UUW46

Cost Assessment Proposal

October 2023

Chapter 8 supplementary document

This document contains UUW's cost assessment proposal. It builds upon UUW's previous submissions to the Future Ideas Lab to set out an appropriate framework for cost assessment, including base cost assessment, enhancement cost assessment and providing better recognition of the cost-service link. We use this framework to demonstrate that our business plan is efficient.

United Utilities

Water for the North West

Contents

Appendices

1. Cost assessment proposal

1.1 Key headlines

- **An efficient benchmark.** We have calculated an efficient level of total expenditure for AMP8. Our business plan totex (£13,743 million) is significantly lower than this efficient benchmark (£14,390 million). This demonstrates that our plan is efficient.
- **A reasonable approach to base cost modelling.** We have proposed a robust modelling suite. This modelling suite has been guided by our extensive contributions to the Future Ideas Lab.
- **A new approach to the cost-service relationship.** We promote an approach that reflects key regional differences in wastewater operations within performance targets, rather than through cost targets.
- **A focus upon robust data.** We have serious concerns about the quality of average pumping head data and as such do not include this variable within our model suite.
- **A principled approach to enhancement.** We have set out some key principles that should guide enhancement cost assessment at PR24.
- **A stretching catch-up challenge and an evidence-led productivity challenge.** We consider a catch-up challenge 'in-the-round' by acknowledging all sources of implicit and explicit stretch within the regulatory framework. Our evidence-led approach on productivity estimates has identified a frontier shift challenge which is stretching but achievable, given our performance targets.
- **An RPE adjustment is inappropriate.** While energy costs are expected to fall, the base year reflects a historic high that will not be reflected within cost assesment. As such, we consider that the progressive fall in energy prices will lead to a broadly neutral cost position for companies.
- **A proportionate approach to cost adjustments.** We have developed and submitted a series of high quality cost adjustments, which reflect the key regional challenges faced by UUW.
- **A response to the symmetrical cost adjustment consultation.** We set out our response to other companies' proposed symmetrical adjustments.

1.2 Document overview

1.2.1 Cost assessment is the process by which Ofwat challenges the efficiency of companies' business plans. Companies have more information about their cost base than the regulator, which leads Ofwat to develop an independent view of how much the proposed service and investment package will cost, allowing it to challenge inefficiencies and reveal efficiencies.

1.2.2 This document sets out how we calculated an efficient benchmark for each element of total expenditure (totex). This benchmark provides confidence that our business plan is efficient, and that customers are receiving good value for money.

1.3 UUW's thought leadership in cost assessment

1.3.1 Cost assessment is a key aspect of economic regulation and ensures that companies are appropriately stretched to provide a good standard of service at an efficient price. As such, UUW has been an active contributor to Ofwat's Future Ideas Lab and has also commissioned several reports that explored areas where there is scope for the cost assessment framework to evolve:

- **The Principles of Regulatory Cost Assessment[1].** This paper drew upon our experience of PR19, the subsequent CMA appeals and a look ahead to PR24 to establish six basic principles for cost

[1] UUW (2021) *The principles of regulatory cost assessment*. Available here.

assessment. The approach to cost assessment set out within this document is grounded upon these principles.

- **What lessons can we learn from cost assessment at PR19?**[2] This paper introduced an innovative way to reflect regional environmental pressures within performance targets, specifically for the internal sewer flooding Performance Commitment. It also highlighted the implicit sources of stretch within the regulatory framework and the importance of an appropriately diverse and well-triangulated model suite.
- **Making the cost assessment framework resilient to future challenges[3].** This paper focused on ensuring that cost assessment can respond to the challenges faced in future AMPs. There is a risk that an approach based upon backward looking data is not able to fully reflect new emerging cost drivers or changes in the relationships between existing cost drivers and cost.
- **The opportunities for a more coherent regulatory approach for Ofwat's funding of base expenditure and enhancements[4].** This paper explored the opportunities for a more coherent framework to assess base and enhancement expenditure. It includes options to help tackle the capex bias for enhancement initiatives that arose at PR19 and proposed practical suggestions for other key topics at PR19. It built on a firm conceptual foundation - including on the performance levels that are funded by base-plus allowances - and was informed by simulation modelling analysis.
- **Frontier shift at PR24[5].** This report considered the evidence supporting the level of a frontier shift efficiency at PR24 by assessing the most recent publication of the EU-KLEMS dataset.

1.4 UUW's cost assessment proposal

1.4.1 Table 1 sets out a summary of UUW's cost assessment proposal, including each separate element of total expenditure. This document sets out how each element has been derived. It's clear that our proposed business plan totex is efficient.

[2] UUW (2022) *What lessons can we learn from cost assessment at PR19?* Available here.

[3] UUW (2022) *Making the cost assessment framework resilient to future challenges.* Available here.

[4] Reckon LLP (2022) *The opportunities for a more coherent regulatory approach for Ofwat's funding of base expenditure and enhancements*. Available here.

[5] Economic Insight (2023) *Frontier shift at PR24*. Available here.

Table 1: UUW's cost assessment proposal

	WR	WNP	WwNP	BR	WS	RET
Modelled botex (post-efficiency)	318	2,114	2,276	499	5,207	742
Cost adjustment claims	186	0	85	173	444	0
Botex	**504**	**2,114**	**2,361**	**672**	**5,652**	**742**
Unmodelled costs						
Abstraction charges	117	1	0	0	118	0
Business rates	98	264	152	45	560	0
Traffic Management Act costs	0	9	2	0	11	0
Equity Issuance costs	1	3	18	2	23	0
Statutory water softening	0	0	0	0	0	0
Industrial Emissions Directive	0	0	0	3	3	0
Non-s185 diversions (recoverable from customer bills)	0	15	19	0	34	0
Third party costs (price control) - excludes non-s185 diversions	0	7	2	0	9	0
Unmodelled cost total	**216**	**300**	**194**	**50**	**758**	**0**
Botex proposal						
Base expenditure	**720**	**2,414**	**2,555**	**722**	**6,410**	**742**
Enhancement costs						
Total enhancement expenditure	184	838	5,821	330	7,173	0
Income						
Infrastructure charge receipts	0	78	91	0	169	0
s185 diversions - water	0	20	0	0	20	0
Totex						
Total expenditure	**904**	**3,153**	**8,285**	**1,051**	**13,393**	**742**
Business plan	782	3,119	8,208	979	13,088	677
Comparison	-122	-34	-77	-72	-305	-65

Source: UUW data

1.5 Structure of this document

1.5.1 This document is structured as follows:

- **Section 2** outlines our approach to modelled base costs.
- Details of our assessment of unmodelled base costs are set out in **Section 3.**
- **Section 4** contains principles guiding our approach to enhancement modelling.
- Our approach to the catch-up efficiency challenge is provided in **Section 5.**
- We set out our assessment of frontier shift and Real Price Effects in **Section 6.**
- **Section 7** explains our approach to reflecting regional factors affecting wastewater companies in the regulatory contract.
- **Section 8** explains how our cost adjustment submissions fit within this framework.
- **Section 9** sets out our response to the symmetrical cost adjustment claim consultation.

2. Our approach to assessing modelled base costs

2.1.1 Base cost modelling allocates a substantial proportion of total expenditure across the industry. The approach uses econometric models to allocate costs to each company on the basis of a set of cost drivers. These cost drivers aim to reflect key regional differences so that each company receives an allowance commensurate to the challenges it faces in delivering its services.

2.1.2 Ofwat's approach to base cost modelling at PR19 was largely supported by the Competition and Markets Authority (CMA). Ofwat has continued to engage with the sector via a series of Cost Assessment Working Groups and consulted on its proposed base cost model suite in Spring 2023[6]. We are supportive of much of the approach Ofwat has taken to base cost assessment so far in PR24 although we have reservations about certain elements of its approach. In particular, we consider it would be a serious error to use average pumping head within the cost model suite despite there being clear evidence of the underlying data being inconsistent. Ofwat itself expressed concerns over the robustness of average pumping head data in its consultation document, and we consider that these concerns are well founded.

2.1.3 This section sets out UUW's approach to base cost assessment. It covers our definition of modelled cost and sets out the aggregations of cost used in our model suite. It then develops a framework by which we have selected the most appropriate explanatory variables and robust models. It sets out an innovative approach to triangulation which will enhance the predictive power of the model suite overall. Finally, we explain why our approach to forecasting cost drivers will result in cost targets that are reflective of future cost pressures.

2.2 What is the appropriate definition of modelled cost?

2.2.1 We have aligned our definition of modelled cost to that proposed by Ofwat in its PR24 final methodology.

2.2.2 We strongly agree that non-s185 diversion costs should be excluded from the scope of modelled costs. This is because related expenditure is company-specific, lumpy and unrelated to the chosen set of cost drivers. We also consider that non-s185 diversion costs should be excluded from the price control to avoid undue customer bill volatility. Please see supplementary document *UUW54 - Developer Services* for our proposal in this area.

2.2.3 As part of a study commissioned by UUW, Anglian and Wessex, Reckon published a paper[7] that suggested enhancement operating expenditure (opex) should be included within the scope of modelled costs. This is because this opex will form part of ongoing base expenditure (botex) from the next AMP onwards. Therefore, including enhancement opex within the scope of modelled costs will help the models to reflect the incremental ongoing expenditure companies will be expected to make as a result of their enhancement programmes. We note that Ofwat agreed with this viewpoint in its methodology[8] and included elements of enhancement opex into base costs. While the overall impact on modelled costs is relatively small, we acknowledge this is due to lack of availability of enhancement opex data prior to 2020-21.

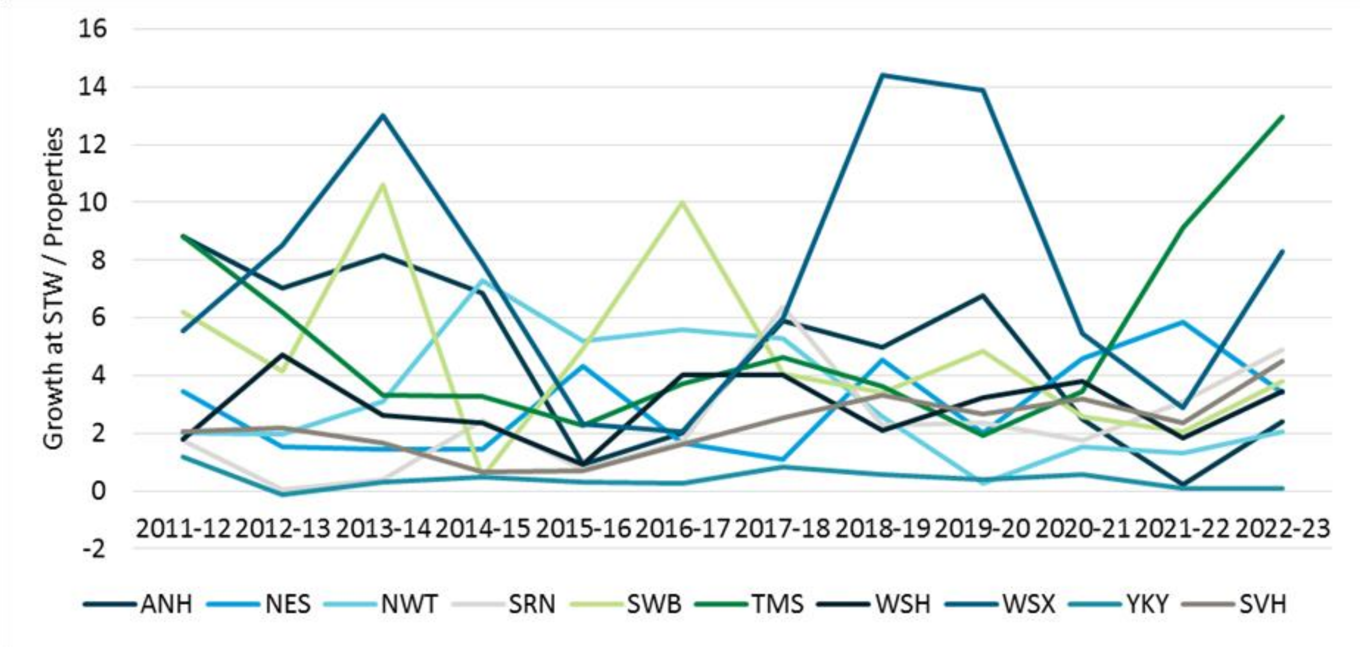
2.2.4 We also exclude growth at STW expenditure from the definition of modelled base costs. As Figure 1 makes clear, investment in growth at STWs is extremely variable from year to year. This means it is unrealistic to expect a base cost model to provide an appropriate allocation of this type of expenditure. If a separate enhancement model is not viable, then we consider that a deep dive assessment of companies' proposed growth at STW costs should be implemented.

[6] Ofwat (2023) *Econometric base cost models for PR24.* Available here.

[7] Reckon LLP (2022) *The opportunities for a more coherent regulatory approach for Ofwat's funding of base expenditure and enhancements*. Available here.

[8] Ofwat (2022) *Final Methodology: setting expenditure allowances.* Available here.

Figure 1: Growth at STW varies significantly each year and as such is unsuited for inclusion in base cost models



Source: APR datashare

2.2.5 We have aligned with Ofwat's approach of including flooding risk for properties enhancement expenditure within the scope of modelled cost. However, we continue to have some reservations about the appropriateness of this. At PR19, Ofwat set a common industry upper quartile target for internal sewer flooding. This target has never been met by a company with UUW's characteristics of high urban rainfall and high prevalence of combined sewers. This means that the historical cost record does not reflect the activity needed to move towards this target. This means that any subsequent allocation of historical costs via the botex models will not provide sufficient allowances for UUW to meet the industry target. In fact, the level of expenditure required to achieve this would be uneconomic.

2.2.6 On this basis, our business plan proposes that performance targets for internal sewer flooding are adjusted for each company to reflect the different regional challenges each faces, rather than ask customers to fund inefficient activity. For this reason, we do not seek to adjust costs in response to regional challenges, although we have submitted a conditional symmetrical cost adjustment claim if our approach to a company-specific target is not accepted. We provide more detail of this approach in section 7.

2.2.7 Additionally, we consider that there may be some benefit in including additional specific elements of enhancement expenditure into the scope of base modelled costs. In particular, water efficiency activity would be a good candidate to include within modelled costs because it consists of relatively constant ongoing interventions that are aligned with base activity.

2.2.8 We note that it may be beneficial to include leakage enhancement expenditure within the scope of modelled costs. This could allow companies to improve their leakage performance without additional need to assess enhancement claims. Indeed, it is not clear to us why 'reduce flooding risk for properties' enhancement is considered appropriate for inclusion within modelled base costs but leakage enhancement isn't. For example, in its PR19 FD Ofwat said: "*We consider it appropriate to include costs driven by population growth because growth activities and base costs share similar characteristics, notably companies experience these costs on a year-on-year basis. The integrated approach also mitigates for known reporting differences between operating, capital maintenance and growth related expenditure [emphasis added].*"[9] Based upon this reasoning, it would seem reasonable to conclude that leakage enhancement would also be a suitable candidate for inclusion in base cost models.

[9] Ofwat (2019) *Securing cost efficiency technical appendix*. Available here.

Treatment of income

2.2.9 In principle, we agree with Ofwat that costs should be modelled on a gross basis i.e. before any related income has been deducted. However, we consider it is essential to ensure that the view of income aligns with the costs reflected in the subsequent modelled allowance e.g. the application of an efficiency challenge to botex but not to income would create a material inconsistency in net cost allowances.

2.3 What combination of upstream services should be modelled?

2.3.1 The water and wastewater value chain is made up of a number of distinct upstream services. The way in which each upstream service is delivered can have a consequential impact on the costs incurred by subsequent elements in the value chain. Importantly, this impact can be different for different companies, depending upon each company's regional circumstances. Potential inter-relationships of this nature between different elements of the value chain are known as 'substitution effects'.

2.3.2 For example, companies with a high proportion of impounding reservoir sources will tend to have lower power costs in the water resources service because these sources use gravity to move water to treatment works. However, surface water sources require additional treatment due to the risk of environmental contamination, which could lead to higher costs in the treatment service. In contrast, a company with a high proportion of groundwater sources would tend to see high power costs in water resources due to the need to pump water against gravity to be treated, but lower treatment costs because groundwater tends to be of better quality.

2.3.3 A robust modelling approach must be capable of recognising substitution effects or there is a risk that any resulting benchmark may be too stretching for some companies and too lax for others. This would subject customers across England and Wales to allocative inefficiency.

Our proposed aggregations of cost

2.3.4 Engineering and operational rationale suggests that substitution effects exist across the entire water and wastewater value chain:

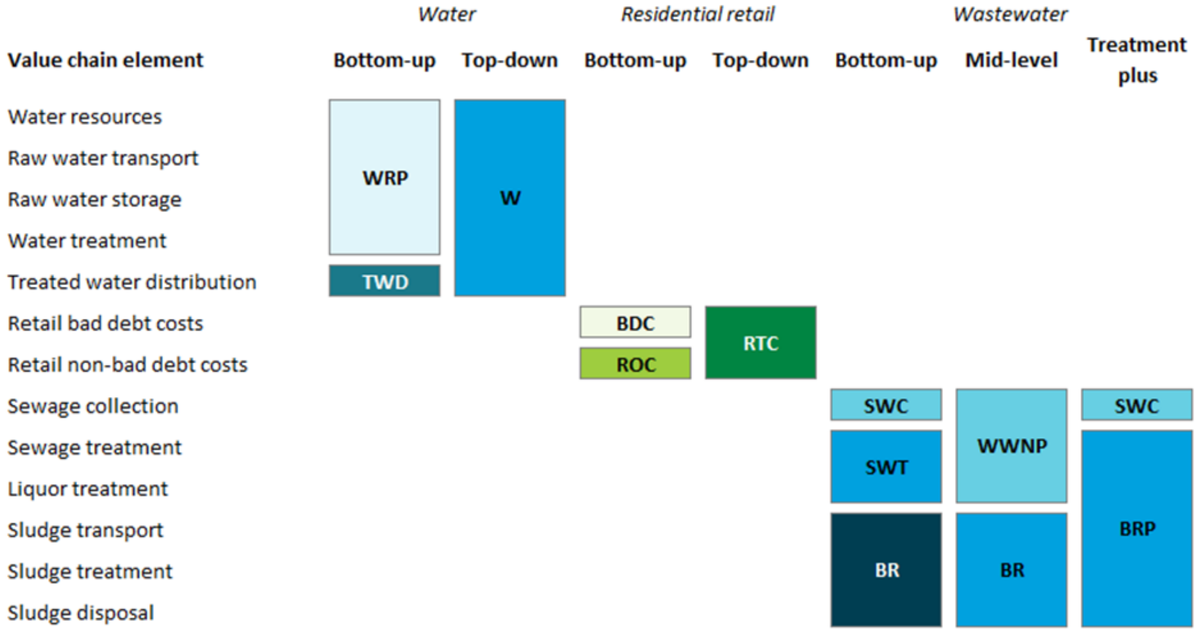
- As discussed in paragraph 2.3.2, substitution effects exist between water resources and water treatment.
- High lift pumps move treated water from treatment works into the network. Companies may have located these pumps on different sides of the boundary between water treatment and treated water distribution.
- Wastewater companies with a high prevalence of combined sewers need to treat additional volumes of sewage at wastewater treatment works because there is less potential to redirect surface water to a watercourse.
- Prior to service separation, wastewater companies adopted different sludge treatment technology which led to a difference in how bioresources assets are structured across the wastewater treatment/bioresources boundary.

2.3.5 We have previously promoted the benefits of a diverse model suite that incorporates triangulation between different aggregations of upstream service costs[10]. A more granular cost aggregation facilitates a more precise estimation of the relationship between cost and driver, while a more aggregated cost model mitigates the influence of differences in cost allocation and asset configuration across different companies. The use of both approaches within an appropriately triangulated model suite should result in a more realistic cost target for PR24.

[10] UUW (2022) *What lessons can we learn from cost assessment at PR19?* Available here.

2.3.6 Figure 2 below illustrates the different cost aggregations used across UUW's cost model suite. We consider that this aggregation captures the more material substitution effects that occur across the value chain.

Figure 2: Cost aggregations used in UUW's model suite

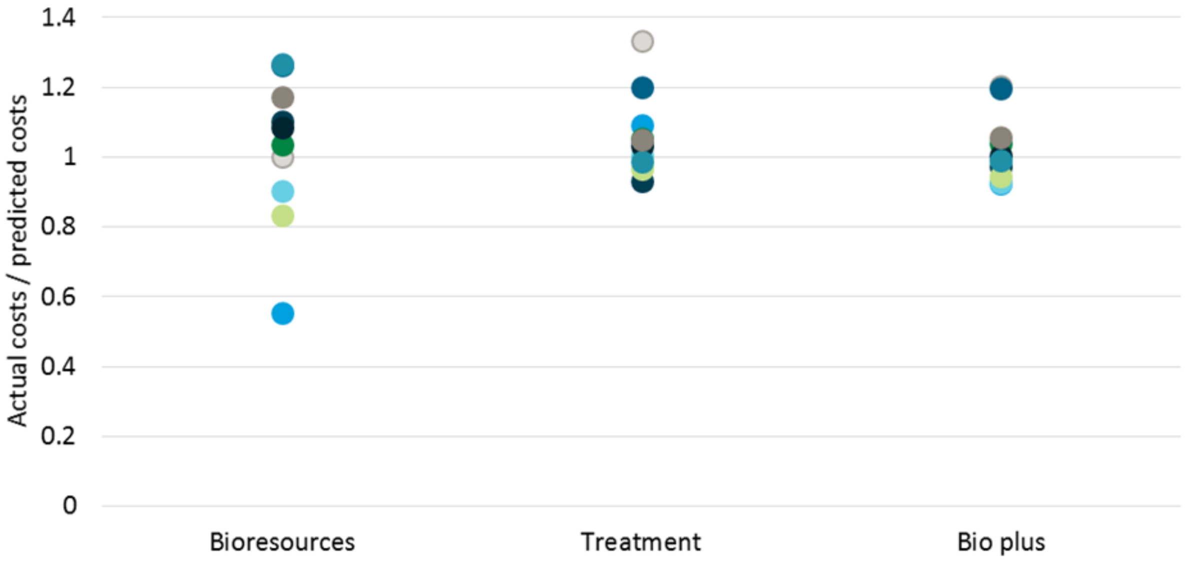


Source: UUW's model suite

2.3.7 We note Ofwat's stated desire to move away from the bioresources plus model split. We disagree with this approach. The price control boundary between Wastewater Network Plus and Bioresources was defined during AMP6, once companies had taken decisions on asset configuration. This has led to some companies having relatively more assets on the Bioresources side of the boundary and vice versa. However, this will mean that companies with more assets within the Bioresources boundary will appear to have more costly Bioresources operations (and vice versa). This is entirely unrelated to relative efficiency and is simply the physical manifestation of historical regulatory decisions. Therefore, cost assessment should ensure that it doesn't confuse differences in asset configuration with differences in efficiency. This means appropriately accounting for any substitution effects between wastewater treatment and bioresources.

2.3.8 As Figure 3 below shows, output from models using data up to 2022-23 demonstrates clear evidence of substitution effects. Both the wastewater treatment and bioresources models have a significant spread of residuals, which suggests these models are not explaining a large portion of cost variation across the industry whereas the spread of residuals for the bioresources plus model is significantly smaller. This demonstrates that aggregating wastewater treatment and bioresources costs into a bioresources plus aggregation removes a large proportion of unexplained variation in costs. Given that the Bioresources Plus model does not introduce any additional cost drivers, the reduction in unexplained variation can only be attributable to differences in asset configuration i.e. how different companies allocate costs between Wastewater Network Plus and Bioresources.

Figure 3: Evidence of substitution effects between wastewater treatment and bioresources



Source: UUW's model suite

2.3.9 This proves that there are extensive substitution effects between the wastewater treatment and bioresources boundary. Failure to appropriately recognise these could lead to poor outcomes for customers. For example, a company with fewer assets within bioresources would be seen as efficient by a bioresources-only model (all else equal) and would be rewarded by keeping any 'outperformance' versus the benchmark. Such outperformance wouldn't be due to genuine efficiency but simply due to having lower operation and maintenance costs within the bioresources price control (because there are relatively less assets in bioresources and more in wastewater treatment). This could affect customers in three ways:

(1) They would fund the full amount of 'outperformance' in bioresources.

(2) They would contribute towards a share of the corresponding 'underperformance' relating to higher operation and maintenance costs in wastewater treatment because the wastewater network plus price control is subject to cost sharing.

(3) An inappropriately high benchmark could encourage inefficient market entry, which would lead customers to pay more than they otherwise would.

2.3.10 There are two potential ways to address these problems:

(1) One is to adopt an aggregation of cost that removes any substitution effects between wastewater treatment and bioresources – this would be achieved by a bioresources plus cost aggregation.

(2) The other is to implement cost drivers that reflect the exogenous factors that led companies to adopt different asset configurations across the bioresources boundary.

