliver a certain level of maintenance activity on the basis of the historical cost models, companies may deliver more or less maintenance activity than what was funded, depending on the company's priorities but still manage to deliver the outcomes set on them. While this flexibility is a principal advantage of Ofwat's TOTEX framework, it makes it difficult to: (i) assess exactly what companies' have been funded to deliver on the basis of historical cost modelling; (ii) hold companies accountable for under-delivery, or compensate companies delivering more maintenance activity than anticipated.

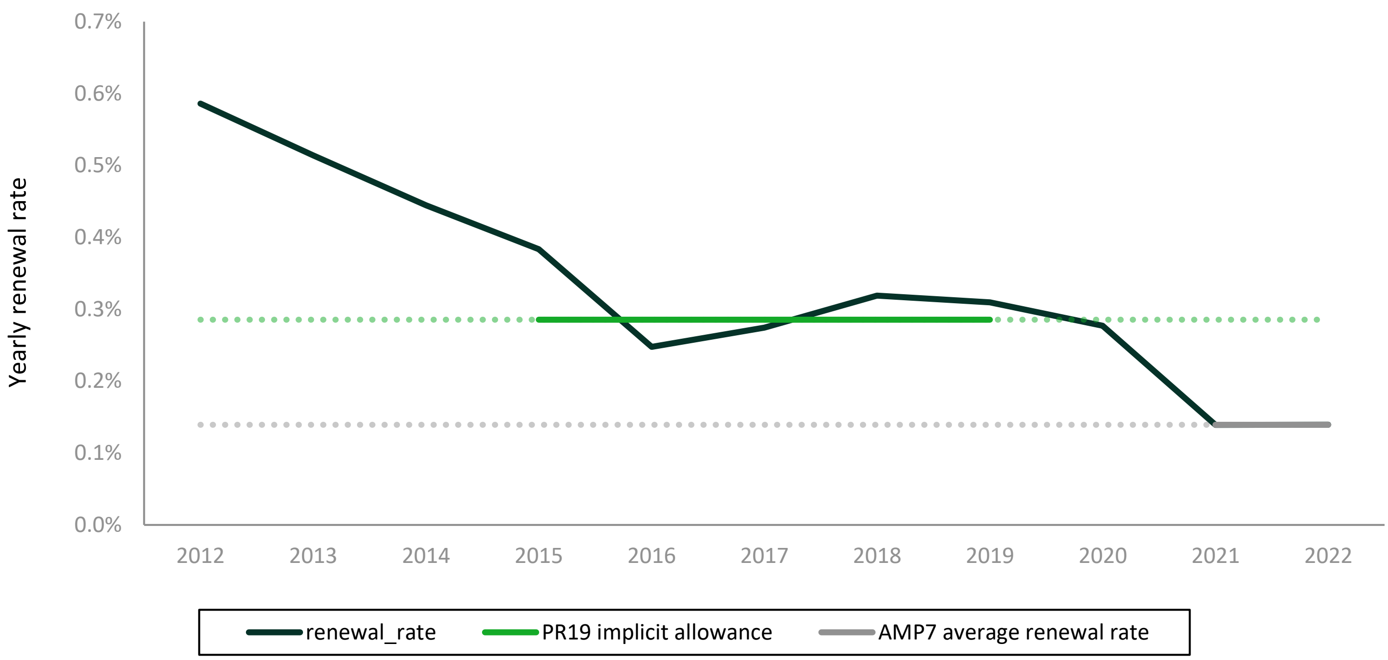
Third, and relating to the above, Ofwat has set increasingly stringent targets regarding cost and service performance in recent price controls. At PR19, for example, Ofwat set a cost benchmark at the third-ranked and fourth-ranked companies (in water and wastewater services, respectively), while also benchmarking some service-quality measures to the upper quartile. The stringency of the PR19 settlement was compounded by recent, unforeseen macroeconomic developments, such as the material increase in input prices that were not sufficiently accounted for in the determinations. As companies are strongly incentivised to spend within their allowances (while meeting service performance commitments), the overall framework can incentivise companies to undertake cost-effective, short-term solutions to meet cost and performance targets instead of more expensive, long-term solutions.

For these reasons, Ofwat's framework could lead to underinvestment in maintenance activities.

Why is an adjustment required?

As an indicator of how the potential underfunding of maintenance activity manifests, the chart below shows how the industry-wide water mains renewal rate has evolved since 2012.

Figure A3.1 Industry-wide evolution of mains renewal



Note: The renewal rate is averaged across all companies.
Source: Oxera analysis.

The chart shows that industry-wide mains renewal rates have decreased significantly over the modelling period, from c. 0.48% p.a. in AMP5 (2012–15) to c. 0.14% p.a. in AMP7 (2021–22). As a result, the extent to which the models implicitly fund maintenance activity has also fallen over time. If the current AMP7 renewal rate continues, companies would only be funded to deliver a mains renewal rate of 0.14% p.a. in AMP8.

Whether such a renewal rate is appropriate or not may depend on:

- the extent to which asset age affects consumer-facing service performance, such as supply interruptions and leakage (i.e. if asset age is strongly associated with deteriorating service performance);

- companies' current asset ages (e.g. companies with very young assets may be better able to delay renewal activity without deteriorating performance than companies with older assets);
- the performance targets that Ofwat seeks to set for companies at PR24 (i.e. if Ofwat wants companies to improve or maintain existing performance measures, then more maintenance activity may be required).

We understand that companies (including YWS) use asset management tools to assess the level of maintenance activity that would be required to achieve a certain level of asset failure. While the specificities of the models may differ across companies, we envisage that such tools would be constructed on the following basis.