2.3.11 Our work in this area suggests that (2) (finding appropriate cost drivers) is difficult. This is because exogenous regional circumstances didn't necessarily lead companies to adopt a different asset configuration. Rather, it was individual company strategy. This means it is difficult to identify appropriate exogenous cost drivers that are able to account for asset configuration.

2.3.12 Even if this were possible, we still consider it would be beneficial to include a bioresources plus cost aggregation. This would mean the modelled benchmark is better able to reflect aspects of substitution effects that might not be reflected by the model's cost drivers, which would result in a more appropriate cost target overall. Therefore, **we maintain a bioresources plus cost aggregation in our model suite.**

2.3.13 We do not consider that this undermines competition in the bioresources market. Companies would still be incentivised to engage in efficient trades and the technical approach to setting their relative benchmarks cannot realistically be expected to factor into such decisions. Furthermore, a more appropriate benchmark (i.e. one that recognises efficient costs, including those driven by substitution effects) would facilitate efficient trades and send appropriate signals to the market.

2.4 Which variables best reflect engineering, operational and economic rationale?

2.4.1 At PR19, Ofwat defined four categories of cost driver:

- **Scale.** A larger customer base or a larger area served will lead to more costs.
- **Complexity.** More complex treatment processes (both water and wastewater) will lead to additional costs. Additionally, urban run-off can increase the complexity of wastewater network operations.
- **Density.** Density can have mutually conflicting effects on costs across different parts of the value chain. Higher population density can allow companies to realise economies of scale at treatment works but it might drive additional costs on its networks because of the added complexity of working within busy, urban environments.
- **Topography.** Water and wastewater must be pumped against gravity. Therefore, differences in topography can lead to differences in costs.

2.4.2 We consider that this categorisation is generally appropriate, noting that we consider urban rainfall to fall under the complexity cost driver (Ofwat did not choose to reflect urban rainfall in the PR19 FD).

2.4.3 Therefore, the next step is to consider which explanatory variables are best capable of reflecting the engineering, operational and economic rationale within the model suite. We have previously published our Principles of Cost Assessment[11], which sets out our overarching approach to selecting appropriate variables for use within cost assessment. Ofwat has also published its own principles of cost assessment[12], which for the most part align with our own. These publications suggest the following criteria should be followed when selecting explanatory variables:

- **Robust data.** Data should be of good quality;
- **Strong rationale**. Cost drivers should be motivated by, and align with, engineering, operational and economic rationale; and
- **Exogenous.** Explanatory variables should be outside of company control in the short-term.

2.4.4 We note that these criteria may sometimes conflict e.g. when faced with unreliable or non-existent data, it may be necessary to use a variable that is endogenous in the long-term (note, variables that are endogenous in the short-term should never be used). In such cases, it is important that any decisions are well-justified or that models account for a range of different variables within a diverse model suite.

2.4.5 We have largely aligned our choice of cost drivers to Ofwat's recommended model suite[13]. The next sections summarise our chosen set of cost drivers by reference to the criteria set out in paragraph 2.4.3. We provide further explanation on any cost drivers from Ofwat's recommended model suite that we have not included within our model suite. We also provide an explanation for any cost drivers Ofwat did not include in its recommended model suite but which we include.

Water

2.4.6 Table 2 sets out all cost drivers included within Ofwat's recommended model suite, along with any additional cost drivers included within UUW's model suite, assessed against the criteria set out in in

[11] UUW (2021) *The Principles of Regulatory Cost Assessment*. Available here.

[12] Ofwat (2022) *Final Methodology: setting expenditure allowances.* Available here.

[13] Ofwat (2023) *PR24 Econometric base cost models.* Available here.

paragraph 2.4.3. We provide further commentary against any variables not assessed as green beneath the table.

Table 2: UUW's choice of water explanatory variables

Explanatory variable	Robust data	Strong rationale	Exogenous	Used in Ofwat's suite?	Used in UUW's suite?
Properties (log)				Yes	Yes
% water treated in complexity bands 3-6				Yes	Yes
Weighted average density - MSOA to LAD (log)				Yes	Yes
Weighted average density - MSOA to LAD (log) squared				Yes	Yes
Weighted average density - MSOA (log)				Yes	No
Weighted average density - MSOA (log) squared				Yes	No
Weighted average treatment complexity (log)				Yes	Yes
Property density (log)				Yes	Yes
Property density (log) squared				Yes	Yes
Mains length (log)				Yes	Yes
Booster pumps per length of main (log)				Yes	Yes
Average pumping head				Yes	No
AMP5 dummy				No	Yes

Source: UUW analysis

Percentage water treated in complexity bands 3-6 and weighted average treatment complexity

2.4.7 We mark the engineering, operational and economic rationale criteria amber because the variables do not distinguish between surface water and groundwater. Our operational experience suggests that surface water is associated with much greater variability in quality, which can lead to additional treatment costs. However, we have not yet found any better candidates for treatment complexity variables.

Weighted average density – MSOA (log)

2.4.8 Ofwat has developed alternative measures of weighted average density. While we consider there is merit in including alternative measures of population density within the same model suite (i.e. WAD and property density), it may not be proportionate to include two alternative measures of the same variable (i.e. both 'WAD - MSOA to LAD' and 'WAD - MSOA') within the model suite. For this reason, we picked WAD – MSOA to LAD because it has marginally better statistical indicators across both p-values and r squared. We provide further details of statistical tests in section 2.7.

Property density and mains length

2.4.9 These variables receive an amber status for exogeneity because they are under the long-term influence of company management. As we stated in our Principles of Cost Assessment paper[14], it is acceptable to use variables that are endogenous in the long-term because companies are not able to influence the outcome of cost assessment in the short-term.

Average pumping head and booster pumps per length of main

2.4.10 Average pumping head and booster pumps per length of mains are both measures of topography. However, they each capture a different aspect of topographical cost pressures:

[14] UUW (2021) *The Principles of Regulatory Cost Assessment*. Available here.

- Average pumping head captures the energy requirements of pumping water against gravity. As Ofwat states: *"APH is a direct measure of pumping requirements. It captures the volume of water pumped and the pressure at which it is pumped"*[15]
- Booster pumps per length of main (booster pump density) reflects how topography affects the asset configuration on a company's water network. As SVE states: *"Boosters per length is a measure of asset intensity within the network. This is the 'true' topography proxy – lots of small boosters are necessary to move water through hilly terrain."*[16].

2.4.11 These two factors are not necessarily related; a company can have high pumping head and low booster pump density e.g. if it operates a small number of large pumps. SVE highlights this in its claim: "*On average, just 30% of pumps contribute 90% of APH.*"[17] Companies with a smaller number of large pumps can expect to benefit from significant power, pumping and maintenance efficiencies and as SSC notes in its claim, operational resilience benefits: *"[A small number of large pumps] is the most resilient approach as it does not materially rely on a larger number of smaller distributed pumping assets that the boosters per length of mains driver assumes*."[18]

2.4.12 Therefore, in theory, cost assessment should reflect both relationships within a triangulated model suite, as they can act in an offsetting and mitigating way. For example, the sole use of average pumping head would over allocate expenditure to companies with low booster pump density because such companies benefit from significant operational efficiencies. However, as we discuss in detail in section 9.2, we continue to have strong concerns about the robustness of average pumping head data. Until such times as a common methodology is established and companies are confirmed as being compliant with this, we strongly oppose the use of average pumping head within cost assessment. There is a clear risk that poor data quality will lead to a change in cost allocations that is entirely unrelated to regional differences in cost pressures. In our view, this is a fundamentally inappropriate outcome.

2.4.13 Therefore, we implement booster pump density within our model suite and exclude average pumping head. We set out our position on average pumping head in more detail in section 9.2.

AMP5 dummy

2.4.14 We consider that there is clear evidence of a structural break in cost data when the totex-outcomes framework was introduced. As such, we attempt to control for this through the use of a dummy variable. We set out our evidence and justification for this approach in section 2.5.

Wastewater

2.4.15 Table 3 sets out all cost drivers included within Ofwat's recommended model suite, along with any additional cost drivers included within UUW's model suite, assessed against the criteria set out in in paragraph 2.4.3. We provide further commentary against any variables by exception below.

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[15] Ofwat (2023) *Econometric base cost models for PR24.* Available here.

[16] Severn Trent (2023) *Network complexity cost adjustment claim.* Available here.

[17] ibid

[18] SSC (2023) *Topography cost adjustment claim.* Available here.

Table 3: UUW's choice of wastewater explanatory variables

Explanatory variable	Robust data	Strong rationale	Exogenous	Used in Ofwat's suite?	Used in UUW's suite?
Sewer length (log)				Yes	Yes
Pumping capacity per km of sewer (log)				Yes	Yes
Property density (log)				Yes	Yes
Weighted average density - MSOA to LAD (log)				Yes	Yes
Weighted average density - MSOA to LAD (log) squared				Yes	Yes
Weighted average density - MSOA (log)				Yes	Yes
Weighted average density - MSOA (log) squared				Yes	Yes
Urban rainfall per km of sewer (log)				Yes	No
Load (log)				Yes	Yes
Weighted average treatment works size (log)				Yes	Yes
Percentage of load treated at WwTW > 100,000 PE				Yes	No
Percent of population in coastal areas				No	Yes
Percent of load with ammonia consent <3mg/l				Yes	Yes
Sludge produced (log)				Yes	Yes
Percent of load treated in size bands 1-3				Yes	Yes[19]
WwTW per connected property (log)				Yes	Yes
AMP5				No	Yes

Source: UUW analysis

Sewer length, pumping capacity, property density and WwTW per property

2.4.16 These variables receive an amber status for exogeneity because they are under the long-term influence of company management. As we stated in our Principles of Cost Assessment paper[20], it is acceptable to use variables that are endogenous in the long-term because companies are not able to influence the outcome of cost assessment in the short-term.

Weighted average density – MSOA (log)

2.4.17 As per paragraph 2.4.8, Ofwat has developed alternative measures of weighted average density. While we consider there is merit in including alternative measures of population density within the same model suite (i.e. WAD and property density), it may not be proportionate to include two alternative measures of the same variable (i.e. both 'WAD - MSOA to LAD' and 'WAD - MSOA') within the model suite. For this reason, we picked WAD – MSOA to LAD because it has marginally better statistical indicators across both p-values and r squared.

Urban rainfall per km of sewer

2.4.18 UUW has developed a large body of evidence that demonstrates urban run-off creates significant challenges for wastewater companies[21]. Rainfall onto impermeable areas increases the likelihood that water enters the sewer system, and heavy and/or prolonged rainfall can lead to sewers being

[19] We do not use this variable to reflect economies of scale at WwTW. We use it in our Bioresources models.

[20] https://www.unitedutilities.com/globalassets/documents/pdf/the-principles-of-regulatory-cost-assessment.pdf

[21] Arup and Vivid Economics (2017) *Understanding the exogenous drivers of wholesale wastewater costs in England and Wales.* Available here.

Arup and Vivid Economics (2018) *Use of econometric models for cost assessment at PR19.* Available here.

UUW (2022) *What lessons can we learn from cost assessment at PR19?* Available here.

overwhelmed. This can manifest in combined sewer overflow activations and/or flooding within customer's properties.

2.4.19 Areas with above average rainfall require larger assets to accommodate higher volumes of surface water run-off, with larger assets being more expensive to maintain[22]. This has been recognised by Ofwat[23]:

"The greater the volume of inflows into drainage and sewerage networks, the larger network and storage assets need to be, and the greater amount of pumping and capital maintenance costs are needed to: avoid sewer flooding incidents; avoid discharges of wastewater from storm overflows; and maintain good asset health."

2.4.20 Other environmental factors also act to exacerbate the detrimental effect of urban rainfall, in particular the prevalence of combined sewers. Urban rainfall can lead to rapid, material swings in the hydraulic capacity of combined sewers. Urban rainfall effectively reduces the capacity of combined sewers relative to an equivalent separated system that carries foul and surface water in separate pipes. In dry weather, this is not usually an issue. However, in times of heavy rainfall, the lack of hydraulic capacity relative to a separated system means that combined sewers are more likely to become overloaded and create operational challenges. This means that there is a compounding effect between urban rainfall and combined sewers - each factor acts to worsen the impact of the other. We set out a full range of other environmental factors in our Drainage cost adjustment claim[24].

2.4.21 The factors set out above will require that, in order to achieve a common target, companies operating in adverse regions will need to implement a different number and type of interventions relative to a company in a less adverse region, for example:

- More surface water separation;
- Increased network capacity;
- Increased storage; and,
- More SuDS and rainwater management.

2.4.22 These are clearly significant infrastructure requirements, which would cost a substantial amount to deliver and would potentially be considered uneconomic. It would also, by its nature, be extremely disruptive to local residents. This was recognised in the Government's SPS, which did not consider surface water separation to be a viable option: *"This evidence project estimates that the complete elimination of all storm overflows at coastal and inland waters by completely separating the sewer network would cost between £350 billion and £600 billion. It would also cause significant disruption. For example, most of the combined system runs under our towns and cities and would have to be dug up"*[25].

2.4.23 Importantly, companies operating in less adverse regions would not need to adopt these solutions and would find the common target relatively easy to hit as a result.

2.4.24 This means that there is not a level playing field between companies and without any associated adjustment being made in the regulatory contract, some companies will find it relatively easy to outperform regulatory assumptions whereas other companies will find it extremely challenging. This will create allocative inefficiency across the industry as a whole and some customers will pay too much for the service they receive as a result.

2.4.25 We do not consider that the most appropriate method to address this is through an adjustment to the cost models. The cost models allocate historical expenditure based upon the set of cost drivers. Historical base expenditure will not contain expenditure relating to the activities set out in paragraph 2.4.21 because these activities are enhancement by their nature. Therefore, even if an urban rainfall variable is included, a botex cost model will not provide sufficient expenditure to allow companies in

[22] UUW (2023) *Cost adjustment claim: drainage.* Available here.

[23] Ofwat (2023) *Econometric base cost models for PR24*. Available here.

[24] Please see '*UUW44 – Cost adjustment claims submission – update to claim*' for more information.

[25] Defra (2022) *Consultation on the Government's Storm Overflows Discharge Reduction Plan*. Available here.

environmentally adverse regions to achieve the same performance level as those in environmentally benign areas. (We note that including an urban rainfall variable would allow the models to reflect the more extensive maintenance requirements attributable to larger assets, but this will not facilitate a move towards equal performance levels.)

2.4.26 We consider that it is more appropriate to reflect the regional environmental challenges faced by each company by adjusting performance levels. This avoids the need for inefficient levels of investment and customer disruption that would be created by reconfiguring the sewer system. It will also ensure that each company is facing equivalently stretching performance targets. We provide more explanation and justification of this position within Appendix A of our drainage cost adjustment claim.

2.4.27 This means that **we do not include an urban rainfall variable within our cost model suite**. **This is because we are reflecting urban rainfall within our proposed Performance Commitment Level for internal sewer flooding**.

2.4.28 If Ofwat disagrees with UUW's position that the internal sewer flooding PCL should be adjusted to account for regional environmental factors, then we consider it is legitimate for urban rainfall to be reflected within the cost targets, noting however that this would not provide sufficient allocation of cost to enable UUW to achieve a common PCL for internal sewer flooding. We provide more explanation and justification of this position within section 7 and Appendix A of our drainage cost adjustment claim[26].

Weighted Average Treatment Size (WATS)

2.4.29 Within its consultation 'Base econometric models for PR24'[27] Ofwat introduced a variable that captures the average size of each company's WwTW, and in Appendix 3 of its consultation specifies WATS in the following way:

$$WATS = \sum_{n=1}^{6} \frac{Load_{band\ n}}{WwTW_{band\ n}} \times percentage\ of\ load\ in\ band_n$$

2.4.30 This can equivalently be written as:

$$WATS = \sum_{n=1}^{6} \frac{Load_n}{WwTW_n} \times \frac{Load_n}{Load}$$

2.4.31 Which in turn is equivalent to:

$$WATS = \sum_{n=1}^{6} \frac{Load_n^2}{WwTW_n \times Load}$$

2.4.32 In this way WATS can be seen to capture the economies of scale at each size band (through the non-linearity expected by economic theory), weighted by the relative mix of a company's WwTW across the size bands.

2.4.33 Therefore, we consider WATS to be an intuitive and compelling way to reflect economies of scale across all wastewater treatment works size bands. It best aligns to the engineering prior that economies of scale exist at WwTW because it reflects the non-linearity that defines economies of scale. Figure 4 illustrates the industry average value of WATS at each WwTW band. It's clear that WATS reflects an exponential relationship[28], which is the relationship engineering, operational and economic rationale predicts between cost and economies of scale at wastewater treatment works.

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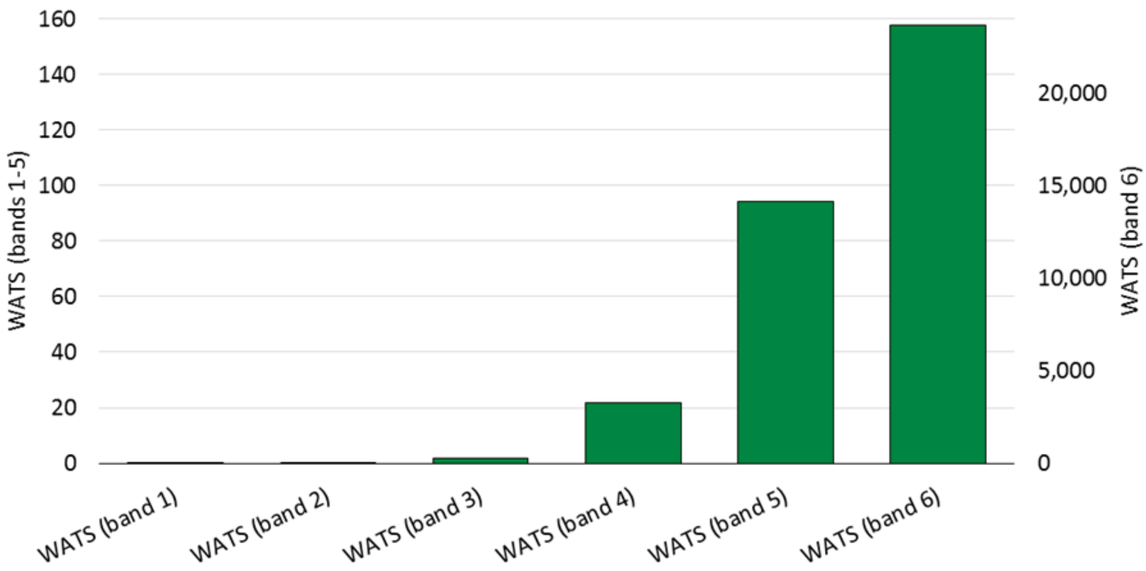
[26] UUW44 – Cost adjustment claims submission – update to claim

[27] Ofwat (2023) E*conometric base models for PR24.* Available here.

[28] We graphed WATS at band 6 on a different axis scale to facilitate comparisons.

Figure 4: WATS appropriately reflects non-linearity in economies of scale at WwTW



Source: Economies of scale at sewage treatment works derivation (Ofwat)

Percentage of population living in coastal areas

2.4.34 Southern Water has proposed a symmetrical cost adjustment claim relating to the cost pressures it faces by serving a region where the population centres are clustered in coastal areas. It sets out a number of different ways this can drive costs, including:

- More stringent discharge requirements at WwTWs in coastal areas;
- The saline environment drives maintenance costs through increased corrosion;
- Space constraints drive higher operational and maintenance costs because assets cannot be configured in an optimum way.
- Stricter spill frequency constraints drives additional costs relating to enhanced pumping, storm screening etc.

2.4.35 UUW was initially sceptical of Southern's proposal, and highlighted this within our response to the base econometric modelling consultation. We noticed that it would have resulted in a slight upward increase in our base cost allocation, despite us having a lower than average coastal population. We also noticed that Thames received an upwards cost allocation despite having no coastline and Wessex would have received a negative adjustment despite having an above average coastal population. At the time, Southern did not provide any evidence to justify why such apparently unintuitive reallocations were appropriate.

2.4.36 However, we consider that the evidence provided in Southern Water's cost adjustment claim addresses our previous concerns. As we discuss in detail in section 9.3, Southern highlights that there is a strong negative correlation between coastal population and company scale. Econometric theory is clear that we would expect downwards bias on a coefficient that is negatively correlated with the error term i.e. the coefficient is smaller than it would be in the absence of bias. In the case where coastal population is excluded from the model, then coastal population forms part of the error term and due to its negative correlation with scale, biases the scale coefficient downwards. This artificially reduces the power of the scale coefficient, which effectively under remunerates larger companies and over remunerates smaller companies.

2.4.37 Therefore, the apparently unintuitive reallocation of cost away from companies with a high coastal population and towards companies with low coastal populations is simply the result of removing an implicit bias from the model suite that favours smaller WaSCs. We consider this argument to be compelling and supported by empirical theory and evidence, as set out in Southern's claim. Therefore, we have adopted the variable within our model suite. We found the variable performed best when included within sewage treatment models only.

AMP5 dummy

2.4.38 We consider that there is clear evidence of a structural break in cost data when the totex-outcomes framework was introduced. As such, we attempt to control for this through the use of a dummy variable. We set out our evidence and justification for this approach in section 2.5.

Residential retail

2.4.39 Our residential retail model suite aligns to that used by Ofwat, with the exception of an economies of scale driver. As we set out in section 9.8, we consider that scale economies is within company management control. Two other companies have made statements supporting this position:

- Sutton and East Surrey highlights[29] that the choice of small retail operations is an active choice, made to improve customer service quality: *"There are consumer benefits from SES Water's relatively small-scale, local retail operations even though this increases our efficient costs of operation. We are able to better understand, and pay greater attention to, local stakeholder and our customer requirements, and maintain operations, such as our local call centre, that are highly valued by customers because they provide a bespoke and locally focused service that results from the company serving a relatively small supply area."* Service quality is already incentivised through performance measures such as C-Mex, which creates the risk of customers funding the same service twice if scale is also reflected in retail cost models.
- Southern Water states[30] that it has relocated its customer service centre to Yorkshire to reduce costs: *"Our HR strategy has been to locate such roles outside our area to lower wage regions where this is beneficial to customers, in order to mitigate the exposure to higher wages in the South East. This has included relocating our retail customer service contact centre to Yorkshire."* This also helps to demonstrate the the functional form of retail operations is within management control.

2.4.40 We continue to strongly support the use of deprivation variables within cost assessment to provide a *'propensity to default'* cost driver and the use of bill size to reflect the overall amount of revenue at risk. As we set out in paragraph 2.9.6, bill size should include Direct Procurement for Customers (DPC) revenues and forecasts shold be stated in outturn prices.

2.5 Should the model take account of intertemporal effects?

2.5.1 Over time, the relationship between cost and cost driver can change. This could be due to:

- Legislation e.g. where a more stringent permit leads to higher treatment cost per customer;
- External environmental factors e.g. where a changing climate leads a company to adopt a different mix of interventions to that implemented in the past;
- Wider economic factors e.g. supply side shortages could drive up the cost of capital solutions; or
- A change in regulatory approach e.g. the move to a totex-outcomes approach at PR14 could represent a structural break if it led companies to change the way they deliver their services.

2.5.2 It is important for cost assessment to account for these changing relationships. This relates to the concept of external validity which we introduced in our Future Ideas Lab paper[31]. The manner in which cost assessment accommodates such changes should vary to ensure that companies face appropriate incentives. For example, a more stringent permit can be reflected in the cost driver forecasts used to derive the forward-looking benchmark (see section 0). A changing climate may require a step-change in

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[29] SES (2023) *Retail scale*. Available here.

[30] SRN (2023) *Regional labour costs.* Available here.

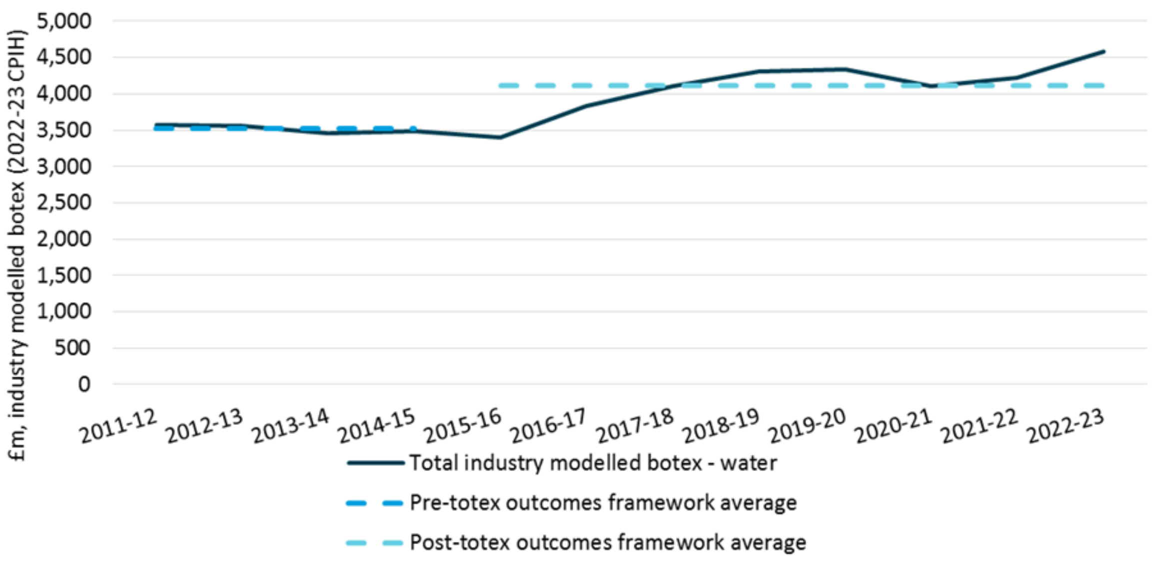
[31] UUW (2021) *The Principles of Regulatory Cost Assessment*. Available here.

resilience enhancement expenditure to ensure services to customers are unaffected. An economy-wide increase in capital costs can be accommodated through the use of forward-looking enhancement models to ensure that the benchmark doesn't reflect lower capital costs seen in the past (see section 4). We consider the most appropriate way to reflect a structural break within cost assessment is through the adoption of a dummy variable.

2.5.3 We first need to assess whether there is evidence that a structural break exists. Our hypothesis is that the introduction of the totex-outcomes framework led to a step-change in base expenditure across the industry, as companies targeted better performance without an associated enhancement allowance. If this hypothesis holds, then we would expect to see a step up when comparing AMP5 base expenditure (pre-totex-outcomes) and base expenditure in subsequent AMPs.

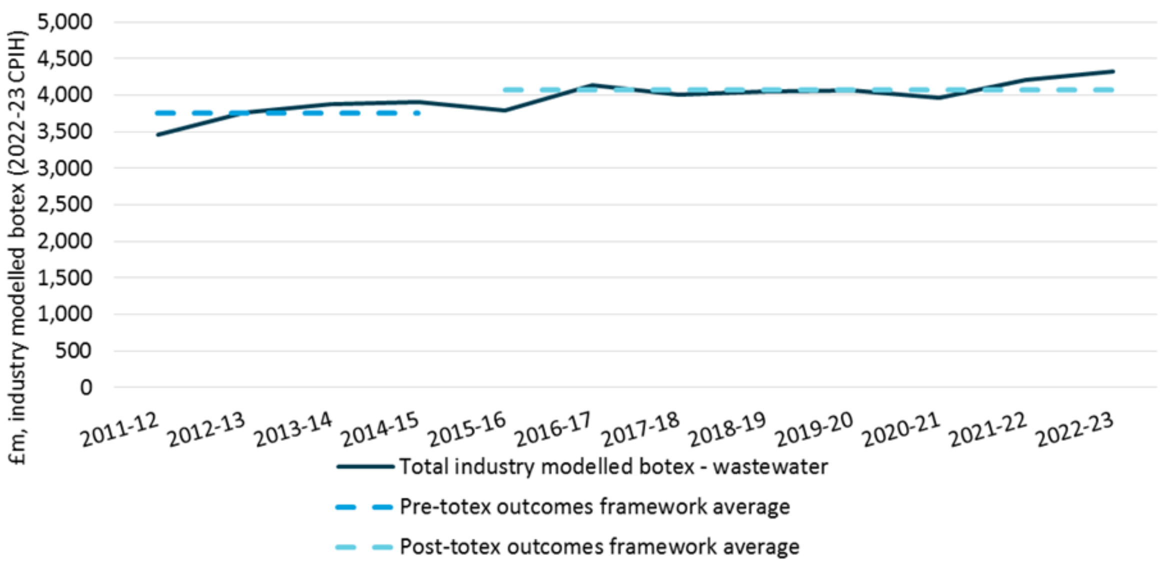
2.5.4 As Figure 5 and Figure 6 show, this pattern can be found in the industry' historical costs, although the step-up is much more pronounced in water than in wastewater.

Figure 5: Outturn water base expenditure



Source: PR24 water base cost dataset (Ofwat)

Figure 6: Outturn wastewater base expenditure

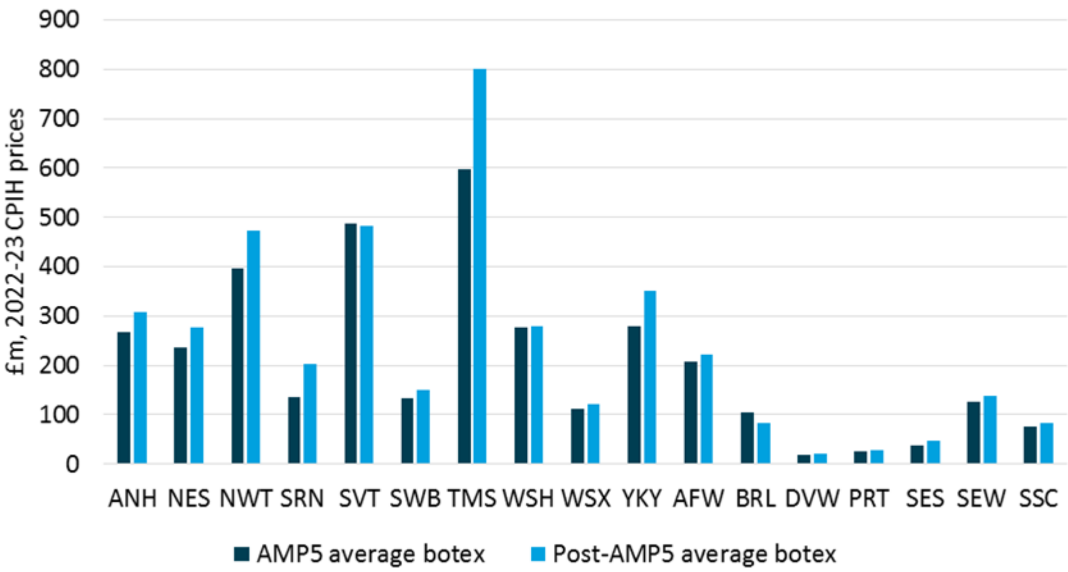


Source: PR24 wastewater base cost dataset (Ofwat)

The differences in expenditure across these periods by company are illustrated in Figure 7 and Source: PR24 water base cost dataset (Ofwat)

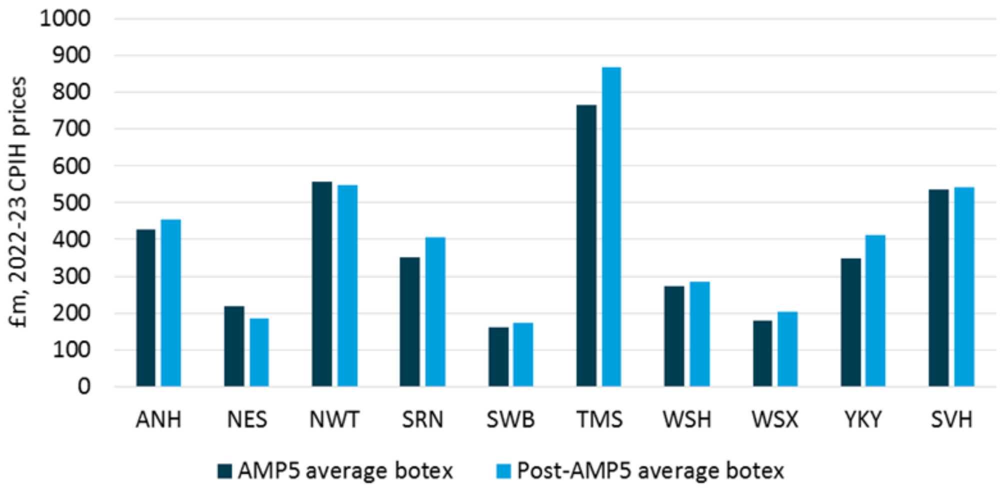
2.5.5 Figure 8. These differences are statistically significant at the 5 percent level for water (p value = 0.02) and the 10 percent level for wastewater (p value = 0.06). The slightly weaker result for wastewater was expected given the slightly smaller difference in expenditure between the two periods illustrated in Figure 6. These results hold when data from 2022-23 is excluded – this is relevant because there was a general increase in prices in this year due to increased energy costs.

Figure 7: Differences in botex between AMP5 and subsequent periods, by company



Source: PR24 water base cost dataset (Ofwat)

Figure 8: Differences in botex between AMP5 and subsequent periods, by company



Source: PR24 wastewater base cost dataset (Ofwat)

2.5.6 We consider that this is clear evidence of a structural break within the dataset. There are alternative ways to reflect this within cost assessment:

(1) Exclude data from years prior to the structural break to remove any unrepresentative years from the dataset;

(2) Include a dummy variable to capture the effect of the period prior to the introduction of the totex outcomes framework; or

(3) Ignore the structural break.

2.5.7 We do not consider (1) to be appropriate; a smaller dataset would affect the precision of the model estimates and could result in an inappropriate benchmark as a result. Likewise, we do not consider (3) to be appropriate; failure to account for the period prior to the introduction of the totex-outcomes framework will mean that cost assessment does not fully reflect the cost pressures that are created by the current regulatory regime.

2.5.8 Therefore, we adopt (2) within our cost assessment proposal and **test a dummy variable within our cost models that 'turns on' for all years prior to the start of AMP6 and 'turns off' for all subsequent years**. We found that this variable performed well within all water models but poorly within some wastewater models. Therefore, we only include the dummy variable in models where it has an intuitive negative sign.

2.5.9 Ofwat has also highlighted the possibility of using a a dummy variable within an interaction term to control for the effect of structural breaks[32]. This would be necessary in the case where the structural break affects both the constant and the relationship between cost and cost driver. However, while using a dummy variable within an interaction term may facilitate better control of, for example, treatment complexity variables in future periods as discharge consents tighten, we do not implement this approach in our proposal for PR24.

2.6 What functional form and estimation method is most appropriate?

Functional form

2.6.1 The functional form of a model refers to the way that model attempts to reflect the relationship between the independent variables and the dependent variable. At PR14, Ofwat implemented a translog functional form, which while extremely flexible, was difficult to interpret and was found to be unstable and at odds with engineering rationale[33]. At PR19, Ofwat used the simpler Cobb-Douglas function form, which is widely used within the economic field and as such is more accessible and transparent.

2.6.2 In principle, we consider that we should strive for simplicity unless there is compelling engineering, operational or economic rationale to add additional complexity to the process. As such, **we support the continued use of the Cobb-Douglas functional form at PR24.**

Estimation method

2.6.3 The estimation method refers to the type of statistical process used to 'estimate' the relationship between dependent and independent variable. Common estimators used within the field of econometrics include Ordinary Least Squares (OLS), fixed effects and random effects.

2.6.4 We consider the choice of estimator is largely an empirical matter. While fixed and random effects are able to reflect the panel structure of the dataset, we still consider OLS to be a legitimate choice (providing cluster robust standard errors are used). However, we do discount fixed effects because it requires the assumption that the company-specific effect is fixed over time, which is not realistic as it implicitly assumes companies don't respond to incentives to become more efficient and improve performance. Therefore, we implement the Breusch-Pagan LM test to choose between OLS and random effects estimation. Generally, this test prefers random effects so **we adopt random effects estimation in our model suite**.

2.6.5 We also consider it is legitimate to choose between estimators depending upon the estimate's alignment with engineering, operational and economic rationale. For example, if random effects

[32] Ofwat (2021) *Assessing base costs at PR24.* Available here.

[33] Arup and Vivid Economics (2017) *Understanding the exogenous drivers of wholesale wastewater costs in England and Wales.* Available here.

produced a model with unintuitive coefficients, then it would be entirely appropriate to implement OLS estimation instead if this produced more sensible results.

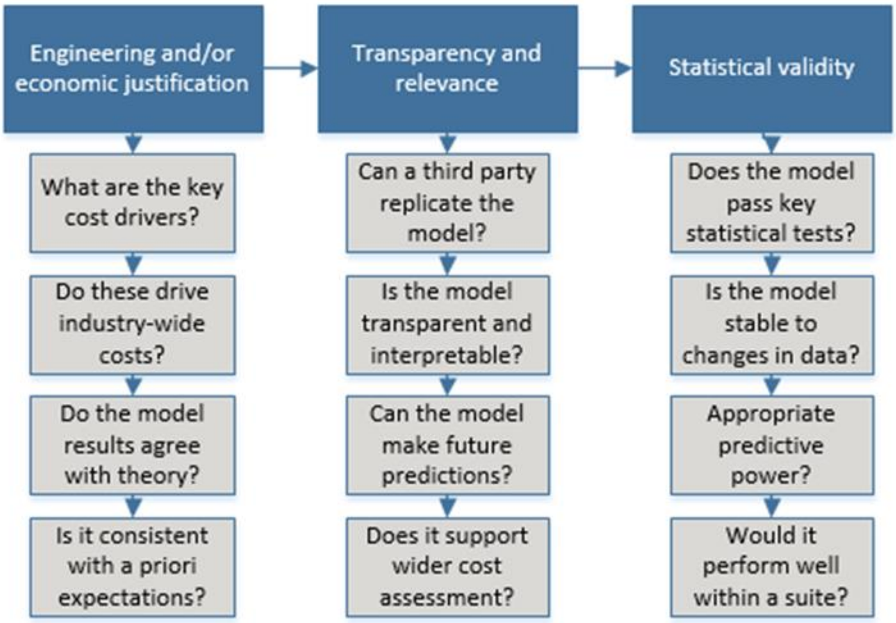
2.7 What tests should be used to determine which models are most appropriate?

2.7.1 Model selection criteria apply an objective series of tests to proposed models to determine the most appropriate set of models to use within cost assessment. The structure of the criteria should promote models with strong underlying engineering and economic narratives.

2.7.2 For example, within our Future Ideas Lab paper[34] we sequenced our model selection criteria deliberately to place the greatest emphasis on engineering and economic justification. This does not mean that we do not value statistical validity; this structure simply helps aid the assessment of models with strong engineering priors.

2.7.3 As Figure 9 illustrates, our starting point for model selection is the engineering and economic narrative underpinning a model. This will ensure that models which are best able to reflect the relationship between cost and cost driver (now and in the future) are taken forward, while models which could produce spurious relationships are not considered further.

Figure 9: UUW's model selection criteria



Source: UUW's PR19 cost assessment proposal

2.7.4 Once we have established that a model is consistent with the relevant theory, we assess the model's transparency and relevance as part of the second step. To understand the importance of this step, we need to remember that benchmarking is one of several components of cost assessment. Opaque models will mask any cross-over between the different components, possibly resulting in companies being compensated twice or not at all.

2.7.5 For the final step of our model selection criteria, we assessed the statistical performance of the model. Any model assessed at this point was grounded in engineering logic and complemented the wider cost assessment process. Applying statistical performance as a final test allowed us to choose the models most able to make robust forecasts of cost. We deliberately considered the statistical performance of a model last to discourage data fitting. Placing any emphasis on data fitting would dilute the focus on

[34] UUW (2021) *The Principles of Regulatory Cost Assessment*. Available here.

engineering narratives, which would objectively reduce the ability of the model suite to make predictions based on causal evidence

2.7.6 Appendix A contains full details on our approach to model selection.

2.8 What is the best way to triangulate the results of the model suite?

2.8.1 A diverse model suite has a variety of different cost aggregations, along with a variety of models *within* cost aggregations. Triangulation refers to the way that these different models and aggregations are combined to derive a single benchmark for each of the water, wastewater and retail services. Triangulation also affects the efficiency adjustment as it influences the spread of residuals around the triangulated benchmark.

2.8.2 Historically, Ofwat has tended to triangulate using a simple average, with some exceptions[35]. A simple average approach implicitly assumes that each model or cost aggregation is equally capable of predicting costs for each company. This assumption may be appropriate where companies are relatively homogenous because it might be reasonable to expect that a parsimonious model suite is able to reflect key differences without further adjustments to the approach. However, in cases where companies are heterogeneous or there is the potential for omitted variable bias, then simple averaging may not be the most appropriate approach. This is because averaging could potential place too much weight on models that are unsuited to predict a particular company's costs, which could result in a company receiving too high a cost allowance and its customers paying too much.

2.8.3 We consider that there is scope to build upon Ofwat's PR19 approach by adopting a **targeted approach** to triangulation. This would triangulate models and cost aggregations depending upon their predictive ability for each individual company. Companies are heterogeneous and certain cost drivers may be better suited to some companies and poorly suited to others. Targeted triangulation would ensure that companies receive an appropriate benchmark based upon the objective ability of the models to predict each individual company's costs.

2.8.4 This effect would be symmetrical; targeted triangulation can result in a lower cost allowance for some companies and a higher one for others. However, the subsequent benchmark would be a more realistic basis on which to set cost targets for AMP8.

Evidence from international regulators

2.8.5 There are a number of instances where regulators have historically used a more targeted approach to triangulation as a method of correcting for modelling deficiencies. The German energy regulator, Bundesnetzagentur, utilises both SFA and DEA[36] approaches when developing their benchmarks for each distribution system operator (DSO). Accepting that neither statistical method is perfect and that the different approaches will have varying success in predicting required expenditure for individual companies, they determine the actual efficiency score using a 'best off approach' whereby the maximum efficiency score is applied, with a minimum of 60%[37].

$$ES = \max(DEA_1, DEA_2, SFA_1, SFA_2, 0.6)$$

[35] For example, the top-down and bottom-up retail model splits at PR19 were weighted 75:25 respectively, although limited justification for this position was provided.

[36] Stochastic frontier analysis (SFA) and data envelopment analysis (DEA) are alternative statistical approaches for the estimation of comparative benchmarks.

[37] WIK-Consult (2011) *Cost benchmarking in energy regulation in European countries.* Available here.

2.8.6 The same principle is applied within the regulation of Austrian gas distribution but in this case, the weighting assigned to the 'best off' estimation method (DEA and MOLS[38]) is pre-determined using a 60/40 ratio with the larger weighting applied to the models that give the highest efficiency score.

$$ES = 0.6 \times \max(DEA, MOLS) + 0.4 \times \min(DEA, MOLS)$$

"The weighting of the different approaches is a compromise between industry and the regulator. Originally, the regulator argued in favour of an equal weighting of DEA(average) and MOLS(average), whereas the industry preferred a best-off calculation, which means that the highest score of all four models should be used to determine the cost reduction requirements"[39].

2.8.7 The next section sets out our proposals for how similar concepts can be adapted for use in England and Wales. Rather than focusing upon an approach which leaves the regulated company 'better off' as in the above examples, our method of triangulation prioritises models and cost aggregations which are objectively better predictors of expenditure for each individual company. The result is a symmetric approach that may be beneficial for some companies but may in fact be detrimental for others (e.g. those companies whose costs are unusually low relative to the modelled benchmark).

Our proposed approach to targeted triangulation

2.8.8 At PR19, we developed an approach to targeted triangulation, which we consider remains a credible and robust way to minimise the spread of residuals across an entire model suite[40]. In our view, minimising the spread of the residuals represents a better outcome than applying arbitrary weights to individual models because it addresses both over and under predictions symmetrically. This may help to avoid a situation where a company's cost allowance has to be capped because the models appear to be over predicting cost requirements, as happened with Portsmouth Water at PR19[41].

2.8.9 Our approach gives greater weight within triangulation to models or cost aggregations that lead to a smaller residual *for a particular company*. So for example, a model or cost aggregation that produced a residual of 1.01[42] for a particular company would receive greater weight than a model that produced a residual of 1.05. Likewise, a model that produced a residual of 0.99 for a particular company would receive greater weight than a model producing a residual of 0.95.

2.8.10 Table 4 sets out UUW's approach to targeted triangulation in more detail. This framework allows the user to set the strength of the targeted triangulation in line A. Setting this to 0% would result in a simple average approach to triangulation. Conversely, setting this to a high number (e.g. 1000%) would result in an extremely targeted approach to triangulation, with much greater weight being given to the most predictive model or suite. We would expect increasing strengths of targeted triangulation to be associated with a smaller spread of residuals overall, all else equal.

2.8.11 We have set the targeted triangulation strength to 50% because we consider this to be a reasonable compromise between an approach whereby all weight is placed upon the most predictive model and an approach where all models are weighted equally.

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[38] MOLS = modified ordinary least squares

[39] WIK-Consult (2011) *Cost benchmarking in energy regulation in European countries.* Available here.

[40] UUW (2018) *Cost assessment proposal.* Available here.

[41] Ofwat (2019) *Securing cost efficiency technical appendix*. Available here.

[42] A residual of this size would represent a situation where actual costs are one percent higher than predicted costs. Technically, the residual reflects the actual difference to the model prediction.

Table 4: UUW's approach to targeted triangulation

Number of models to trianguate	1	2	3	4	5	Ref
Targeted triangulation strength (0=simple averaging)	50%	50%	50%	50%	50%	A
This matrix uses the strength of targeted triangulation input from the top row to assign a relative weighting to each mode/suite. The model/suite with the best predictive power for a single company receives the weighting on the bottom row (150%). A further calculation is required to ensure sum of models/suites doesn't exceed 100%.	100%	100%	100%	100%	100%	B
		150%	100%	100%	100%	
			150%	100%	100%	
				150%	100%	
					150%	
Sum of B (used to ensure that triangulation sums to 100%)	1	2.5	3.5	4.5	5.5	C
This matrix uses the relative weightings calculated above to assign a triangulation value to the model/suite with the best predictive power for a company e.g. where there are two models, the 'better' model would receive a triangulation value of 60%.	100%	40%	29%	22%	18%	D
		60%	29%	22%	18%	
			43%	22%	18%	
				33%	18%	
					27%	

Source: UUW analysis

2.9 How can cost drivers best be forecast to ensure the benchmark is externally valid?

2.9.1 As we set out in our Future Ideas Lab paper[43], it is important for cost assessment to have external validity, meaning that it appropriately reflects future cost pressures. It is possible for these cost pressures to be different to those reflected in the historical cost record. For example, companies are increasingly having to comply with phosphorous permits at or approaching the technically achievable level, and the associated costs do not feature in the historical dataset.

2.9.2 There are main two avenues to address this within cost assessment:

(1) Submit a cost adjustment claim to seek an out-of-model adjustment. This may be necessary if the cost pressure is entirely new and not reflected in the historical dataset.

(2) Reflect changes in future cost drivers within the forecasts used to derive the upcoming AMP's botex requirements. This is appropriate in cases where the historical relationship between cost and cost driver can be expected to hold into the future.

2.9.3 This section covers the best approach to take when considering (2) above. Our cost adjustment submissions describe UUW's use of (1) (see *'UUW44 – cost adjustment submission'* for more details).

2.9.4 There are four main alternative approaches to forecasting cost drivers:

(1) Use a linear trend. A linear trend is most appropriate for cost drivers which can be reasonably expected to grow at a relatively constant rate over time.

(2) Use historical values. If a cost driver is expected to be relatively static over time, it may be appropriate to project historical values forward. Alternatively, if a cost driver is relatively volatile and its future values cannot be reasonably forecasted, it may be appropriate to take an average over the historical period.

[43] UUW (2021) *The Principles of Regulatory Cost Assessment*. Available here.

(3) Use company forecasts. Company forecasts are appropriate for cost drivers which are expected to exhibit a structural break in a future period, which a linear trend or historical data cannot reasonably be expected to reflect.

(4) Use a third party source. Third parties may produce independent forecasts that can inform the forecasts used in cost assessment. In certain circumstances, this could be an appropriate way to increase the robustness of forecasts while limiting the extent of company control.

2.9.5 Table 5,Table 6, Table 7 and Table 8 set out the approach we have taken to forecasting each of the cost drivers used in our models suite[44]. We set out specific comments relating to forecasting revenue at risk for the Residential Retail price control.

Forecasting 'revenue at risk' for Residential Retail cost targets

2.9.6 Revenue at risk captures the total amount of revenue at risk if a customer defaults on their bill. This tends to be reflected using average bill size per customer. There are two specific issues we consider need appropriate thought at PR24:

- Residential Retail is a nominal control, meaning no adjustment is made for the effect of inflation. However, wholesale revenues are indexed to inflation. This means that the amount of revenue at risk will increase each year, in line with inflation, but Residential Retail's revenue cap will not. As such, **forecasts of bill size should be expressed in nominal terms**. Expressing bill size in real terms will subject Residential Retail's revenues to a significant implicit efficiency challenge.
- Direct Procurement for Customers (DPC) is recovered via customer bills. This means that it increases the overall element of revenue at risk for the retail provider. As such, **DPC revenues should be included in forecasts of bill size**.

[44] We note that we have not utilised this approach to forecast other companies' cost drivers. This is because we do not have access to other companies' submissions at the time of writing.