1. The company collects data at the asset-level relating to asset characteristics (e.g. length of pipe, pipe material, asset age) and asset failure (e.g. number of pipe bursts).
2. Using such data, a model can be developed to predict the likelihood of asset failure on the basis of the asset's characteristics.
3. The company sets the level of asset failure that is 'acceptable' and, on this basis, the optimal renewal rate can be constructed.

These asset management tools can provide useful evidence to support an increasing need to undertake more maintenance activity. However, such detailed, asset-level data is not in the public domain and, as such, we cannot compile industry-wide datasets to compare YWS's own asset management strategies to the rest of the industry.

Instead, we have compiled company-level information regarding asset failure (defined as 'number of burst pipes'), asset age, and other company-level characteristics in order to provide a simplified view of: (i) how asset failure and asset age are related; (ii) what may happen to asset failure rates if current renewal rates persist.

Table A3.1 below shows the estimated relationship between asset failure and asset characteristics.[31]

[31] We have explored alternative model specifications, including: (i) incorporating measures of population density; (ii) alternative functional forms; and (iii) modelling total mains repairs as opposed to mains repairs per lengths of mains. Given consistency in results, we are presenting a concise model specification. Note that the model fit is relatively low in the unit cost models, comparable to Ofwat's 'other cost' models in the residential retail price control (see Ofwat (2019), 'PR19 final determinations: Securing cost efficiency technical appendix', December, Table A2.3; and Ofwat (2023), 'Econometric base cost models for PR24', April, Table 7.19). This low model fit is driven by the observation that the primary driver of mains repairs is the scale of the company. If these models are instead estimated on a total repairs basis (with lengths of mains as a scale driver), the model fit increases to c. 0.93–0.94.

Table A3.1 Modelling network health using main repairs and average age of network

Model	MR1	MR2
Dependent	Main repairs per 1000km of mains (log)	Main repairs per 1000km of mains (log)
Average age of network	0.0110*** (0.000874)	0.0116*** (0.000443)
Time trend		-0.0238* (0.0796)
Constant	4.268*** (0)	4.414*** (0)
Observations	128	128
Model fit	0.084	0.11
Model	OLS	OLS

Note: ***, **, * indicate statistical significance at the 0.01, 0.05 and 0.1 levels.
Source: Oxera analysis.

The table shows the following.

- The coefficient on asset age indicates that an increase in asset age of one year leads to an increase in asset failure of c. 1.1% of the industry average.
- The coefficient on the time trend indicates that, holding asset age constant, the industry has managed to achieve a reduction in asset failure at a rate of 2.4% p.a.[32]

Given the current low rates of asset renewal, on the basis of this modelling, companies have increased the age of their assets by 5.5 years since 2012. This would have equated to an increase in asset failure of 6%–9%, if not for the coefficient on the time trend.

Importantly, the coefficient on the time trend is likely to capture a combination of general productivity growth and the industry's focus on short-term solutions. For example, companies may have invested in better water-pressure management (or simply reduced water pressure on the network) in order to reduce the probability of asset failure without renewing assets. However, reducing water pressure cannot continue indefinitely—companies can only reduce water pressure by so much before it affects other consumer outcomes, at which point other strategies will need to be deployed. At some point, asset renewal may become the only viable solution to improve service quality.

[32] This is aligned with Ofwat's observation that mains bursts and other performance commitments have improved over time, despite the aging network. For example, see Ofwat (2021), 'Assessing base costs at PR24', December, section 5.1.

Therefore, substantial investment in the asset renewal may be required in future AMPs, in order to improve consumer outcomes beyond what is funded through the historical cost modelling.

How could long-term maintenance be funded?

We consider that the underfunding of long-term maintenance is an overarching concern with Ofwat's approach to cost assessment. Therefore, the issue is applicable to all companies, to varying degrees.

Ofwat's primary concern appears to be that consumers should not have to pay twice for companies to maintain their assets. We agree with this statement, although we disagree that companies are funded to achieve any specific level of maintenance activity, given the arguments highlighted at the start of this section. At most, companies are likely to be funded to deliver a very low rate of renewal activity, and companies may not be able to deliver this if there are other constraints caused by the regulatory regime (e.g. overly stringent cost and performance commitments).

Therefore, we consider that the following mechanism could ensure that: (i) companies receive sufficient funding in order to undertake the required maintenance activity; (ii) consumers do not have to pay for maintenance activity that does not materialise.

First, Ofwat could construct a post-modelling adjustment to reflect the difference between companies' anticipated maintenance activity and the level of maintenance activity funded through the models (currently c. 0.1% p.a.). This could be similar to the post-modelling adjustment for growth enhancement at PR19.

1. Estimate an efficient unit cost for the maintenance activity using industry-wide unit cost data (e.g. cost per length of mains renewed).
2. Apply the efficient unit cost to: (i) the forecast volume of maintenance activity; (ii) the volume of maintenance activity implicitly funded through the models.
3. The difference between the estimated expenditure in (i) and (ii) would form the basis of an efficient post-modelling adjustment for maintenance activity.

Second, Ofwat could introduce monitoring and reporting requirements, alongside an uncertainty mechanism in order to scale back funding if companies do not deliver their planned maintenance activities. In this way, specific funding is 'ring-fenced' for maintenance activity over and above that funded through the base cost models, which mitigates the risk that companies outperform allowances by under-delivering maintenance. Indeed, companies could only outperform their 'maintenance allowance' by delivering the maintenance activity at a lower unit cost than that calculated under step 1.