Table 5: UUW's approach to forecasting water cost drivers

Variable code	Description	Forecast method	Justification
properties	Number of connected properties	Forecast based upon historical trend	Variable grows in a predictable way and there is a large historical sample to ensure the prediction is robust.
lengthsofmain	Length of water mains	Forecast based upon historical trend	Variable grows in a predictable way and there is a large historical sample to ensure the prediction is robust.
pctwatertreated36	Percent of water treated in water treatment works with complexity levels 3 to 6	Company forecast	Variable will depend upon interventions being carried out by the company in AMP8. Therefore, forecast needs to align to the business plan to ensure cost assessment reflects the additional cost pressures companies will face.
wac	Water treatment complexity index	Company forecast	Variable will depend upon interventions being carried out by the company in AMP8. Therefore, forecast needs to align to the business plan to ensure cost assessment reflects the additional cost pressures companies will face.
boosterperlength	Number of booster pumping stations per length of mains	Based upon last year of available data	Exogenous to company control and it is intuitive to assume a constant relationship between mains length and number of pumps into the future i.e. a bigger network will need more pumps
propperlength	Number of properties per length of mains	Derived from other forecasts	Calculated directly from the forecasts above.
WAD_MSOAtoLAD_population	Weighted average population density based on LAD from MSOA	Based upon last year of available data	Population projections unavailable at MSOA level. Population density increases over time, so using last year of available data acts as an implicit productivity challenge.

Table 6: UUW's approach to forecasting wastewater cost drivers (excluding bioresources)

Variable code	Description	Forecast method	Justification
properties	Number of connected properties	Forecast based upon historical trend	Variable grows in a predictable way and there is a large historical sample to ensure the prediction is robust.
sewerlength	Total sewer length (legacy and formerly private)	Forecast based upon historical trend	Variable grows in a predictable way and there is a large historical sample to ensure the prediction is robust.
load	Load entering WwTWs	Forecast based upon historical trend	Variable grows in a predictable way and there is a large historical sample to ensure the prediction is robust.
pumpingcapperlength	Pumping capacity per km of sewer	Company forecast	Exogenous to company control and it is intuitive to assume a constant relationship between sewer length and number of pumps into the future i.e. a bigger network will need more pumps
pctnh3below3mg	Percentage of load with ammonia consent below 3mg/l	Company forecast	Variable will depend upon interventions being carried out by the company in AMP8. Therefore, forecast needs to align to the business plan to ensure cost assessment reflects the additional cost pressures companies will face.
density	Number of properties per km of sewer length	Derived from other forecasts	Calculated directly from the forecasts above.
pct_coastal	Percentage of opulation living in proximity to the coast	Based upon last year of available data	There is no reliable way to forecast this variable. Variable is relatively static so last year of available data is considered appropriate.
urbanrainfallperlength	Urban rainfall from MSOA excluding soil permeability, per sewer length	Average over the historical period in the dataset	The weight of evidence suggests that climate change will lead to more intense rainfall. Using most recent years in the forecast will maximise the extent to which cost assessment reflects an appropriate forward look, while minimising the risk that low/high rainfall in any one year unduly affects the outcome. We note that backward-looking rainfall is likely to result in a conservative estimate due to the reasons set out above.
WATS	Weighted Average Treatment Size (WATS)	Company forecast	Variable will depend upon interventions being carried out by the company in AMP8. Therefore, forecast needs to align to the business plan to ensure cost assessment reflects the additional cost pressures companies will face.
WAD_MSOA_population	Weighted average population density based on MSOA, weighted by population	Based upon last year of available data	Population projections unavailable at MSOA level. Population density increases over time, so using last year of available data acts as an implicit productivity challenge.
WAD_MSOAtoLAD_population	Weighted average population density based on LAD from MSOA	Based upon last year of available data	Population projections unavailable at MSOA level. Population density increases over time, so using last year of available data acts as an implicit productivity challenge.

Table 7: UUW's approach to forecasting Bioresources cost drivers

Variable code	Description	Forecast method	Justification
sludgeprod	Total sludge produced	Company forecast	Sludge produced is outside of Bioresources management control. The WINEP programme will result in materially larger volumes of sludge, meaning a historical trend is unsuitable.
pctbands13	Percentage of load treated at WwTWs with size band 1-3	Company forecast	Variable will depend upon interventions being carried out by the company in AMP8. Therefore, forecast needs to align to the business plan to ensure cost assessment reflects the additional cost pressures companies will face.
swtwperpro	Number of WwTWs per property	Company forecast	Variable will depend upon interventions being carried out by the company in AMP8. Therefore, forecast needs to align to the business plan to ensure cost assessment reflects the additional cost pressures companies will face.
WAD_MSOA_population	Weighted average population density based on MSOA, weighted by population	Based upon last year of available data	Population projections unavailable at MSOA level. Population density increases over time, so using last year of available data acts as an implicit productivity challenge.
WAD_MSOAtoLAD_population	Weighted average population density based on LAD from MSOA	Based upon last year of available data	Population projections unavailable at MSOA level. Population density increases over time, so using last year of available data acts as an implicit productivity challenge.

Table 8: UUW's approach to forecasting Residential Retail cost drivers

Variable code	Description	Forecast method	Justification
hh_t	Total households connected	Forecast based upon historical trend	Variable grows in a predictable way and there is a large historical sample to ensure the prediction is robust.
hhdu_hh	Percentage of households receiving water and wastewater services (dual service)	Set equal to last available year	Variable is unlikely to move materially relative to last available year of data.
rev_hh	Revenue per household	Company forecast	Variable will depend upon interventions being carried out by the company in AMP8. Therefore, forecast needs to align to the business plan to ensure cost assessment reflects the additional cost pressures companies will face. The forecast should be stated in **nominal terms**, because retail is a nominal price control. Using real terms would understate the increase in revenue at risk associated with increases in average bill size. DPC revenues should also be included.
eq_lpcf62	Equifax - Insight Postcode Event - % of households with default	Set equal to last available year	Variable is unlikely to move materially relative to last available year of data.
eq_xpcf2	Equifax - Average number of Partial Insight accounts or county court judgements per household	Set equal to last available year	Variable is unlikely to move materially relative to last available year of data.
incomescore_interpolated	Combined Income Score for England and Wales (IMD) - interpolated	Set equal to last available year	Variable is unlikely to move materially relative to last available year of data.
Covid20	Dummy variable set = 1 if financial year is 2019-20	Set to zero	Setting the dummy variable to zero ensures the model excludes the year-specific effects in 2019-20
Covid21	Dummy variable set = 1 if financial year is 2020-21	Set to zero	Setting the dummy variable to zero ensures the model excludes the year-specific effects in 2020-21

2.9.7 Table 9, Table 10, Table 11 and Table 12 set out the resulting cost driver forecasts used in our cost assessment proposal.

Table 9: Water cost driver forecasts

Variable code	2025-26	2026-27	2027-28	2028-29	2029-30
properties	3,493,919	3,514,989	3,536,059	3,557,129	3,578,199
lengthsofmain	43,162	43,288	43,413	43,538	43,663
pctwatertreated36	86.4	86.4	86.4	86.4	86.4
wac	4.84	4.84	4.84	4.84	4.85
boosterperlength	0.013	0.013	0.013	0.013	0.013
propperlength	80.95	81.20	81.45	81.70	81.95
WAD_MSOAtoLAD_population	1,862	1,862	1,862	1,862	1,862
WAD_MSOA_population	3,231	3,231	3,231	3,231	3,231

Source: UUW analysis

Table 10: Wastewater cost driver forecasts (excluding Bioresources)

Variable code	2025-26	2026-27	2027-28	2028-29	2029-30
properties	3,514	3,537	3,560	3,584	3,607
sewerlength	79,929	80,180	80,432	80,683	80,935
load	564,680	567,582	570,484	573,385	576,287
pumpingcapperlength	1.34	1.34	1.34	1.34	1.34
pctnh3below3mg	55.46	58.43	58.41	58.39	58.37
density	43.96	44.12	44.27	44.42	44.56
pct_coastal	11.43	11.43	11.43	11.43	11.43
urbanrainfallperlength	0.07	0.07	0.07	0.07	0.07
WATS	19,998	20,069	20,142	20,210	20,276
WAD_MSOA_population	3,211	3,211	3,211	3,211	3,211
WAD_MSOAtoLAD_population	1,854	1,854	1,854	1,854	1,854

Source: UUW analysis

Table 11: Bioresources cost driver forecasts

Variable code	2025-26	2026-27	2027-28	2028-29	2029-30
sludgeprod	213.1	214.5	215.7	216.6	217.5
pctbands13	1.48	1.45	1.43	1.43	1.43
swtwperpro	0.0002	0.0002	0.0002	0.0002	0.0002
WAD_MSOA_population	3,211	3,211	3,211	3,211	3,211
WAD_MSOAtoLAD_population	1,854	1,854	1,854	1,854	1,854

Source: UUW analysis

Table 12: Residential retail cost driver forecasts

Variable code	2025-26	2026-27	2027-28	2028-29	2029-30
hh_t	3,255,733	3,287,613	3,319,494	3,351,375	3,383,256
hhdu_hh	95	95	95	95	95
rev_hh	519.9	558.3	581.5	615.1	668.3
eq_lpcf62	28.5	28.5	28.5	28.5	28.5
eq_xpcf2	2.6	2.6	2.6	2.6	2.6
incomescore_interpolated	16.1	16.1	16.1	16.1	16.1
Covid20	0	0	0	0	0
Covid21	0	0	0	0	0

Source: UUW analysis

2.10 Our model suite

2.10.1 The previous section has set out UUW's approach to deriving base cost models.

2.10.2 Table 13, Table 14 and Table 15 sets out the final suite of models. The coefficients in each model are multiplied by the relevant forecast of the cost driver to calculate an estimated forecast cost. This is then combined with other assumptions on efficiency (see section 5) and triangulation (see section 2.8) to derive an efficient forecast cost.

2.10.3 We set out a summary of key assumptions and modelling decisions we have made in arriving at this final model suite below:

- **We do not include a cost driver relating to urban rainfall or combined sewers.** While we are clear that these regional factors drive challenges for our business, we consider that reflecting these factors within relevant Performance Commitment Levels (PCLs) represents the most efficient outcome. As we have reflected both of these factors within our proposed target for the internal sewer flooding PCL, we have excluded them from our botex model suite (see section 2.4).
- **We exclude average pumping head.** We have serious concerns about the underlying data quality and have demonstrated that it results in patently implausible swings in industry allowances (see section 2.4 and section 9.2).
- **We use the recommended water treatment complexity variables.** These variables group water treated into different complexity bands, but do not distinguish between surface water and ground water. Operational rationale demonstrates surface water is associated with more variable water quality. Therefore, we consider that a more preferable approach would be to use a treatment complexity variable that distinguishes between surface water and ground water sources. We have not yet been able to develop a robust variable of this kind but we will continue to explore this issue.
- **We focus upon Ofwat's Weighted Average Treatment Size (WATS) variable.** We strongly support this variable and consider it to be a compelling way to capture economies of scale at treatment works relative to the variables used at PR19. This is because it doesn't impose restrictions upon the model's ability to estimate a relationship between a treatment works size and its associated running cost. This is in contrast to the other economies of scale variables (percentage of load treated in bands 1-3 and percentage of load treated in WwTW serving more than 100,000 people), which impose restrictions on the ability of the model to find an appropriate relationship between cost and cost driver. The specification of these variables assumes that diseconomies of scale begin at size band 3 and below and that economies of scale begin at treatment works serving more than 100,000. While we do not consider these to be unrealistic assumptions, they are to an extent arbitrary in that alternative thresholds could also legitimately be chosen. While the use of such 'threshold' variables is entirely legitimate in the absence of a superior alternative, we consider that the existence of

WATS means that these variables should not be considered further as explanatory factors for economies of scale at wastewater treatment works.

- **We include an AMP5 dummy variable.** This ensures that the structural break created by the move to the totex-outcomes framework does not introduce bias into the modelled estimates. In some wastewater models, the dummy variable has an unintuitive sign and so has been dropped (see section Appendix A).
- **We incorporate Southern Water's coastal population variable.** We consider the evidence presented in Southern's cost adjustment claim to be compelling and as such we incorporate the percentage coastal population variable into our model suite (see section 9.3).
- **We include all Bioresources models developed by Ofwat**. We have found the quality of Bioresources models to be generally poor and all models fail our model selection criteria. Nevertheless, we have included them all because using a wide range of models mitigates the impact of any one poor quality model impacting the results. We consider the poor quality of models to be caused by excluded cost drivers but we have not been able to develop robust variables to reflect these cost drivers[45]. We also consider poor model quality to be caused by substitution effects.
- **We implement a Bioresources Plus cost aggregation.** This is because there is strong engineering rationale to suggest that extensive substitution effects exist between wastewater treatment and Bioresources and empirical evidence supports this rationale. We do not consider that the use of a Bioresources Plus cost aggregation undermines a competitive market within Bioresources or wider regulatory objectives. In fact, fair representation of substitution effects across the industry will ensure that the competitive market receives efficient price signals. It will also prevent companies with a relatively low Bioresources asset allocation unduly benefitting from the 100:100 cost sharing rates Bioresources is subject to.

[45] We made some suggestions as part of our response to Ofwat's consultation 'Base econometric modelling for PR24' but our proposals did not seem to be accepted by Ofwat.

Table 13: UUW's final suite of water botex models

	WRP1	WRP2	WRP5	WRP6	TWD1	TWD3	W1	W2	W5	W6
Number of properties (log)	1.077***	1.075***	1.032***	1.030***			1.068***	1.058***	1.041***	1.034***
	{0.000}	{0.000}	{0.000}	{0.000}			{0.000}	{0.000}	{0.000}	{0.000}
Percentage of water treated in complexity bands 3-6	0.003*		0.003*				0.002*		0.002*	
	{0.066}		{0.058}				{0.062}		{0.071}	
Weighted average density – MSOA to LAD (log)	-1.394**	-1.354*			-2.733***		-1.831***	-1.661***		
	{0.028}	{0.056}			{0.000}		{0.001}	{0.001}		
Weighted average density – MSOA to LAD (log) squared	0.085**	0.082*			0.216***		0.128***	0.116***		
	{0.037}	{0.072}			{0.000}		{0.000}	{0.001}		
AMP5 dummy	-0.078	-0.076	-0.084	-0.081	-0.061*	-0.052	-0.058	-0.046	-0.059	-0.047
	{0.177}	{0.139}	{0.138}	{0.110}	{0.065}	{0.119}	{0.144}	{0.244}	{0.130}	{0.229}
Weighted average treatment complexity (log)		0.24		0.253				0.331**		0.325**
		{0.313}		{0.282}				{0.045}		{0.043}
Properties per km of main (log)			-6.840*	-6.749*		-15.726***			-11.633***	-10.738***
			{0.072}	{0.082}		{0.000}			{0.000}	{0.000}
Properties per km of main (log) squared			0.736*	0.724		1.972***			1.345***	1.240***
			{0.099}	{0.111}		{0.000}			{0.000}	{0.000}
Length of main (log)					1.066***	1.065***				
					{0.000}	{0.000}				
Number of booster pumping stations per km of main (log)					0.299***	0.305***	0.303**	0.327***	0.228**	0.246**
					{0.003}	{0.002}	{0.011}	{0.006}	{0.044}	{0.041}
Constant	-5.455***	-5.663***	5.38	5.108	3.880**	26.641***	-2.195	-2.868*	16.463***	14.429***
	{0.001}	{0.005}	{0.491}	{0.525}	{0.015}	{0.000}	{0.181}	{0.079}	{0.001}	{0.004}
Sample size	204	204	204	204	204	204	204	204	204	204
R squared	0.903	0.898	0.905	0.902	0.956	0.959	0.963	0.966	0.964	0.966
Ramsey RESET test	0.581	0.488	0.396	0.281	0.076	0.48	0.217	0.105	0.248	0.102

Source: UUW analysis

Table 14: UUW's final suite of wastewater botex models

	SWC1	SWC2	SWT3	SWT7	WwNP4	BR1	BR2	BR3	BR4	BR5	BR6	BRP1	BRP2	BRP3	BRP4
Sewer length (log)	0.796***	0.884***													
	{0.000}	{0.000}													
Pumping capacity per km of sewer (log)	0.354***	0.600***			0.316***										
	{0.006}	{0.000}			{0.001}										
Properties per length of sewer (log)	1.116***														
	{0.000}														
Weighted average density – MSOA to LAD (log)		0.226***				-0.161				-0.261			-0.002		-0.102
		{0.009}				{0.252}				{0.237}			{0.975}		{0.128}
Load (log)			0.847***	0.936***	0.723***							0.924***	0.922***	0.974***	0.926***
			{0.000}	{0.000}	{0.000}							{0.000}	{0.000}	{0.000}	{0.000}
Weighted average treatment work size (log)			-0.247***	-0.220***	-0.095***							-0.191***	-0.190***	-0.179***	-0.152***
			{0.000}	{0.000}	{0.007}							{0.000}	{0.000}	{0.000}	{0.000}
Percentage of load with N consent lower than 3mg/l			0.004***	0.004***	0.005***							0.002	0.002*	0.002*	0.005***
			{0.001}	{0.000}	{0.000}							{0.114}	{0.097}	{0.081}	{0.007}
AMP5 dummy			-0.088**	-0.086**	-0.005							-0.048	-0.048	-0.047	-0.027
			{0.027}	{0.037}	{0.794}							{0.107}	{0.112}	{0.118}	{0.335}
Percentage of population living in coastal areas				0.006**										0.003	0.005**
				{0.019}										{0.217}	{0.017}
Sludge produced (log)						1.203***	1.158***	1.158***	1.143***	1.056***	1.050***				
						{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}				
Percentage of load treated in bands 1-3						0.066**	0.067**		0.079**						
						{0.035}	{0.029}		{0.021}						
Weighted average density – MSOA (log)							-0.13				-0.374				
							{0.580}				{0.286}				
WwTW per property (log)								0.304							
								{0.252}							
Constant	-7.974***	-6.501***	-3.443***	-4.949***	-2.849***	-0.745	-0.659	1.06	-1.665*	0.935	2.034	-4.552***	-4.523***	-5.360***	-4.408***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.486}	{0.649}	{0.266}	{0.098}	{0.298}	{0.270}	{0.000}	{0.000}	{0.000}	{0.000}
Sample size	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
R squared	0.919	0.894	0.906	0.92	0.951	0.724	0.718	0.681	0.721	0.679	0.674	0.938	0.938	0.941	0.945
Ramsey RESET test	0.184	0.104	0.5	0.692	0.826	0.575	0.444	0.918	0.255	0.259	0.477	0.899	0.73	0.965	0.474

Source: UUW analysis

Table 15: UUW's final suite of residential retail models

	BD1	BD2	BD3	ROC1	RTC4	RTC5	RTC6
Revenue per household (log)	1.105***	1.152***	1.014***		0.555***	0.608***	0.546***
	{0.000}	{0.000}	{0.000}		{0.000}	{0.000}	{0.000}
Percentage of households with default (Equifax variable ep_lpcf62)	0.051***				0.023***		
	{0.003}				{0.003}		
Covid dummy (2019-20 = 1)	0.402***	0.380***	0.396***		0.177***	0.158***	0.171***
	{0.000}	{0.000}	{0.000}		{0.000}	{0.000}	{0.000}
Covid dummy (2020-21 = 1)	0.226***	0.179**	0.210***		0.056**	0.03	0.046*
	{0.004}	{0.020}	{0.008}		{0.042}	{0.315}	{0.099}
Average number of County Court Judgements per household (Equifax variable eq_apcf2) (log)		0.773**				0.177	
		{0.019}				{0.276}	
Percentage of households classed as income deprived (IMD) - interpolated			0.075***				0.028*
			{0.002}				{0.076}
Percentage of properties receiving water and wastewater services				0.002**			
				{0.031}			
Constant	-5.177***	-4.741***	-4.399***	2.894***	-0.277	-0.147	-0.036
	{0.000}	{0.000}	{0.000}	{0.000}	{0.566}	{0.747}	{0.934}
Sample size	170	170	170	170	170	170	170
R squared	0.661	0.657	0.668	0.117	0.655	0.645	0.64
Ramsey RESET test	0.258	0.233	0.179	0.965	0.375	0.064	0.287

Source: UUW analysis

3. Our approach to assessing unmodelled base costs

3.1.1 Some elements of base costs are unsuited for inclusion in models. As Ofwat notes:

"Unmodelled base costs consist of a small number of cost items that are more suitable for separate assessment - either because they are driven by specific regional requirements and/or are largely outside of company control."[46]

3.1.2 We exclude the following cost items from our base models :

- Costs associated with the Traffic Management Act 2004;
- Business rates;
- Abstraction and discharge service licenses (water service only);
- Industrial Emission Directive compliance costs;
- Statutory water softening costs;
- Third party costs; and,
- Pension deficit recovery costs.

3.1.3 We agree with Ofwat that these costs should be assessed separately from the modelled benchmark. This section sets out our approach to assessing each of these element of cost.

3.2 How should Traffic Management Act 2004 costs be reflected?

3.2.1 The Traffic Management Act (TMA) 2004 places a duty on local authorities to make sure traffic moves freely and quickly on their roads and the roads of nearby authorities. Water companies who want to carry out street works must apply to the highway authority for a permit. Companies incur costs relating to the permits themselves as well as the administration of the permit schemes.

3.2.2 We consider that Ofwat's approach to assessing TMA costs at PR19 was generally appropriate. We note that our proposed TMA costs are in line with our historical TMA costs and as such we consider that it is appropriate to pass these costs through in full.

3.3 What is the most appropriate assumption to make for business rate liabilities?

3.3.1 We consider that Ofwat's treatment of business rates as an unmodelled cost item is appropriate and implement this approach within our cost assessment proposal.

3.3.2 The way in which business rates will be assessed in AMP8 is expected to change, with companies moving to a "duty to notify" approach. The "duty to notify" places an obligation upon companies to alert HMRC to any changes in their asset base, which makes it easier for HMRC to ensure its valuations are kept up to date. This contrasts with the previous approach, where the onus was on HMRC to ensure that its valuations where up to date.

3.3.3 This can be expected to increase business rate costs because HMRC will be able to capture unassessed assets, which was more difficult under the previous regime given the size of UUW's asset base. This means that it would be inappropriate to base expected rate liabilities upon historical levels of business rates, as was the case at PR19. While this was legitimate at the time, the change in assessment approach will lead to a step change in rates liabilities, such that associated historical costs cannot be extrapolated forwards.

[46] Ofwat (2022) *PR24 Final Methodology: appendix 9.* Available here.

3.3.4 As such, we consider the appropriate way to incentivise efficiency in managing business rate costs is to allow a full pass through of forecasts of business rate liabilities, with a 10:10 cost sharing rate. This ensures that companies are able to meet their expected liabilities while ensuring there is an appropriately powered incentive to manage business rate costs efficiently.

3.3.5 The 10:10 cost sharing rate is appropriate because business rate liabilities are largely out of the control of companies, as Ofwat recognises: *"…We recognise that companies have limited control over the level of business rates and the effect of revaluations"*[47]. The move to "duty to notify" does not imply that business rates liabilities are within company control because ultimately business rates are a tax and the change in approach means that tax will be more aligned to companies' actual asset bases. Exposing companies to 10% risk of over and underspend represents an appropriately powered incentive in this context. We also note this position was endorsed by the CMA in its PR19 redeterminations[48].

3.4 How should abstraction and discharge service licence costs be assessed?

3.4.1 The Environment Agency, Canal & River Trust and Natural Resources Wales impose abstraction charges on water companies to recover their costs of managing and regulating abstractions and discharge consents.

3.4.2 We align with Ofwat's position that abstraction charges should be excluded from econometric models because they are influenced by specific regional variation and bespoke company agreements, which can't reasonably be expected to be captured by the set of cost drivers used in botex modelling.

3.4.3 The EA reviewed its charging scheme for abstraction licence costs last year. However, at the time of business plan submission, UUW has not yet received an invoice on the new basis of abstraction charges. We also note that abstraction charges are liable to change at any time. Therefore, UUW's abstraction licence costs in AMP8 are uncertain. As such, we consider that our forecasted abstraction licence costs should be passed through in full with a 10:10 sharing rate for companies. This will provide a degree of protection to companies over the risk of charge increases but will also protect customers from the risk that charges are lower than forecast.

3.5 How should Industrial Emissions Directive compliance costs be assessed?

3.5.1 We agree that Industrial Emissions Directive compliance costs should be treated as unmodelled costs. These costs have historically been unevenly spread among the industry. We note that Ofwat considers that all related maintenance should be treated as part of base modelled costs and that the unmodelled element should only apply to permit and admin costs:

> *"We will continue to assess these costs as unmodelled costs at PR24. However, we consider that this should be limited to the costs of Environment Agency and Natural Resources Wales permits and associated administration costs. Any costs related to the inspection and maintenance of assets should be included in modelled base costs."*

3.5.2 However, we do not agree with this position – not all companies have incurred equivalent inspection and maintenance costs over the full period of the dataset. Given that IED costs are not correlated with any cost driver used in cost assessment, this creates a risk that companies with higher maintenance and permitting requirements relating to IED receive an unduly low allocation of cost. As such, we consider the IED opex line should align to the old definition i.e. include maintenance and inspection costs, until such time it is clear there is an equivalent burden of costs across the industry. At that point, it would be appropriate to alter the definition.

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[47] Ofwat (2019) *Securing cost efficiency technical appendix.* Available here.

[48] CMA (2021) *Final report.* Available here.

3.5.3 We also note that these costs relate to existing IED costs, not incremental costs resulting from updates in the Environment Agency's guidance. The cost of complying with the 2022 Appropriate Measures guidance is set out in our cost adjustment claim *'UUW_CAC_004 Industrial Emissions Directive Compliance'*.

3.5.4 We are also proposing a notified item, which is for both:

- the immediate costs and future investment requirements arising from a significant change in the supply/demand for available landbank that is currently relied upon as an agricultural outlet for recycling of sewage sludge; and,
- the costs required to meet new improvement conditions arising within permits (or the requirements to meet exemption criteria). This could be either as a variation to an existing permit (or exemption), or from the creation of a new permit.

3.5.5 Please see Chapter 9 - Risk, Return and Responsible Behaviour for more details on this proposed notified item.

3.6 Assessment of statutory water softening costs

3.6.1 We do not have any relevant costs so have not provided an assessment of this category.

3.7 Treatment of third party costs

3.7.1 We consider that Ofwat's approach to third party costs at PR19 remains appropriate. As such, so long as costs equate to revenue, third party costs should be passed through. This ensures that customers benefit from any agreements where revenues are greater than costs.

3.7.2 We note that section 185 diversions in the water service are now treated as third party costs and will be subject to an end-of-period reconciliation. We do not have principled objections to this approach as section 185 diversions tend to be relatively small in value meaning there won't be a material impact on bill volatility.

Non-section 185 diversions

3.7.3 In its Final Methodology, Ofwat stated that non-section 185 diversions should be included within third party costs. Non-section 185 diversions largely relate to HS2-related activity and NRSWA. The associated costs are not suited for inclusion in the botex models due to their lumpiness.

3.7.4 Ofwat is proposing to include related costs within third party costs (and therefore within the price control) and subject them to an end-of-period reconciliation. We don't see the merits of this approach opposite that taken at PR19, which we supported. Non-section 185 diversions costs are material and highly uncertain. Including these costs within third party costs could lead to material bill volatility following the end-of-period reconciliation.

3.7.5 We would ask Ofwat to reconsider its approach and instead adopt that taken at PR19 Final Determination, which it indicated it would adopt in its draft methodology. Please see supplementary document *UUW54 - Developer Services* for more details on our proposals in this area.

3.8 Treatment of pension deficit recovery costs

3.8.1 We do not have any relevant costs so have not provided an assessment of this category.

3.9 Summary of UUW's assessment of unmodelled costs

3.9.1 Table 16 below sets out UUW's assessment of unmodelled costs.

Table 16: Summary of UUW's assessment of unmodelled costs

	2025-26	2026-27	2027-28	2028-29	2029-30	AMP8	Cost sharing
Water resources							
Abstraction charges	23.46	23.46	23.46	23.46	23.46	**117.30**	10:10
Business rates	13.45	19.93	19.91	19.94	24.59	**97.82**	10:10
Traffic Management Act costs	0.00	0.00	0.00	0.00	0.00	**0.00**	None
Equity Issurance costs	0.07	0.06	0.22	0.18	0.00	**0.52**	None
Statutory water softening	0.00	0.00	0.00	0.00	0.00	**0.00**	
Non-s185 diversions[49]	0.00	0.00	0.00	0.00	0.00	**0.00**	
Third party costs	0.00	0.00	0.00	0.00	0.00	**0.00**	n/a
Water network plus							
Abstraction charges	0.18	0.18	0.18	0.18	0.18	**0.89**	10:10
Business rates	36.35	53.85	53.80	53.87	66.45	**264.31**	10:10
Traffic Management Act costs	1.86	1.86	1.86	1.86	1.86	**9.32**	None
Equity Issurance costs	0.49	0.52	1.13	1.00	0.00	**3.14**	None
Statutory water softening	0.00	0.00	0.00	0.00	0.00	**0.00**	n/a
Non-s185 diversions	3.04	3.04	3.04	3.04	3.04	**15.22**	
Third party costs	1.33	1.33	1.33	1.33	1.33	**6.64**	
Wastewater network plus							
Business rates	23.92	30.44	31.41	31.71	34.59	**152.08**	10:10
Traffic Management Act costs	0.37	0.37	0.37	0.37	0.37	**1.84**	10:10
Equity Issurance costs	1.89	2.64	6.69	6.79	0.00	**18.00**	None
Industrial Emissions Directive	0.07	0.07	0.07	0.07	0.07	**0.33**	None
Non-s185 diversions	3.85	3.85	3.85	3.85	3.85	**19.24**	
Third party costs	0.42	0.42	0.42	0.42	0.42	**2.09**	n/a
Bioresources							
Business rates	7.15	9.10	9.39	9.47	10.33	**45.44**	10:10
Traffic Management Act costs	0.00	0.00	0.00	0.00	0.00	**0.00**	10:10
Equity Issurance costs	0.26	0.31	0.60	0.50	0.00	**1.67**	
Industrial Emissions Directive	0.51	0.51	0.51	0.51	0.51	**2.54**	None
Non-s185 diversions	0.00	0.00	0.00	0.00	0.00	**0.00**	
Third party costs	0.00	0.00	0.00	0.00	0.00	**0.00**	n/a

Source: UUW data

[49] This only reflects the element of non-s185 expenditure that is recoverable from customer bills.

4. Our approach to assessing enhancement expenditure

4.1.1 Enhancement expenditure facilitates a step-change in the quality of service we provide to customers. It can be driven by statutory obligations, statutory planning frameworks or through wider business strategy.

4.1.2 The PR24 business plan data tables indicate that Ofwat will have access to a much richer dataset at PR24 than it did at PR19, which substantially increases the scope for modelled assessments to play a role in a wider range of enhancement areas[50]. However, it is important for these modelled assessments to be based upon a principled understanding of the activities involved. Otherwise, technical modelling choices could result in an inappropriate benchmark and lead some companies to unduly benefit from the process.

4.1.3 This section sets out UUW's proposed approach to assessing enhancement expenditure. At the time of business plan submission, we do not have access to other companies' business plans, meaning we are unable to develop and implement cost assessment models as we have done for base costs in section 2. Therefore, we focus this section upon principled methodological approaches to enhancement cost assessment, which Ofwat could implement when it has received business plan data from companies.

4.2 Enhancement costs should be assessed separately from base costs

4.2.1 Enhancement expenditure tends to be lumpy, meaning its profile over time is uneven and can vary significantly between years. In the past, this has caused totex models (which aim to predict both base and enhancement costs within a single model) to perform poorly because it makes it harder for the models to reflect the relationship between cost and cost driver. Totex models would also struggle to reflect any future step changes in enhancement requirements, unless suitable (but very specific) explanatory variables could be identified.

4.2.2 At PR19 Ofwat generally assessed enhancement expenditure separately from base expenditure, either through standalone enhancement models or through deep-dive/shallow-dive assessments. We continue to support this approach. This is because base and enhancement expenditure are fundamentally different in nature e.g. base expenditure generally reflects similar activities being carried out each year whereas activity underlying enhancement expenditure is much more intervention/project specific.

4.3 Forecast costs should continue to be used at PR24

4.3.1 As we promoted within our Future Ideas Lab paper, a key goal of cost assessment should be to ensure that cost targets are reflective of future conditions[51]. If cost targets are set in a way that does not account for changes in the relationship between cost and cost driver, then they are likely to be set at an inappropriate level.

4.3.2 We present extensive evidence within Chapter 8 of our business plan[52] of the recent increase in input prices. A number of supply-side issues have combined to lead to a general tightening across the economy, including Brexit, the war in Ukraine and the legacy of Covid. These factors mean that the economy and the construction market is fundamentally different today than when companies submitted their PR19 business plans in September 2018.

4.3.3 This means that the constant and coefficients within the PR19 enhancement models are unlikely to appropriately reflect the relationship between cost and cost driver within AMP8. Indeed, evidence

[50] Although, we note that the majority of enhancement expenditure when expressed in £m was assessed using a benchmarking model approach.

[51] UUW (2021) *The Principles of Regulatory Cost Assessment*. Available here.

[52] *Chapter 8 Delivering at efficient cost*

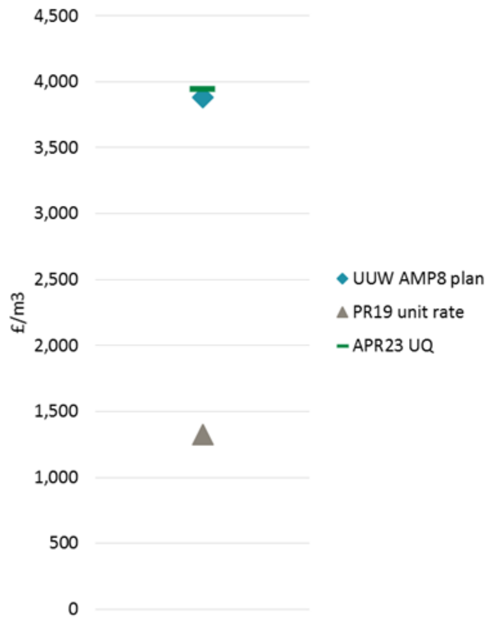
suggests that the cost pressures faced by companies in AMP8 are fundamentally different to that reflected in their business plans, upon which the PR19 enhancement models were based.

4.3.4 Figure 10 below compares:

- the PR19 unit rate (calculated from the storm tank storage enhancement models in the PR19 FD);
- the upper quartile unit rate, as calculated from storm tank storage schemes completing in the 2022-23 financial year. (This information is available in the cumulative enhancement section of table 4M in the 2022-23 APR); and,
- UUW's proposed PR24 business plan unit rate for storm tank storage.

4.3.5 We used storm tank storage costs in this example because the sample size of outturn costs within APR23 is relatively large. It's clear that the PR19 models predicted a unit rate far below outturn unit costs for the upper quartile unit costs of projects completing in 2022-23. It's also clear that UUW's proposed unit rate for storm tank storage is efficient by comparison to the upper quartile of outturn industry costs.

Figure 10: Unit rate comparisons for storm tank storage



Source: PR19 Final Determination, APR23 and UUW AMP8 business plan

4.3.6 We consider that this illustrates the importance of ensuring that the approach to enhancement cost assessment sufficiently accounts for external validity i.e. the ability of cost assessment to predict future relationships between cost and cost driver. While the PR19 approach was unsighted to the economic shocks to follow, the PR24 approach should ensure that any cost targets are set in reference to the new economic environment in which companies are operating. **Therefore, the most recent outturn data (where possible) and forecast business plan costs should be used**. However, we note that outturn cost data for majority of AMP7 schemes will only start to become available in the 2023-24 APR, which means outturn cost data may not be available in significant quantity to create confidence in the robustness of a subsequent assessment.

4.3.7 We note Ofwat's concern that using forecast data in cost assessment may encourage companies to become more pessimistic in the potential for efficiency gains in their business plan submissions[53]. However, we consider that it is appropriate to use forecast business plan information because incentives contained within the Business Plan Assessment (BPA) mean that companies whose plans are deemed inefficient receive a penalty. The incentives within the BPA have been increased at PR24

[53] Ofwat (2020) *PR24 and beyond: our reflections on lessons learned from PR19.* Available here.

meaning that this provides a strong incentive to companies to submit efficient plans. In addition, PCDs ensure that customers are protected from under or non-delivery of their proposed enhancements. Therefore, we support the continued use of business plan forecasts in principle due to the benefit in supporting a realistic future cost target.

4.4 A catch-up efficiency challenge should be applied 'in-the-round'.

4.4.1 The PR19 approach applied a 'WINEP in-the-round' efficiency challenge to the WINEP enhancement programme. As Ofwat said:

"This is because there are interactions between many of the different categories of cost and we therefore take into account any cost allocation differences in companies' proposals."[54]

4.4.2 We support this approach to enhancement efficiency assessment and consider it should be continued at PR24. In particular, we consider that the 'in-the-round' approach to catch-up efficiency should be applied to the entire enhancement programme, rather than just WINEP items. Cost interactions and cost allocation differences are present across the entirety of enhancement, not just the areas of WINEP.

4.4.3 Additionally, the approach would align with the top-down, 'in-the-round' way in which companies manage the risk in their enhancement programmes. A more segmented, solid approach which applied an upper quartile efficiency challenge to each enhancement area and summed this up would reduce the ability of companies to balance risk across their entire programme, which could adversely affect deliverability. This is analogous to the issues on botex model cost aggregations noted in sections 2.3 and 5.4.

4.5 The 'lesser of' approach undermines incentives for long-term efficiency

4.5.1 At PR19, the approach to enhancement cost assessment meant that companies received the 'lesser of' either:

(i) Their business plan enhancement proposed cost; or

(ii) The modelled allowance.

4.5.2 This meant that any companies considered inefficient by the model would receive the modelled allowance and any companies considered efficient would receive their own view of cost. In practice, this creates an incentive for companies to adopt more conservative cost forecasts than they otherwise would. In turn, this weakens the ability of cost assessment to induce companies to reveal their true position on efficient costs in future price reviews.

4.5.3 However, it may not be appropriate to fully align to the approach taken in botex modelling, where all companies receive the benchmark view of cost. This approach may not adequately protect customers from the risk that some enhancement models are not suitably robust (relative to botex models).

4.5.4 We consider that a suitably pragmatic position would be for a mechanism that provides companies with some incentive to submit stretching plans at future Price Reviews by allowing them to keep a proportion of 'outperformance' versus the models. We consider that a suitable proportion would be 50 percent, which provides a strong incentive for efficiency but also ensures customers share a material proportion of the benefit. This will provide appropriate pricing signals to future reviews and improve the ability of cost assessment to reveal an efficient view of costs in the long-term, while providing customers with appropriate protections in the short-term.

[54] Ofwat (2019) *Securing cost efficiency technical appendix.* Available here.

4.6 Engineering rationale should support the choice of linear or log model specifications

4.6.1 At PR19, Ofwat employed relatively simple econometric models to assess a majority of enhancement costs. These models used AMP7 forecast costs for each WaSC and contained one or two explanatory variables. The underlying dataset tended to be relatively small – ten data points for wastewater models and 17 for water models. In general, we supported the modelling approach taken. However, smaller datasets make it harder for a statistical model to estimate a robust, precise relationship between cost and cost driver e.g. because outliers have relatively more weight. This does not undermine the use of statistical models in enhancement cost assessment, but it does mean the chosen approach should recognise and mitigate the risk of statistical bias.

4.6.2 In our Future Ideas Lab publication[55], we promoted the prioritisation of engineering, operational and economic rationale. This should help to mitigate the risk that a statistical model is unduly influenced by statistical noise within a small dataset because it is less focused upon statistical fit and more focused upon ensuring the chosen approach best aligns with engineering rationale. In turn, this means the approach is likely to provide a more representative relationship between cost and cost driver and therefore an appropriate allowance.

4.6.3 We consider that engineering, operational and economic rationale should lead the decision to adopt a particular functional form. At PR19, both linear and logarithmic functional forms were used, although the justification for the choice tended to be focused upon the statistical fit of the model. As we have previously argued[56], focusing upon statistical fit (or 'internal validity') can produce a misstated understanding of the true relationship between cost and cost driver.

4.6.4 This section sets out the engineering rationale for why particular functional forms are more suited to certain enhancement areas. We consider that this rationale is a useful starting point for enhancement cost assessment.

Grey storage enhancement schemes

4.6.5 Grey storage schemes involve the creation of large concrete tanks, which can be filled with wastewater in times of high rainfall and then attenuated back into the network when flow is lower. This reduces the risk of hydraulic issues within the localised network and can reduce spills from storm overflows.

4.6.6 A number of factors affect the unit cost for a given grey storage scheme:

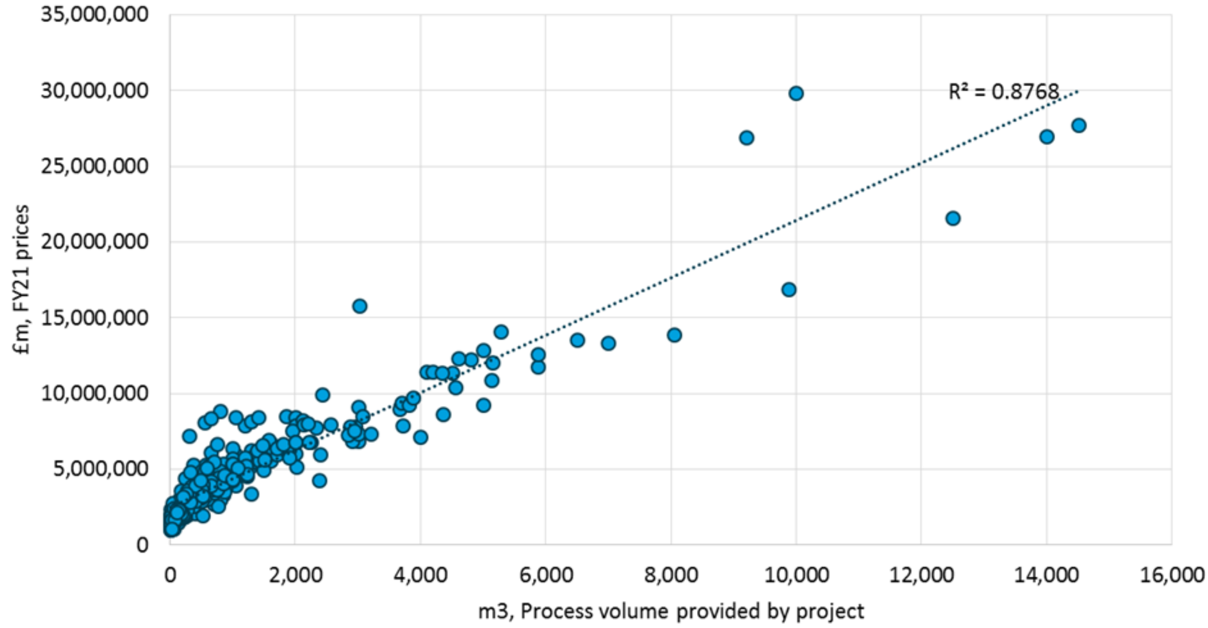
- **Volume of storage.** All else equal, building a larger volume tank will result in lower unit costs. This is because the fixed costs of equipment hire and an element of variable costs are spread over a larger volume.
- **Excavation volume to process volume ratio.** Process volume is the volume of storage provided within the storage tank. However, the actual excavation volume can be significantly larger. For example, a deeper sewer will require a deeper hole to be dug but this doesn't necessarily result in a larger process volume. A higher excavation volume-process volume ratio will act to offset any benefits in unit costs realised by constructing larger tanks.
- **Ground conditions.** Worse ground conditions (e.g. ground water, rock, contaminated material, mine workings, old industrial waste) all act to increase the cost at a specific site. Building larger tanks increases the likelihood that adverse ground conditions are encountered, which acts to offset any benefit in unit costs realised by constructing larger tanks.
- **Site-specific engineering issues.** Site-specific issues cover problems like tunnelled connections between tanks, expensive reinstatement requirements, railway/public highway access.

[55] UUW (2021) *The Principles of Regulatory Cost Assessment*. Available here.

[56] ibid

4.6.7 Our AMP8 storage projects have been estimated at a project level, meaning the estimated costs are able to account for the factors outlined above (to an extent – some issues only become obvious once work begins). Figure 11 demonstrates that the resulting costs are best explained by a linear relationship, suggesting that any economies of scale from building larger tanks are offset by associated higher costs. For comparison, the r squared of a logarithmic trend line fitted to the data in Figure 11 is 0.5449. This is supported by evidence from the PR19 models, where the linear models had superior fit relative to the logarithmic models[57].

Figure 11: There is a linear relationship between cost and cost driver in our AMP8 grey network storage plan



Source: Internal UUW estimating data

4.6.8 Therefore, we consider that the most appropriate functional form for storage scheme models is a linear form. This is because any economies of scale benefit realised through building larger tanks is offset by other offsetting increases in costs.

4.6.9 We consider that cost assessment across each area of enhancement should be grounded in engineering rationale, similar to that set out above. This will ensure that the approach to setting cost targets uses appropriate and realistic assumptions.

4.7 Our assessment of our enhancement costs

4.7.1 We are confident that the activity we have undertaken to challenge costs internally (as described within *Chapter 8 - Delivering at efficient cost*) means that our enhancement programme will be considered as efficient by Ofwat's assessment. As such, we pass through in full our enhancement programme into our cost assessment proposal. A summary by price control is set out in Table 17, Table 18, Table 19 and Table 20.

[57] In the PR19 FD, models 1 and 2 were linear and had r squares of 0.9642 and 0.9638 respectively, whereas models 3 and 4 were logarithmic and had r squares of 0.9 and 0.87 respectively.

Table 17: Water Resources enhancement business plan costs

	2025-26	2026-27	2027-28	2028-29	2029-30	AMP8
EA/NRW environmental programme (WINEP/NEP)	35.43	12.79	30.22	21.79	5.33	**105.56**
Supply-demand balance	5.96	12.53	24.11	20.06	14.07	**76.72**
Metering	0.00	0.00	0.00	0.00	0.00	**0.00**
Water quality improvements	0.00	0.00	0.00	0.00	0.00	**0.00**
Water resilience and security	0.00	0.00	0.00	0.00	0.00	**0.00**
Net zero	0.19	0.21	0.59	0.47	0.02	**1.49**
Other enhancement (Freeform lines - by exception)	0.00	0.00	0.00	0.00	0.00	**0.00**
Total	**41.58**	**25.53**	**54.92**	**42.32**	**19.41**	**183.77**

Source: UUW business plan submission

Table 18: Water Network Plus enhancement business plan costs

	2025-26	2026-27	2027-28	2028-29	2029-30	AMP8
EA/NRW environmental programme (WINEP/NEP)	0.00	0.00	0.00	0.00	0.00	**0.00**
Supply-demand balance	20.00	32.20	31.88	34.26	45.98	**164.32**
Metering	63.60	45.95	43.28	44.08	43.88	**240.78**
Water quality improvements	63.09	58.22	90.57	48.14	22.70	**282.71**
Water resilience and security	12.59	16.45	24.54	19.07	23.49	**96.14**
Net zero	5.70	8.09	17.17	15.25	7.69	**53.90**
Other enhancement (Freeform lines - by exception)	0.00	0.00	0.00	0.00	0.00	**0.00**
Total	**164.98**	**160.91**	**207.44**	**160.79**	**143.74**	**837.85**

Source: UUW business plan submission

Table 19: Wastewater Network Plus enhancement business plan costs

	2025-26	2026-27	2027-28	2028-29	2029-30	AMP8
EA/NRW environmental programme wastewater (WINEP/NEP)	1,004.68	1,113.22	1,469.69	1,340.65	467.07	**5,395.30**
EA/NRW environmental programme bioresources (WINEP/NEP)	0.00	0.00	0.00	0.00	0.00	**0.00**
Other enhancement	47.80	31.79	74.74	68.50	27.71	**250.54**
Other enhancement (Freeform lines - by exception)	27.75	3.87	46.75	48.55	48.55	**175.47**
Total	**1,080.23**	**1,148.88**	**1,591.18**	**1,457.70**	**543.33**	**5,821.31**

Source: UUW business plan submission

Table 20: Bioresources enhancement business plan costs

	2025-26	2026-27	2027-28	2028-29	2029-30	AMP8
EA/NRW environmental programme wastewater (WINEP/NEP)	1.78	6.62	10.05	5.56	1.51	**25.52**
EA/NRW environmental programme bioresources (WINEP/NEP)	15.04	51.15	51.39	44.03	7.74	**169.36**
Other enhancement	19.47	10.85	15.27	14.59	10.28	**70.45**
Other enhancement (Freeform lines - by exception)	19.92	21.44	21.97	1.01	-0.02	**64.33**
Total	**56.20**	**90.07**	**98.68**	**65.19**	**19.51**	**329.66**

Source: UUW business plan submission

5. Our approach to the catch-up efficiency challenge

5.1.1 Ofwat challenges the sector to become more efficient by setting cost benchmarks through reference to an efficient peer. This forces less efficient companies to operate at the efficient level i.e. they have to 'catch-up' with their peers. We have previously promoted an approach to setting efficiency within a transparent, stable and coherent framework[58]. This means that the catch-up challenge should be set with reference to all sources of stretch within the regulatory framework. We consider that there is substantially more evidence to inform this decision than existed at PR19.

5.1.2 This section sets out our approach to ensuring the catch-up efficiency assumption results in an appropriately challenging but realistic cost target.

5.2 Historical evidence does not suggest additional stretch is required

5.2.1 The scope for companies to make efficiency gains in future AMPs should be informed by an objective appraisal of the industry's performance against totex targets since the introduction of the totex-outcomes regime. The totex-outcomes regime gives companies freedom to choose the most efficient way to deliver agreed outcomes. While this does unlock the potential for companies to realise substantial efficiencies in the delivery of outcomes because they are not tied to prescriptive capital interventions, such performance improvements have generally had to be funded through base expenditure. Indeed, as we saw in Figure 7 and Figure 8, the introduction of the totex-outcomes framework resulted in a clear statistically significant increase in base expenditure across the industry.

5.2.2 While the move to totex-outcomes likely resulted in an efficiency dividend companies could use to fund performance improvements, this would be a one-off benefit. This was recognised within KPMG's 2018 assessment for Ofwat of the move to the totex-outcomes regime[59]. Once this initial dividend was exhausted, targeting substantial performance improvements from relatively static base allowances would effectively constitute an implicit productivity challenge. The key question is at what point this implicit productivity challenge becomes unobtainable. We consider there is evidence to suggest the industry may have passed this point within AMP7 and therefore that either efficiency targets or performance targets should be moderated in AMP8.

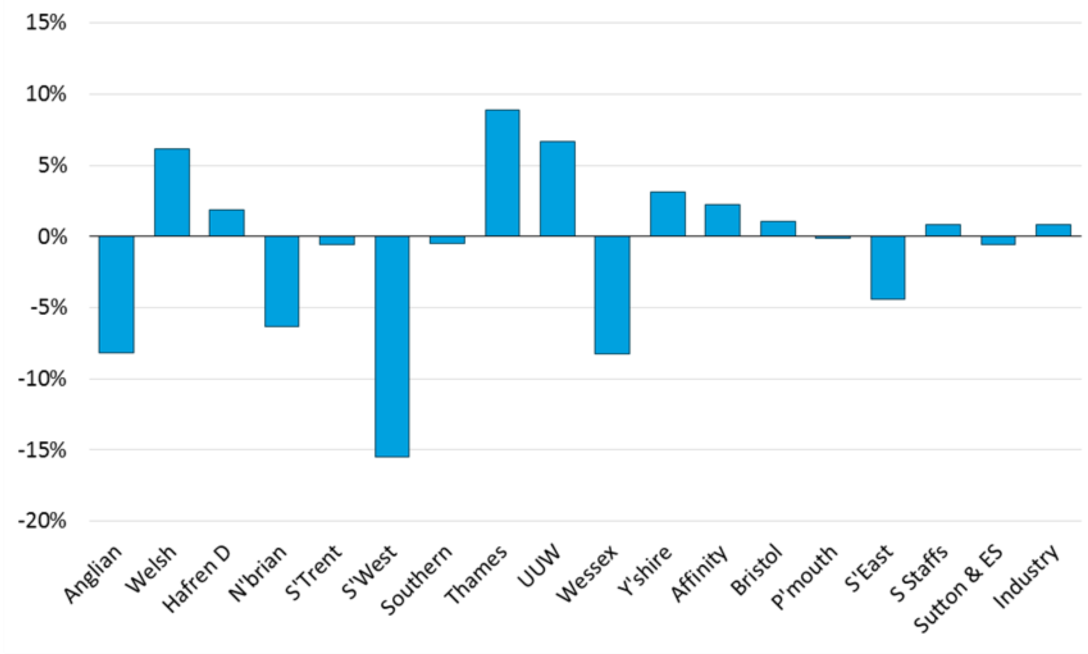
5.2.3 Figure 12 contains data showing each company's performance against the totex targets set Ofwat at PR14[60]. A positive value indicates that company has underperformed i.e. that they have spent more than Ofwat assumed in its PR14 FD (and vice versa). It's clear that there is a wide range in industry performance with some companies reporting significant underspends and some reporting significant overspends. The industry as a whole spent slightly more than its target.

[58] UUW (2021) *The Principles of Regulatory Cost Assessment*. Available here.

[59] KPMG (2018) *Innovation and efficiency gains from the totex outcomes framework.* Available here.

[60] Ofwat (2020) *Service Delivery Report*. Available here.

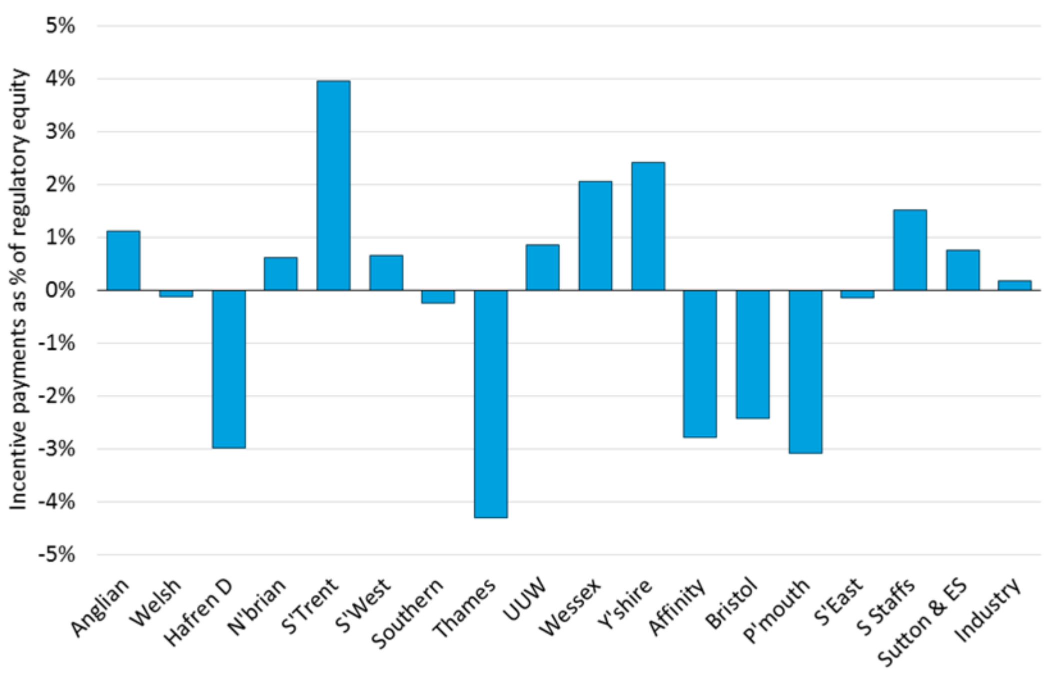
Figure 12: Actual totex relative to allowed totex - AMP6



Source: APR

5.2.4 While considering the industry's cost performance is important, it does not tell the full story – a company could outperform its totex target by reducing the quality of service it provides. Figure 13 shows the performance incentives received by companies over the course of AMP6, normalised by regulatory equity. This acts as a measure of the performance levels delivered by companies over AMP6. A positive value indicates the company has received a net positive reward and has outperformed the assumptions made at PR14. Again, there is substantial variation across the industry but overall the industry slightly outperformed its targets.

Figure 13: AMP6 incentive payments as % of regulatory equity



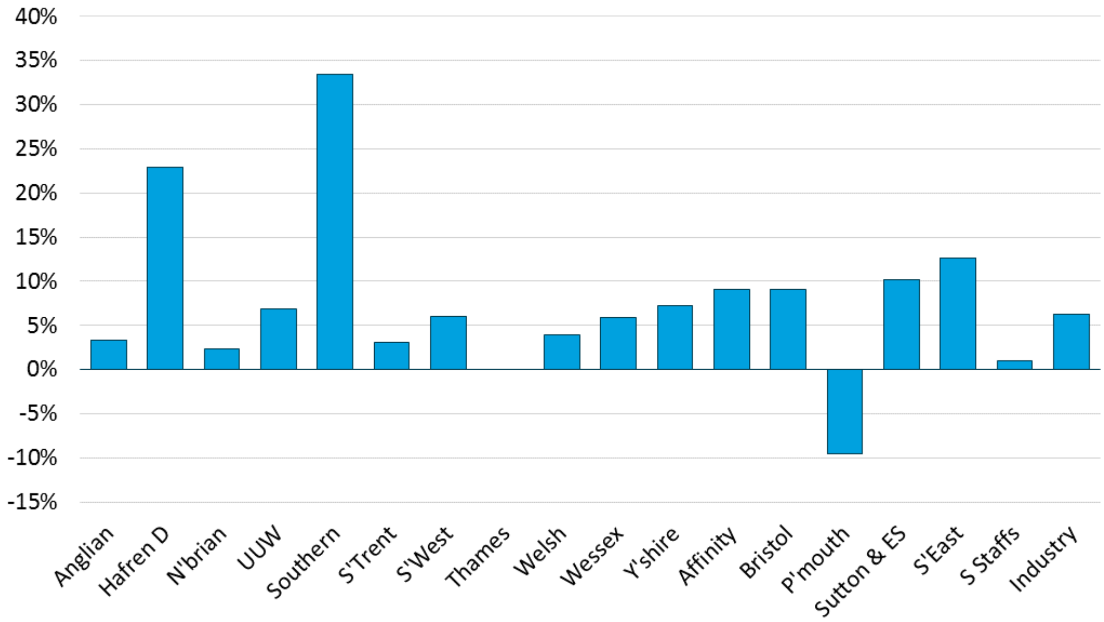
Source: APR

5.2.5 Figure 12 and Figure 13 together suggest the level of stretch at PR14 was generally appropriate – the industry slightly overspent totex allowances in order to earn a slight reward on its performance targets.

5.2.6 In contrast, analysis of cost and performance data from AMP7 to date suggests that the industry is currently subject to an unobtainable level of stretch.

5.2.7 Figure 14 shows the level of totex overspend attributable to efficiency[61] as a percentage of allowed totex (net of business rates and abstraction licence costs) over the first three years of AMP7. Almost every company is reporting underperformance against their totex target, with the industry as a whole underperforming by over five percent.

Figure 14: Over (under)spend attributable to efficiency as % of allowance - AMP7 to date



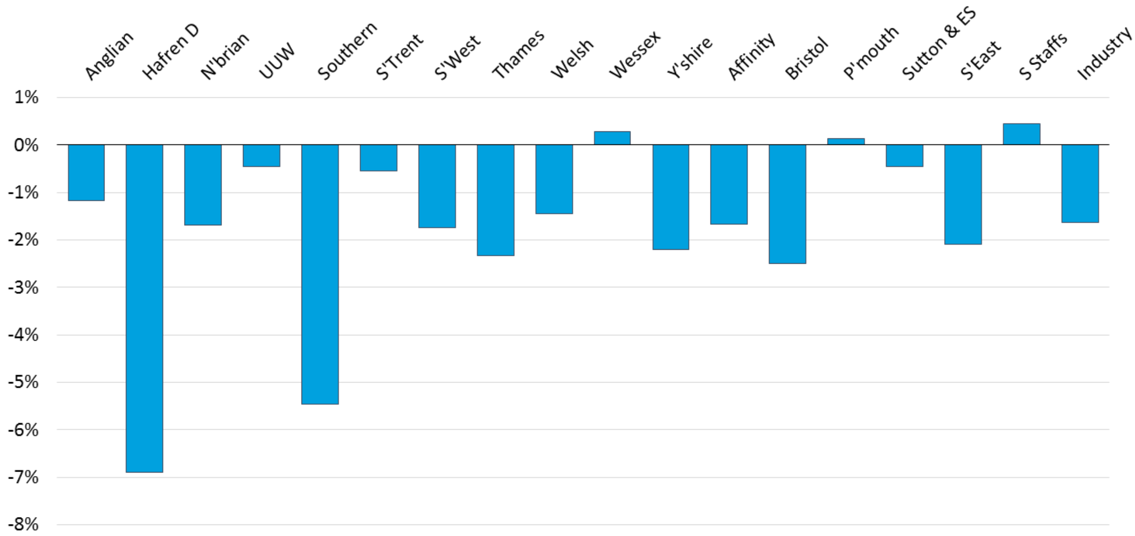
Source: APR

5.2.8 This may be explainable if companies were spending more in order to earn performance-related incentive payments. However, as Figure 15 shows, almost every company is in net penalty on their common ODIs across the first three years of AMP7. We only consider common ODIs as part of this analysis as Ofwat has stated its clear intention to focus AMP8 performance targets upon its common ODIs[62]. We note that the overall conclusion in Figure 15 doesn't change if bespoke ODI performance is included.

[61] In this context, this means any differences in expenditure that cannot be attributed to differences in expenditure profiling within the AMP.

[62] Ofwat (2022) *Final Methodology: appendix 7.* Available here.

Figure 15: Industry performance against common ODIs as % of regulated equity



Source: APR

5.2.9 We consider that the evidence set out in section 5.2 demonstrates the level of stretch being imparted upon the industry is not sustainable. We also consider that there is no evidence that would support additional stretch being placed upon companies at PR24.

5.3 Sources of stretch in the regulatory framework

5.3.1 A coherent framework should take account of all sources of stretch within the regulatory framework and ensure that any efficiency challenge is carefully calibrated against this assessment. While it is entirely legitimate and appropriate for companies to be subject to stretch, it is crucial that the different sources of stretch are not applied independently in an incremental and uncoordinated manner.

5.3.2 There are a number of ways in which stretch can be introduced into the regulatory framework which are both explicit and implicit:

- Since the introduction of the totex-outcomes regime, PCLs have generally required continual improving performance. However, this has not generally been accompanied by incremental expenditure allowances. This acts as a significant implicit productivity challenge.
- Cost drivers can be forecast in a conservative manner. When these forecasts are combined with the botex model coefficients, the expenditure allowance will be lower than it otherwise would. For example, at PR19 the forecast for '% of load treated with ammonia consent less than 3mg/l' was set at the last year of available data despite company forecasts predicting this (and associated costs) to grow over the course of AMP7.
- As we highlighted in our Future Ideas Lab paper[63], a high evidential bar for cost adjustments in a parsimonious model suite makes it more unlikely that a company will be able to recover the efficient costs associated with providing water and wastewater services in its region.
- A real increase in input prices can put considerable stretch on a companies' cost base if the increase is not recognised within cost assessment.
- The catch-up efficiency challenge represents an explicit source of stretch. At PR19, it was deemed appropriate to move beyond the upper quartile company although this decision was not adopted by the Competition and Markets Authority in its redeterminations.

[63] UUW (2021) *The Principles of Regulatory Cost Assessment*. Available here.

- Inflation represents the general increase in prices in the economy. As such, it reflects aggregated productivity improvements being made by companies operating in a variety of competitive markets. By linking economic regulation to inflation (e.g. through rebasing of historical costs), Ofwat requires companies to match general productive improvements being made in the wider economy[64].
- Frontier shift requires companies to match the productivity improvements being made by similar industries over and above that already reflected within inflation (see previous bullet). The choice of comparator industries and time period used in the historical dataset has a material impact upon the final challenge so conservative or unrealistic choices can act as an additional source of stretch.
- Where neither the cost assessment process or the PCL reflects company-specific circumstances, then companies operating in adverse regions receive disproportionate stretch relative to companies in benign regions.
- The Residential Retail price control does not increase with inflation. This means that is subject to inflation as an implicit productivity challenge. During times of high inflation, this productivity challenge becomes substantial.
- The treatment of Residential Retail as a nominal control means that Residential Retail is exposed to nominal increases in bill sizes but the PR19 approach to cost assessment assumed that it is only exposed to real increases. This is because forecasts of average bills were stated in real terms.
- The application of frontier shift to elements of cost that companies have no/limited control over e.g. business rates.

5.3.3 While there are other sources of stretch within the regulatory framework, we focus upon these when considering an appropriate catch-up challenge.

5.4 We implement the catch-up challenge at the wholesale level

5.4.1 Section 2.3 evidenced the presence of substitution effects across the water and wastewater value chain. In that section, substitution effects led us to adopt specific cost aggregations (water resources plus and bioresources plus) to address the most material instances of substitution effects. However, substitution effects between companies will exist across the entirety of both water and wastewater value chains, even in those elements of the value chain not covered by our cost aggregations. Additionally, differences in cost allocation could introduce bias into company comparisons of costs across individual elements of the value chain (e.g. sewage collection).

5.4.2 Therefore, we will set catch-up efficiency challenges at the overall water and wastewater wholesale level. This prevents the efficiency challenge being influenced by the company with the least assets/lowest cost allocation in each specific value chain element. As Table 21 demonstrates, such an approach would result in an unachievable cost target, even for an efficient company. For the purposes of this stylised example:

- We assume that the four companies have allocated assets across their value chain based upon local operating conditions, which results in a different percentage asset allocation across the value chain.
- We assume that each company is equally efficient at a company level, spending £200m of totex.
- We assume that each company incurs costs proportionate to their asset allocation.
- We assume that each company delivers the same quality of service.
- We assume that the upper quartile company is chosen as the efficiency benchmark.

[64] UUW (2022) *Making the cost assessment framework resilient to future challenges.* Available here.

Table 21: Stylised example of a disaggregated efficiency challenge leading to unobtainable stretch

Company	WR	WT	TWD	Total
Company asset allocation across the value chain				
A	10%	50%	40%	100%
B	15%	45%	40%	100%
C	5%	60%	35%	100%
D	8%	55%	38%	100%
Totex	200	Assume equal totex for this example		
A	20	100	80	200
B	30	90	80	200
C	10	120	70	200
D	15	110	75	200
UQ	**15**	**100**	**75**	**190**

Source: UUW analysis

5.4.3 It is clear from this stylised example that an efficiency assessment at a disaggregated value chain level will create an unobtainable benchmark company. This happens because the efficiency assessment reflects the lowest cost company within each value chain. However, the lowest cost company is determined by differences in asset configuration or cost allocation, not genuine efficiency.

5.4.4 An efficiency assessment at the wholesale water and wastewater level will remove any influence that differences in asset configuration or cost allocation have on the benchmark. The resulting benchmark will be a realistic target that efficient companies can reasonably expect to meet (all else equal). For this reason, we implement a catch-up challenge at the water, wastewater and residential retail level.

5.5 We consider that the upper quartile is an appropriate challenge given the overall level of stretch in the framework

5.5.1 Our starting point for the catch-up efficiency challenge is the upper quartile. We then assess the stretch imposed elsewhere to assess whether the catch-up challenge should be strengthened or weakened from this point.

5.5.2 It's clear from the assessment set out in Table 22 that considerable stretch is being imposed elsewhere within our business plan submission and the wider regulatory framework. This means that we cannot justify strengthening the efficiency challenge beyond the upper quartile level without risking setting an unobtainable cost target. Indeed, the analysis below suggests that a catch-up challenge that is less stringent than the upper quartile could be justified.

Table 22: Is it appropriate to impose more or less stretch than the upper quartile?

Justification for less stretch		Justification for more stretch	
Our proposed PCLs target continued improvements from base expenditure. This represents a substantial implicit productivity challenge.	High	We use company forecasts of cost drivers within our cost assessment proposal.	Low

Justification for less stretch		Justification for more stretch	
UUW is not seeking an adjustment relating to RPEs. This means our cost base is subject to a substantial level of stretch.	High	We assume our cost adjustment submissions will be accepted in full.	Low
We do not include within our proposal cost drivers to reflect the ongoing challenges our wastewater business faces e.g. urban rainfall and combined sewers.	High	(Residential Retail only) We forecast average bill size in outturn prices. This means cost assessment reflects the actual increase in revenue at risk retail functions will be subject to in AMP8.	Medium
(Residential Retail only) The nominal structure of the control means inflationary pressures have to be absorbed.	High	Our proposed cost aggregations account for material substitution effects across the value chain (e.g. between wastewater treatment and bioresources).	Medium

Source: UUW analysis

5.5.3 Despite this assessment suggesting that a less stretching benchmark is justifiable, **we select the upper quartile as our efficiency benchmark across water, wastewater and residential retail**. This additional stretch ensures that we are appropriately challenging ourselves and aligns with the precedent set by the CMA in its PR19 redetermination.

5.5.4 We note that if a disaggregated approach to the efficiency challenge is adopted, then the catch-up challenge should reflect this. A disaggregated approach increases the likelihood that differences in asset configuration or cost allocation will impact the quality and robustness of the model by introducing unexplained variation into the estimation. Unless suitable cost drivers are chosen, this unexplained variation will result in a large residual spread and likely an unrealistic efficiency challenge. Therefore, if such an approach is taken, the average company would be a more suitable benchmark than the upper quartile company.

6. Frontier shift and Real Price Effects

6.1.1 Frontier shift relates to the ability of the most efficient companies to continuously become more productive by taking advantage of technological improvements. Frontier shift differs from catch-up efficiency gains, where companies lagging in efficiency 'catch-up' with the performance of the industry leaders. Once laggards have caught up, then frontier shift reflects the extent to which they need to keep up with the most efficient companies.

6.1.2 Real Price Effects (RPEs) occur where the price of an input rises at a different rate to inflation. At PR19, Ofwat provided a revenue adjustment in recognition that labour costs were expected to rise at a faster rate than inflation. It did not consider that an RPE for power or chemicals was appropriate.

6.1.3 This section sets out our approach to assessing an appropriate frontier shift and whether any RPE adjustments are appropriate.

6.2 Our approach to assessing frontier shift

6.2.1 Frontier shift has typically been assessed by reference to Total Factor Productivity (TFP) analysis produced using the EU KLEMS dataset[65]. TFP growth measures the change in output that cannot be explained by changes in the quantity of inputs used. Importantly, this is different (although closely related) to the concept of frontier shift, which represents the efficiency improvement that the most efficient company is able to make. TFP is broader because it could capture the effect of embodied technological change and the impact of different types of efficiencies (like catch-up efficiency or economies of scale). TFP is also affected by the time period over which it is estimated. These factors need to be taken into account when judging an appropriate frontier shift challenge.

6.2.2 UUW, along with several other companies, commissioned Economic Insight to estimate an appropriate range for the frontier shift efficiency challenge. We consider Economic Insight's approach to be sensible and pragmatic, with any differences to Ofwat's PR19 approach well-justified. As such, we consider that it is entirely appropriate to base our frontier shift challenge upon its analysis. Table 23 sets out Economic Insight's estimates and associated assumptions. Table 24 sets out the different industries used in each comparator set as well as that used by Ofwat at PR19. Interested parties should refer to Economic Insight's report[66] for full justification of its assumptions and approach.

Table 23: Economic Insight's estimates of frontier shift

	Plausible range		PR24-focused range		Sensitivity analysis range	
	Low	*High*	*Low*	*High*	*Low*	*High*
Frontier shift	0.3%	0.8%	0.3%	0.7%	0.1%	1%
Time period	2010-2019	1970-2007	2010-2019	Weighted average of 1970-2008 and 1995-2018	2010-2019	1970-2007
Comparators	Preferred set	Preferred set	Preferred set	Preferred set	Sensitivity 1	Sensitivity 3

Source: Economic Insight's Frontier shift at PR24

[65] EU KLEMS standards for EU level analysis of capital, labour, energy, materials and service inputs. The dataset collects industry-level data on production, value-added, labour, investment and capital stocks across the EU and other high income countries. For more information, please see the EU's website.

[66] Economic Insight (2023) *Frontier shift at PR24*. Available here.

Table 24: Economic Insight's comparator industries

Industry	Preferred set	Sensitivity 1	Sensitivity 3	Ofwat PR19 approach
Total industries	☑	☑	☒	☒
Agriculture, forestry and fishing	☑	☑	☑	☒
Mining and quarrying	☒	☑	☒	☒
Manufacturing	☑	☑	☒	☑
Chemicals; basic pharmaceutical products	☑	☑	☒	☑
Manufacture of rubber and plastic products and other non-metallic mineral products	☑	☑	☑	☒
Manufacture of furniture: jewellery, musical instruments, toys; repair and installation of machinery and equipment	☑	☑	☒	☑
Manufacture of machinery and equipment i.e.	☒	☒	☒	☑
Construction	☒	☒	☒	☑
Wholesale and retail trade; repair of motor vehicles and motorcycles	☑	☑	☒	☒
Transportation and storage	☑	☑	☑	☑
Professional, scientific and technical activities; administrative and support service activities	☒	☒	☒	☑

Source: Economic Insight

6.2.3 Table 23 contains a range of frontier shift estimates that vary depending upon the assumptions used. We focus upon the PR24-focused range as we consider that this aligns most to the potential for frontier shift in AMP8. This will ensure that our benchmark is externally valid, stretching but achievable and in alignment with our principles of cost assessment. Therefore, we had to consider which value within the range 0.3% to 0.7% is most appropriate. The following items guided our thinking:

- External validity would favour a value closer to 0.3% as this uses post-financial crash data.
- Embodied technological change is included to an extent (although it isn't clear to what extent), which would favour a value towards the higher end of the PR24-focused range.
- TFP will include an element of catch-up efficiency, which means TFP-derived estimates of frontier shift will be overstated. This favours a value towards the lower end of the PR24-focused range.
- We do not consider scale efficiencies. This is because scale efficiencies could have a positive or negative effect on frontier shift estimates depending upon whether the potential for scale economies within the comparator industries is greater or smaller than the water industry.

6.2.4 Given that there is potentially both upwards and downwards pressure on frontier shift estimates, on balance we consider that the midpoint of the PR24-focused range (0.5%) is most appropriate. We add a further 0.05% to act as additional stretch. **Therefore, we use a frontier shift of 0.55% in our benchmark**. This is likely an overestimate due to the use of data that predates the financial crash and the subsequent stagnation in productivity. However, it is appropriate that we set a stretching challenge. We also note that this brings our frontier shift efficiency assumption closer to that typically applied by Ofwat before PR14 e.g. at PR09, Ofwat applied a 'continuing efficiency' assumption of 0.25%.

Retail frontier shift

6.2.5 At PR19, Ofwat set the residential retail price control on a nominal basis, meaning residential retail's revenues do not increase with inflation each year. Given inflation represents the general increase in prices across the economy (and therefore the aggregated net effect of productivity gains and real price effects), setting the retail allowance in this way subjects the retail control to a substantial level of stretch, particularly in a high inflation environment.

6.2.6 As such, we consider a frontier shift challenge in retail to be inappropriate. In fact, we consider that a positive frontier shift challenge could be justified. However, we do not implement this in our proposal. For clarity, this position means that our retail frontier shift assumption is 0%.

6.3 How we reflect the cost-service relationship within the frontier shift challenge

6.3.1 Since the introduction of the totex-outcomes framework, Ofwat has required the industry to improve performance without additional expenditure allowances. And because the efficient benchmark is generally set with reference to historic expenditure, the benchmark won't reflect the costs associated with improving performance in future periods. As a result, performance improvements have effectively represented an implicit productivity challenge.

6.3.2 The scale of performance improvement should be taken into account when frontier shift is set at PR24. This aligns with our principle of cost assessment, which states that efficiency should be challenged within a transparent and coherent framework. We have developed an approach that we consider achieves this, which we set out in this section.

6.3.3 As part of the PR24 business plan submission, companies must state the performance improvements that will be delivered from base expenditure i.e. without additional expenditure allowances and therefore funded via efficiency gains. This information is captured in table OUT2.

6.3.4 In a competitive market, marginal benefit equals marginal cost. We can use this assumption to calculate the overall implied cost of delivering the service improvements from base expenditure by multiplying the performance improvements in OUT2 by the marginal benefit, as captured by the relevant incentive rate. While the water sector is not competitive, we consider that it is appropriate and in the best interests of customers to align the incentives within the regulatory framework to those faced by companies in a competitive market. We note that the water sector's relative capital intensity means that actual marginal costs may be higher that marginal benefit in the short-run e.g. because the long-run nature of water companies' assets means that they are not able to quickly reallocate capital. Additionally we note that this analysis focuses on performance improvements – addressing deterioration in performance (e.g. due to a natural rate of rise effect) also acts as an implicit productivity challenge. This means that the mc=mb assumption is likely to produce an underestimate of the implicit productivity challenge.

6.3.5 This calculation will produce an overall marginal cost of service improvements achieved through base expenditure. This amount should be netted off against the frontier shift challenge to ensure that the regulatory settlement is achievable. It is entirely possible (and legitimate) that this results in a positive frontier shift. We note that customers would be protected from inefficiency through ODI penalties. ODI rewards would then reward companies that go beyond the productivity improvement implied through our proposed PCLs.

6.3.6 We demonstrate this approach using UUW's business plan. However, Ofwat could use information from across the industry to implement this methodology. We do note that a coherent approach to efficiency wouldn't seek to impart stretch beyond the average company during this process because costs are already subject to a catch-up challenge. For example, finding the upper quartile level of performance improvements from table OUT2 while requiring upper quartile levels of catch-up efficiency would result in an unobtainable benchmark for an efficient company.

6.3.7 We provide an overview of our approach in Table 25. This analysis suggests that UUW is targeting additional productivity improvements of around £130m within AMP8, over and above the productivity improvements implied by our frontier shift assumptions and wider assumptions about catch-up efficiency. We note that this analysis is indicative and we will look to refine it going forward.

Table 25: Estimated implicit productivity improvements made from base expenditure

	Indicative ODI rate	Benefit sharing factor	Implied marginal benefit	Assumed marginal cost	2024-25 level	2029-30 level	Estimated productivity improvement
units	*£m*	*%*	*£m*	*£m*	*various*	*various*	*£m*
Internal sewer flooding	15.10	70%	21.57	21.57	2.88	1.99	19.20
External sewer flooding	6.76	70%	9.66	9.66	15.66	13.72	18.73
Bathing water quality	1.64	70%	2.34	2.34	N/A	N/A	
Customer contacts	19.06	70%	27.23	27.23	1.49	0.93	15.15
CRI	1.90	70%	2.71	2.71	2.74	0.00	7.42
Water supply interruptions	2.06	70%	2.94	2.94	00:05:00	00:04:55	0.00
Mains repairs	0.37	70%	0.53	0.53	106.5	106.4	0.05
Unplanned outage	4.06	70%	5.80	5.80	2.34%	0.41%	0.11
Sewer collapses	1.71	70%	2.44	2.44	13.07	12.41	1.61
Total pollution incidents	1.78	70%	2.54	2.54	16.03	12.02	10.19
Serious pollution incidents	1.14	70%	1.63	1.63	0.00	0.00	0.00
Discharge permit compliance	2.88	70%	4.11	4.11	1.00	0.98	0.07
Storm overflows	1.29	70%	1.85	1.85	29.26	29.26	0.00
Leakage	0.36	70%	0.52	0.52	380.6	330.66	26.03
PCC	2.57	70%	3.67	3.67	135.70	130.37	19.57
Business demand	0.36	70%	0.52	0.52	362	340	11.47
River water quality	0.001	70%	0.00	0.00			0.00
Total							**129.61**

Source: UUW analysis of UUW's PR24 business plan

6.3.8 It is appropriate to focus upon base expenditure within this analysis. This is because the marginal costs incurred by delivering the benefits outlined in enhancement cases will be remunerated via enhancement allowances. Therefore, including enhancement will result in a double count. If Ofwat does not allow enhancement allowances but still requires related performance improvements, then this should be reflected through an offset to the frontier shift in the same way as base efficiency.

6.3.9 In order to provide a stretching cost challenge, we do not net off the implied productivity challenge of £130m from our annual frontier shift assumption of 0.55%. We consider that this will provide a stretching efficiency challenge in the round. However, this assumes that frontier shift will not be increased above 0.55%. Were this to happen, we would consider it appropriate for the implied productivity challenge to be netted off against frontier shift to reflect the additional efficiencies now being asked of companies.

6.4 What elements of cost should frontier shift be applied to?

6.4.1 At PR19, Ofwat applied the frontier shift to all elements of base cost, along with cost allowances for the environmental enhancement programme and new meter installations. The CMA removed the application of frontier shift to abstraction licence costs and business rates because it considered these were largely outside of company control.

6.4.2 We accept the CMA's principle[67] that the frontier shift efficiency challenge should only be applied to elements of cost under the influence of companies. For this reason, we do not apply frontier shift to the following categories of cost:

[67] The Competition and Markets Authority (2021) *Water redeterminations – summary*. Available here.

- **Abstraction licence costs.** These costs are determined by the Environment Agency (EA) and are stated in the EA's charges scheme. There is no scope for these charges to reduce over time in line with frontier shift assumptions.
- **Business rates.** Business rates are a tax. There is no scope for these charges to reduce over time in line with frontier shift assumptions.
- **Industrial Emissions Directive compliance costs.** IED compliance costs are determined by the EA and as such it is inappropriate to assume these costs can decrease in line with frontier shift assumptions.
- **Traffic Management Act costs.** TMA costs are determined by the local authority and as such it is inappropriate to assume these costs can decrease in line with frontier shift assumptions.
- **Third party costs.** Applying frontier shift to third party costs would be to the detriment of customers.

6.4.3 We also do not apply frontier shift to the enhancement costs stated in tables CW1 and CWW1. These costs reflect our enhancement programme after we have carried out internal and third party reviews of our cost build, including benchmarking against our peers, as well as an application of frontier shift. Therefore, applying further efficiencies will result in a double count.

6.5 Real Price Effects

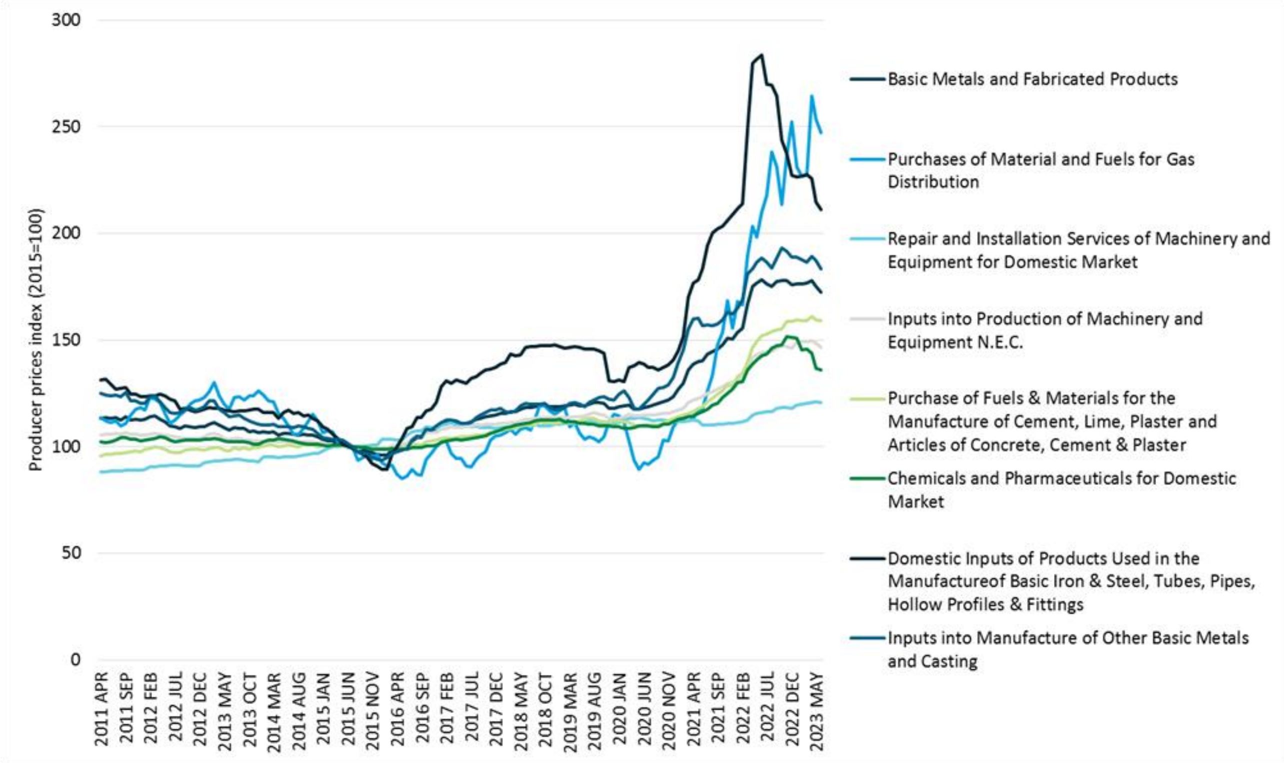
6.5.1 Real Price Effects (RPE) capture the extent to which the change in input prices differs from the change in general inflation as measured by CPIH. For example, if the price of a given input increases at 5% but inflation is increasing at 2%, then the real price effect is 3%. The PR19 Final Determination implemented an RPE relating to labour inputs, but not other input costs. The labour cost RPE assumption is subject to a reconciliation mechanism.

6.5.2 Whatever approach is used to assess energy costs at PR24, it should be applied as a common adjustment across the entire industry and not selectively to ensure fair and equal treatment. Otherwise, companies may be incentivised to adopt a more conservative stance in future submissions, by proposing inefficient costs in order to avoid losing out on any adjustments. This will worsen the problem of information asymmetry.

Input price movements within AMP7

6.5.3 There has been a substantial economy-wide increase in input prices in recent years. Figure 16 shows the production prices index for areas with relevance to water and sewerage supply. There is a clear spike from the start of AMP7 onwards.

Figure 16: Production prices index (2015=100)



Source: Office for National Statistics

6.5.4 This spike is manifesting itself in AMP8 in the following ways:

- Hedged electricity products have become more expensive. Buying hedged products insulated companies from the worst of the increases in energy prices. However, because of the recent energy price spike, the price of hedged electricity is now correspondingly larger.
- Construction costs have gone up, which has had substantial implications for the AMP8 enhancement programme.
- Currently, chemical suppliers are unwilling to provide spot prices beyond three months into the future (in turn this is due to uncertainty about energy costs). This means that there is considerable uncertainty over the cost of chemicals throughout AMP8.

How recent increases in input prices feed into cost assessment

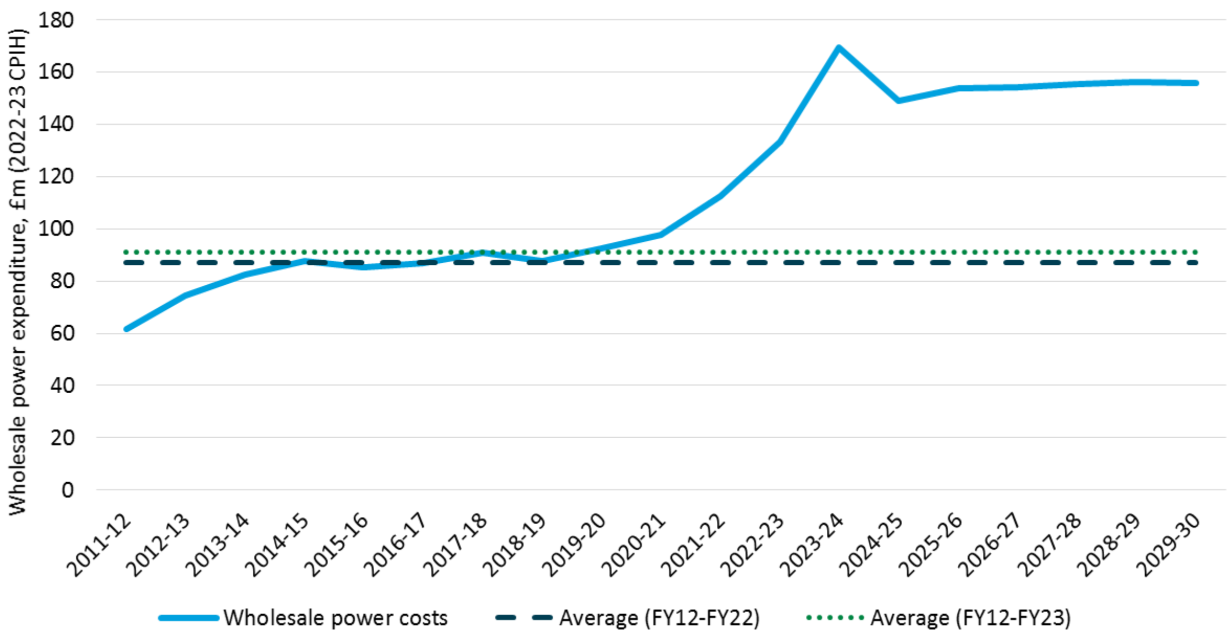
6.5.5 Botex allowances are set by reference to econometric models which draw upon the historical cost record covering the period since 2011-12. At the time of business plan submission, we have outturn data up to 2022-23 and at the time of the Final Determination, cost data from the 2023-24 financial year will be available. This means that cost shocks will be reflected in at least part of the historical dataset used to set botex allowances.

6.5.6 However, this does not mean that the botex models will fully reflect the cost pressures companies can expect to face in AMP8. Most years in the historical dataset could be classed as ‘low cost’, relative to the current period. Even if ‘high cost’ years are added, then the effect of these on overall botex allowances is mediated by the presence of ‘low cost’ years. A simple rule-of-thumb is that each year in the historical dataset carries proportional weight. So for example, if the historical dataset covers 12 years, of which 11 are ‘low cost’ and one is ‘high cost’, the model would place a weight of 1/12th on the ‘high cost’ year. If costs remain at the ‘high cost’ level in the future period, then a botex allowance would only provide 1/12th of the increase needed. Appendix B contains a full substantiation for this rule-of-thumb.

6.5.7 We can build on this logic to understand the extent to which the highest cost ‘peak’ year in the dataset will be reflected in AMP8 cost allowances. Figure 17 has the following components:

- **Wholesale power costs.** This is made up of outturn wholesale power costs to 2022-23 then our business plan power costs to 2029-30.
- **Average (FY12-FY22).** This is UUW's average cost of power in the period 2011-12 to 2021-22 and approximates[68] the allowance for energy a botex model would make if it used this data period. The distance between this line and the 'wholesale power cost' line approximates the stretch UUW will be under in AMP8 should power costs outturn in line with forecasts.
- **Average (FY12-FY23).** This is similar to the previous component, but also includes 2022-23. This approximates the additional allowance for power a botex model would make if it included the year 2022-23. Clearly, the increase in costs in 2022-23 only has a muted impact on overall botex allowances, which is what we would expect based upon the proof in Appendix B. The distance between this line and the 'wholesale power cost' line approximates the stretch UUW will be under in AMP8 should power costs outturn in line with forecasts. While the stretch is slightly less as a result of the inclusion of 2022-23 data (a 'high cost' year), it is still substantial.

Figure 17: UUW's actual and forecast power costs



Source: APR for historical information, UUW business plan for forecast information

6.5.8 This demonstrates that, while the models will reflect an element of the power increases within the 'peak' year, this peak year implicit allowance will not be material. The next section explains why this means an RPE adjustment is unnecessary.

A downwards adjustment for RPEs in AMP8 would be inappropriate

6.5.9 BEIS's forecasts suggest energy prices will begin to fall throughout AMP8, as shown in Figure 18.

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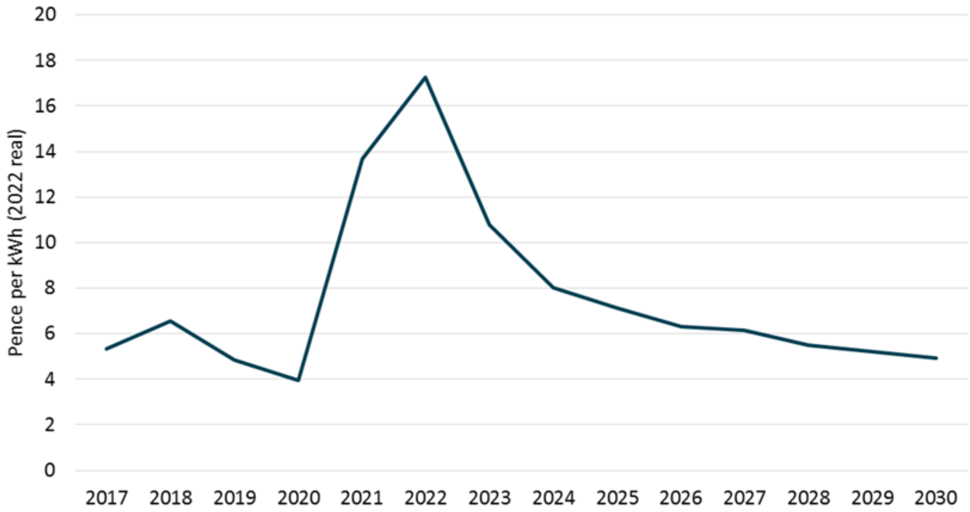
[68] In reality, the allowance would be based upon the industry average power expenditure, but we abstract away from this added complication for the purposes of this example.

Figure 18: BEIS forecasts of wholesale electricity prices



Source: Department for Business, Energy and Industry Strategy

6.5.10 We understand that there may be a desire to seek to implement a downward adjustment in response to these falling prices, either through excluding from cost modelling certain years where costs are considered to be atypically high or through an explicit downwards RPE adjustment. However, we strongly consider this would be entirely inappropriate.

6.5.11 This is partly because wholesale electricity prices do not generally reflect the actual price company's pay. As Ofwat itself recognises: *"…Water companies tend to manage energy costs through hedging arrangements, long-term offtake contracts and investing in self-generation. This means that over recent years water companies have on average paid far less than the wholesale price of energy."*[69] We consider these points to be entirely valid and correct.

6.5.12 However, this does mean that should wholesale electricity prices fall over the course of AMP8, companies that hedge electricity will likely pay more than the wholesale price. This is because the price of hedged products will reflect the high energy costs of recent years and so will remain at a relatively high level.

6.5.13 There is a risk that the implementation of a downwards adjustment to reflect expected falling energy costs could incentivise companies to adopt more risky positions in the energy market in order to benefit from falling wholesale prices, in the hope of aligning their cost base to regulatory assumptions (with the associated risk from increasing wholesale prices). Or conversely, by hedging, a company will have to accept that it will (in part) underperform against its regulatory cost targets in order to insulate itself from volatile energy prices.

6.5.14 Finally, while a downwards adjustment would be entirely appropriate if the models reflected the recent increases in energy costs in full, as the previous section evidenced, they do not. The models will only contain a partial 'implicit allowance' for higher power costs (see Figure 17). Therefore, implementing a downwards adjustment in line with forecasted wholesale power prices would reflect an asymmetric adjustment that would place undue stretch on companies.

6.5.15 Therefore, we do not consider that an RPE adjustment is neccessary. While energy costs are expected to fall from the 2022-23 peak, the cost models will only reflect a small portion of this peak year and so the increase in cost allowances will be muted. Overall, we consider that the net impact of these two opposing factors will be immaterial. As such, we consider the existing mechanisms within the regulatory framework provide sufficient protection to both customers and companies from RPE risk and an additional adjustment would be disproportionate.

[69] Ofwat (2023) *Approach to energy cost forecasts in PR24 (letter to Regulatory Directors).*

7. Why our proposed cost targets do not reflect urban rainfall or combined sewers

7.1.1 This section summarises UUW's approach to reflecting regional environmental factors within the regulatory framework. We do not reflect environmental factors within our cost targets. Instead, we consider that it is most economic to adjust performance targets according to the regional challenges faced by companies. This is unequivocally not about making performance targets 'easier'. In fact, it will ensure that all companies face equivalent levels of stretch – we demonstrate that a common PCL for internal sewer flooding is comparatively easy for some companies to meet (but impossible for others). This section summarises UUW's approach and references other key documents within the business plan submission and elsewhere, which collectively provide the theoretical foundation for our approach.

7.1.2 As we set out within this section, we consider the most economic outcome is for regional environmental factors to be reflected within performance targets. However, we recognise that Ofwat may not align to this position. As such, we have submitted a conditional cost adjustment claim, which we consider reflects the higher ongoing expenditure associated with our regional factors. We will withdraw this claim should Ofwat adopt our proposals to adjustment performance targets. However, as we discuss below, even if this conditional claim was accepted in full, meeting a common PCL for internal sewer flooding would be extremely challenging for a company with our characteristics.

7.2 UUW's proposals are based upon a substantial body of evidence

7.2.1 UUW has been a prolific contributor to the debate on how best to reflect the regional characteristics of wastewater companies within the regulatory framework. Our work during PR19 focused upon the effect that different levels of urban run-off have on cost:

- During AMP6, we commissioned Arup and Vivid Economics[70] to provide a bottom-up assessment of cost drivers associated with providing a wastewater service. This project also developed an approach to reflecting urban rainfall as an explanatory variable, which has since been largely adopted by Ofwat.
- We worked with Arup to develop and submit a cost adjustment claim[71] relating to the drainage challenges we face. Ultimately, this claim was not accepted by Ofwat.

7.2.2 Our work since PR19 has demonstrated that adjusting cost targets may not be the best approach to facilitating a level playing field amongst WaSCs:

- Our internal sewer flooding 'Hackathon;' brought together multi-disciplinary teams from inside and outside of UUW. It analysed a wide range of data to develop a bottom-up understanding of how certain characteristics of the wastewater network can lead to internal flooding incidents. This found a clear link between internal flooding incidents and combined sewers; urban rainfall; local topography; and Food Service Establishment density (among others).
- One of our Future Ideas Lab submissions[72] developed an approach by which performance targets for appropriate Performance Commitments could be set, with a specific focus upon setting performance targets for internal sewer flooding. The paper validated the Hackathon's findings at an industry level and set out an innovative approach by which performance targets could be adjusted according to exogenous regional environmental factors such as urban rainfall and combined sewer prevalence. It

[70] Arup and Vivid Economics (2017) *Understanding the exogenous drivers of wholesale wastewater costs.* Available here.

[71] UUW (2018) *Combination of exogenous factors impacting surface water run-off.* Available here.

[72] UUW (2022) *What lessons can we learn from cost assessment at PR19?* Available here.

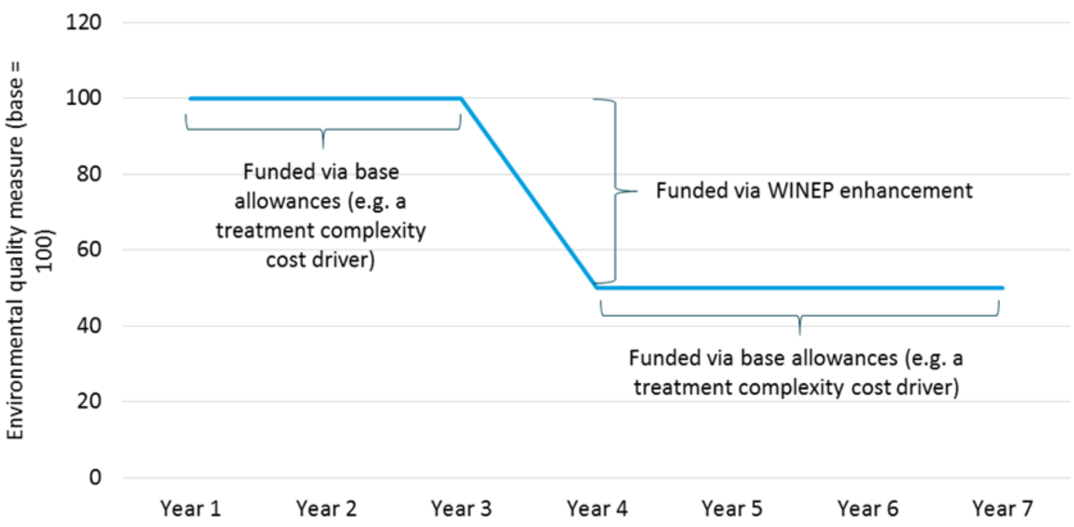
also highlighted that exogenous factors play a fundamental part in determining performance and addressing such factors would be very costly.

- Another of our Future Ideas Lab submissions[73] provided an updated approach to assess how the regulatory framework could set performance and cost targets in a variety of scenarios e.g. is it most appropriate to adjust performance targets, cost targets or both?
- Jointly with Anglian and Wessex, we commissioned Reckon[74] to explore how base cost models allocate costs for particular activities e.g. service improvements, and how cost assessment could better align its approach to base and enhancement activities. This demonstrated that the presence of regional environmental factors could lead the botex models to fund different performance levels for different companies.

7.3 It is appropriate for the foul sewerage service to be subject to common performance targets

7.3.1 Improvements in the service quality provided by foul service tend to be funded by the WINEP e.g. meeting more stringent phosphorous consents. Efficient differences in ongoing higher costs are then reflected within base costs through the adoption of appropriate cost drivers e.g. treatment complexity. In these circumstances, it is reasonable to apply common PCLs e.g. treatment works compliance. This is because companies have been equivalently funded and as such are able to compete on a level playing field. Absent WINEP enhancement, it would be entirely inappropriate to expect companies to improve environmental quality through base costs alone.

Figure 19: How enhancement and base costs are recognised for improvements in quality provided by the foul sewerage service



Source: UUW analysis

7.3.2 For example, discharge permit compliance measures companies' performance against the permits in force at their wastewater treatment works. Companies with more stringent permits receive a higher allocation of costs through the adoption of a treatment complexity cost driver. If a future WINEP requires companies to comply with more stringent discharge permits, the cost of moving towards this higher standard of performance would be remunerated via an enhancement allowance. The subsequent higher ongoing cost of maintaining performance at this new level would then be remunerated through

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[73] UUW (2022) *Making the cost assessment framework resilient to future challenges.* Available here.

[74] Reckon LLP (2022) *The opportunities for a more coherent regulatory approach for Ofwat's funding of base expenditure and enhancements*. Available here.

base allowances (assuming the explanatory variable used to reflect treatment complexity is correlated with the change in permit).

7.3.3 Therefore, it is entirely appropriate for the foul sewerage service to be subject to common performance targets – cost allowances have historically reflected the full cost of improving and maintaining performance against environmental measures. This allows all companies to compete on a level playing field for related measures e.g. discharge permit compliance.

7.4 Companies do not operate on a level playing field when delivering the surface water drainage service

7.4.1 While it is generally appropriate for companies to be targeted against common PCLs when delivering their foul sewerage service, this is not the case for the surface water drainage service. This is due to the existence of exogenous regional environmental factors that drive a substantial proportion of relative performance and a lack of sustained enhancement commensurate to allow companies to overcome these regional factors. Our prior work (set out in section 7.2) has demonstrated that the following regional environmental factors drive significant variation in companies' relative performance for wastewater measures (note this list focuses on certain key factors and is not exhaustive):

- Urban rainfall;
- Combined sewer prevalence;
- Food Service Establishment (FSE) density;
- Population density;
- Cellar density; and,
- Local topography.

7.4.2 Simply adding these factors into the cost model suite will not provide an adequate cost allowance to meet a common performance level, because that performance level isn't currently being achieved. Rather, it will reflect the differences in company costs in achieving the current level of actual performance, **not** the target level of performance. Supplementary document *UUW44 - Cost adjustment submission* makes clear that reflecting a subset of these factors within cost models will increase UUW's predicted costs by £152m. This is the cost of achieving UUW's current level of performance i.e. we are incurring more costs and still incurring higher than average levels of internal sewer flooding.

7.4.3 This is not due to poor management practice. If this was the case, then variations in performance around the common target would be **randomly distributed** and **entirely unrelated** to the regional factors set out in paragraph 7.4.1. However, we provide robust evidence that disproves this statement.

7.4.4 To do this, we developed a performance modelling approach which sought to test whether these factors drive performance at an industry level. This is set out in our Future Ideas Lab paper[75]. We have subsequently updated this model with more data as part of our business plan submission[76]. We found that these factors (particularly urban rainfall, combined sewer prevalence and FSE density) are key performance drivers for internal sewer flooding. This evidences that these exogenous factors are directly related to performance and that company performance is not randomly distributed around the common internal sewer flooding target. As such, this is clear evidence in support of a company-specific target, which would ensure all companies are given an equivalent level of stretch in their performance targets.

7.4.5 Furthermore, the presence of these environmental factors means that targeted interventions at a relatively small number of properties each year (as captured by 'reduce flooding risk for properties'

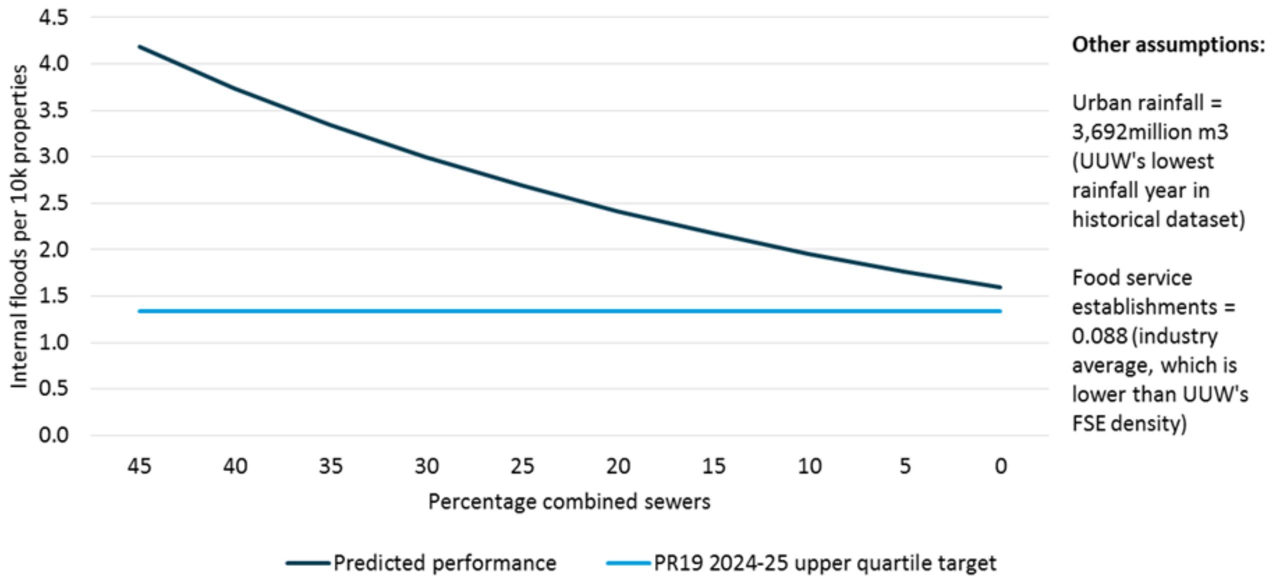
[75] UUW (2022) *What lessons can we learn from cost assessment at PR19?* Available here.

[76] UUW30 '*Internal sewer flooding technical document'.*

enhancement – see paragraph 7.4.7 below) is not sufficient to facilitate companies operating in adverse regions to move towards a common performance target and therefore will not allow companies to compete on a level playing field.

7.4.6 If companies are expected to compete on a level playing field, then companies in areas with adverse environmental conditions will need to substantially reconfigure their networks e.g. by separating their combined sewer systems or preventing urban rainfall entering the sewers. Our performance model allows us to predict how performance is expected to improve as the percentage of combined sewers reduces, holding other factors equal. This is set out in Figure 20. It's clear that even with a substantial programme of combined sewer separation, other interventions will be necessary to hit the common PCL.

Figure 20: How performance improves as combined sewer prevalence decreases



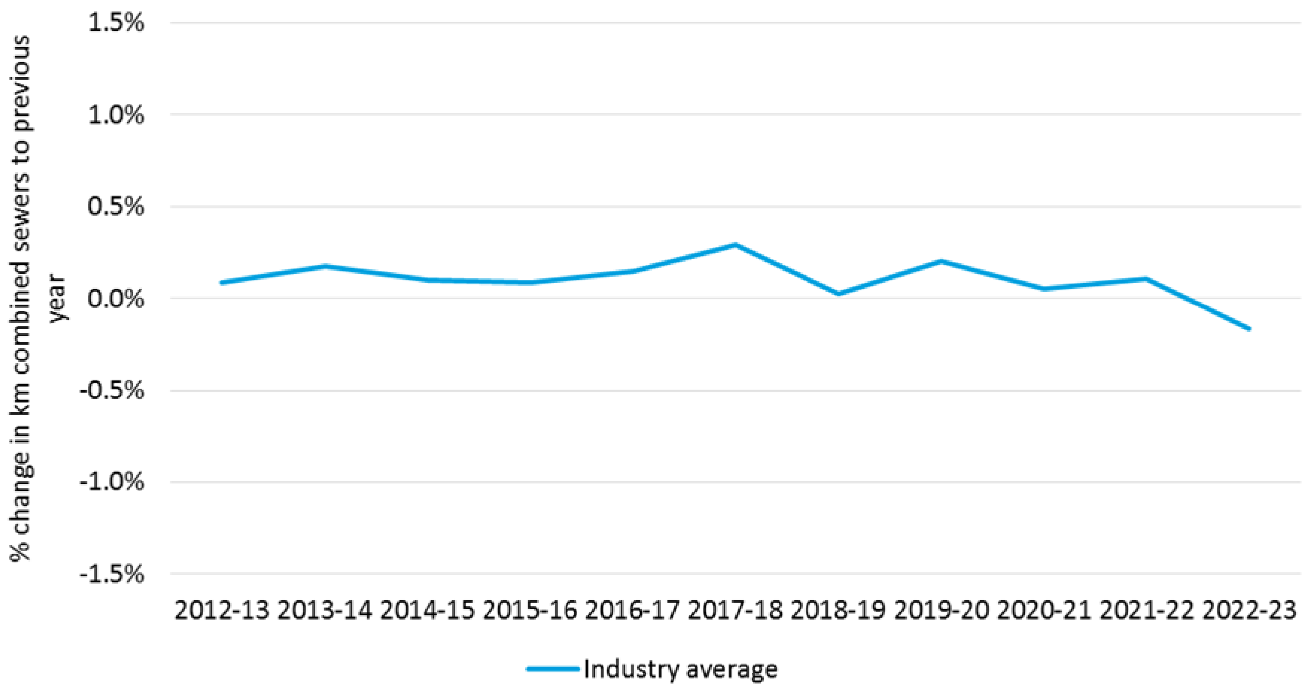
Source: UUW analysis

7.4.7 Ofwat may consider that its inclusion of enhancement expenditure relating to 'reduce flooding risk for properties' within the scope of modelled cost means that companies are appropriately funded, such that a level playing field exists and a common PCL is appropriate. However, this is not the case. 'Reduce flooding risk for properties' reflects targeted interventions at individual properties (usually repeat flooders), not wholesale reconfiguration of the wastewater network. More information about this enhancement and related activity can be found in our 'reduce flooding risk for properties' enhancement case[77].

7.4.8 Therefore, we are clear that base allowances derived from historical expenditure would not facilitate a level playing field and common levels of performance. This is because the scale and nature of activity required for companies in adverse operating areas to move towards common performance is not contained in the historical dataset. For example, Figure 21 shows the relative change in combined sewers over the historical period covered by the base cost models. It's clear that there has been no fundamental separation of the combined sewer system. The rate of change in Figure 21 can be contrasted with the change required to achieve the PR19 upper quartile target for internal sewer flooding, as set out in Figure 20 above. This comparison makes clear that base allowances are unable to facilitate the activity required for a company with UUW's characteristics to hit a common PCL.

[77] *Wastewater Quality Additional requirements section 'Reduce flooding risk for properties enhancement case'*

Figure 21: Rate of change in combined sewer length (industry average)



Source: UUW analysis of Industry data share

7.4.9 We note that performance could also be improved by preventing surface water entering the combined sewer system, which would mitigate the impact of urban rainfall. Our 'surface water separation' enhancement case sets out our initial investment as part of a multi-AMP plan to achieve this[78]. We note that there is a clear difference in the type of enhancement included within 'reduce flooding risk' and our 'surface water separation' enhancement case.

7.5 Adjusting performance targets is the most appropriate outcome

7.5.1 We are clear that the only way for companies to compete on a level playing field against a common internal sewer flooding target would be to have similar levels of surface water separation and equivalent network capacity relative to the volume of each company's urban rainfall.

7.5.2 However, separating the combined sewer system and reducing surface water run-off entering our sewers are both complex and costly interventions. While we consider surface water separation to be an economic intervention with multi-faceted benefits, this is not the case for combined sewer separation. Combined sewer separation would entail the reconfiguration of the entire sewer system in the North-West and would be extremely costly and disruptive. We note that the Government's SPS did not consider this to be a viable option: *"This evidence project estimates that the complete elimination of all storm overflows at coastal and inland waters by completely separating the sewer network would cost between £350 billion and £600 billion. It would also cause significant disruption. For example, most of the combined system runs under our towns and cities and would have to be dug up"*[79]. We note that companies with high levels of urban rainfall **and** combined sewer prevalence would face costs orders of magnitude higher than companies in more benign areas – this cost cannot be expected to be accommodated by the addition of 'reduce flooding risk for properties' expenditure to the scope of modelled cost.

7.5.3 Without significant investment in **both** combined sewer separation and surface water removal, companies' performance will continue to be significantly affected by environmental factors outside of

[78] *UUW65 Wastewater Quality Additional requirements section 'Rainwater management enhancement case'.*

[79] Defra (2022) *Consultation on the Government's Storm Overflows Discharge Reduction Plan*. Available here.

their control, which means it is entirely inappropriate to expect companies to operate on a level playing field e.g. by setting a common PCL for internal sewer flooding.

7.5.4 As such, we consider it is more appropriate for related PCLs to be set according to regional environmental factors, which is exactly analogous to the way cost targets are set. This would avoid the need for customers to fund uneconomic levels of infrastructure investment.

7.5.5 We note that this is unequivocally not about setting 'easier' performance targets for some companies. In fact, it would result in all companies facing equivalently stretching targets i.e. a level playing field. In contrast, a common PCL applies unequal stretch, with companies in more benign regions finding it relatively easy to meet the target while other companies will find it impossible. As such, customers in different regions will pay the same price for fundamentally different service standards. Our approach ensures that customers in different regions pay the same price for the same service.

7.5.6 For this reason, we propose performance targets for internal sewer flooding that are adjusted for regional environmental factors. In order to avoid a double count, we do not reflect these environmental factors within our proposed cost targets.

8. Cost adjustment claims

8.1.1 UUW submitted five cost adjustment claims as part of the early submission. We summarise these below.

- **Reservoir maintenance.** UUW operates an unusually large fleet of impounding reservoirs. Historically, this has driven higher costs relative to other sources, due to the need to monitor and maintain the reservoir dam. However, future maintenance requirements are expected to increase because of the more stringent inspection regime in place following the publication of the Balmforth Report. Additionally, a change in the Environment Agency's flood risk maps will require additional mitigation activity as a result of the Health and Safety at Work Act, beyond that undertaken in the past.
- **Ongoing P-removal opex arising from AMP7 WINEP.** The AMP7 WINEP seeks to reduce the phosphorous content of final effluent to historically low levels. The associated ongoing opex is not reflected in the historical cost record because this is a new requirement and most schemes won't complete until the final year of AMP7. This means that base modelled allowances won't be sufficient and an out-of-model adjustment is necessary to allow companies to recover efficient ongoing costs.
- **IED permit compliance at anaerobic digestion sites.** This claim relates to the higher future permit compliance costs resulting from more stringent requirements from the Environment Agency's 2022 appropriate measured guidance (over and above the requirements of its 2018 guidance).
- **Waste permit compliance at physico-chemical sludge sites.** We have withdrawn this claim. The EA has confirmed that these sites are eligible to operate under a wastewater exemption, rather than requiring bespoke wastewater permits and a full review against requirements set out in the Appropriate Measures guidance. As such, the expenditure set out in this claim is no longer required.
- **Drainage.** This is a conditional claim. Our first preference is for Ofwat to reflect relevant environmental factors (urban-run off, combined sewer etc.) in setting PCL targets for sewer flooding for all companies, under a common methodology). If adjusting our performance targets is seen as unacceptable, then this cost adjustment should be applied to reflect additional costs of managing such factors in the UUW region.

8.1.2 We do not seek to reflect these factors within our base modelling suite. This is because these factors generally reflect future incremental cost pressures and as such can't be explained by reference to historical costs. We do value the conditional drainage claim using a modelling approach, although we do not implement that approach within our base modelling suite to avoid a double count, given our proposed targets for internal sewer flooding are based upon the same regional factors. See section 7 for more details.

8.1.3 Within the business plan submission, we have submitted a document containing our updated claims, with any changes relative to our early submission made clear. Please see supplementary document *UUW44 – Cost Adjustment Claims*.

9. UUW's response to other companies' symmetrical CACs

9.1.1 This section sets out UUW's response to other companies' proposed symmetrical cost adjustment claims. It should be treated as UUW's submission to the symmetrical cost adjustment claim consultation process.

9.1.2 Symmetrical cost adjustment claims seek to mimic the way that econometric models allocate historic expenditure, based upon a set of cost drivers. Companies that consider they face significant regional costs pressures can suggest a symmetrical adjustment, whereby cost is reallocated away from companies operating in less challenging environments.

9.2 Average pumping head

9.2.1 This section should be read as passing comment on the following proposed symmetrical cost adjustment claims:

- Average pumping head (Anglian Water)
- Power, maintenance and investment costs associated with pumping requirements (Sutton and East Surrey Water)
- Network complexity (Severn Trent Water)
- Regional topography (South Staffordshire and Cambridge Water)

9.2.2 The section begins with general comments on themes underlying all these claims and following that sets out specific comments relating to each claim.

9.2.3 These claims share a common characteristic in that they consider the models do not appropriately reflect cost pressures relating to topography. Specifically, the claims make the case that power costs are not appropriately remunerated through the explanatory variable, 'booster pumping stations per km of mains length'. The claims would rather 'average pumping head' be used exclusively to reflect topography in the cost model suite. In Severn Trent's claim, 'average pumping head' is used alongside 'booster pumping stations per km of mains length' to attempt to reflect what it terms 'network complexity'.

9.2.4 UUW remains extremely concerned over the robustness of average pumping head data. While we agree that average pumping head is a theoretically appealing way to reflect power requirements, there are several pieces of compelling evidence that suggest it remains fundamentally inconsistent across different companies and leads to entirely implausible results. We wholly disagree that cost assessment should be exposed to the influence of a variable that has significant question marks over its ability to reflect the true underlying relationship between cost and cost driver and is under the substantive short-term influence of companies. This section sets out evidence to support these concerns.

9.2.5 We also consider that it is inappropriate to drop booster pump density entirely, as some companies propose. We consider that this is motivated by a fundamental misunderstanding of the underlying topographical factor that booster pump density is seeking to capture – asset configuration on the water network. Once pumping head's data quality has been confirmed as robust and consistent by a third party, pumping head and booster pump density should be used alongside each other in a triangulated model suite to reflect different elements of the relationship between topography and cost (to be clear, they should not be used in the same model as Severn Trent proposes in its claim).

There is no evidence that average pumping head data is more robust at PR24 than at PR19

9.2.6 We agree that a measure that reflects pumping effort is a valid driver of cost of water company networks. In principle, APH would appear to be an intuitive way to reflect one aspect of costs related to topographical challenges in a companies' region – the extent to which companies need to lift water to deliver it to their customers. However, APH is a calculated value and, as such, is susceptible to differences in calculation methodology between companies (and hence is partially endogenous). In the case where we were confident in the quality and consistency of reported APH data, we could be more supportive of its inclusion within a subset of the water models. However, we are not confident in the quality and consistency of APH data and so we do not support the use of APH at PR24. We consider that the continued use of booster pumping stations would be more reliable and less at risk from methodological reporting differences.

9.2.7 Ofwat and the CMA both lacked confidence in the robustness and consistency of APH data at PR19. Ofwat stated:

"We tested alternative explanatory variables to capture differences in network complexity and energy requirements (such as average pumping head and pumping capacity) but we did not find a more robust cost driver"[80]

And:

"The low quality of average pumping head data was noted also when we quality assured the data and identified large unexplained annual variations for some companies"[81].

The CMA said:

"…We had concerns regarding the quality of the APH data"[82]

And:

"…We decide that APH should not be included as an explanatory variable in the econometric models"[83].

9.2.8 Following PR19, Ofwat commissioned Turner & Townsend and the WRc to carry out an industry-wide survey into APH and the way in which different companies approach its estimation. The study[84] found significant inconsistencies between the ways in which APH is reported across the industry, including:

- Significant variation between companies in the proportion of measured and estimated data in TWD for both volume and lift;
- Approaches that used static estimates that had not been updated for a number of years in APH calculations;
- Some companies failing to exclude/include relevant items in the calculation of APH, which could either under or overstate APH;
- Different approaches taken to the allocation of APH across the upstream business units; and
- Different approaches taken to estimating APH data.

9.2.9 These issues (along with others noted in the study) suggest that APH is manifestly unsuited for use in cost assessment until Ofwat and the industry can be confident in its robustness and consistency.

9.2.10 The Report made some recommendations on how the industry should address the issue of poor quality APH data, for example:

- Move towards more measurement of APH's components;
- Ofwat should issue updated guidance to reduce the risk of inconsistent calculation across the industry; and,
- Set up a collaborative forum to share ideas and best-practice.

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[80] Ofwat (2019) *Draft determinations – securing cost efficiency technical appendix.* Available here.

[81] Ofwat (2020) *Response to common issues in companies' statement of case*. Available here.

[82] CMA (2021) *Final report*. Available here.

[83] ibid

[84] Turner & Townsend and the WRc (2022) *Average pumping head: data quality improvement.* Available here.

9.2.11 We note that Ofwat has issued updated guidance for the industry for 2021-22 and 2022-23 reporting years, which should help to mitigate an element of the inconsistency in the calculation of APH going forward.

9.2.12 However, we are not aware of any material progress being made against any other recommendations. We attended one cross-industry working group hosted by South Staffordshire and Cambridge Water on 29 November 2022. Our observation of this session was that a wide variety of approaches are still used across the industry and the session did not establish any best practice guidance. To our knowledge there have been no subsequent meetings to promote or track progress made in APH calculation across the industry.

9.2.13 Given Ofwat's requirement for there to be a compelling reason to make changes to its PR19 model suite and its principle that data should be of good quality[85], we consider it is imperative for an in-depth appraisal of APH data to be carried out before APH could be considered for inclusion in cost assessment. This would track progress made against the Turner & Townsend and WRc recommendations and give confidence that the resulting benchmark is representative of regional operating conditions and not individual companies' APH methodology. However, we have not yet seen such an assessment.

9.2.14 Even as APH data is improved going forward, inconsistent data will remain in the historical dataset. This was noted in the study:

"If companies move to using more measured data instead of estimating it is unlikely they will be able to accurately back-cast the measured data. The relationship between measured and estimated data may not be consistent over time."

9.2.15 While the detrimental effect of inconsistencies may reduce over time assuming future years' data is consistent, for PR24 we consider the relative weight of consistent versus inconsistent in the historical dataset will lean towards inconsistent data. This is illustrated in Figure 22, which shows the data judged to be unsuitable for use by Ofwat and the CMA at PR19 still comprises the majority of the years used in the consultation model suite. It also shows that any improvements made to APH calculation will only just start to feed into cost assessment through years 2021-22 and 2022-23 (and we note that many consistency issues will likely be present within these years, as we discuss in paragraph 9.2.16).

Figure 22: Timeline of work relating to improving APH data

A: Ofwat and the CMA do not use APH in cost assessment due to concerns about data quality.

B: Ofwat appoints Turner & Townsend and the WRC to investigate data quality surrounding APH.

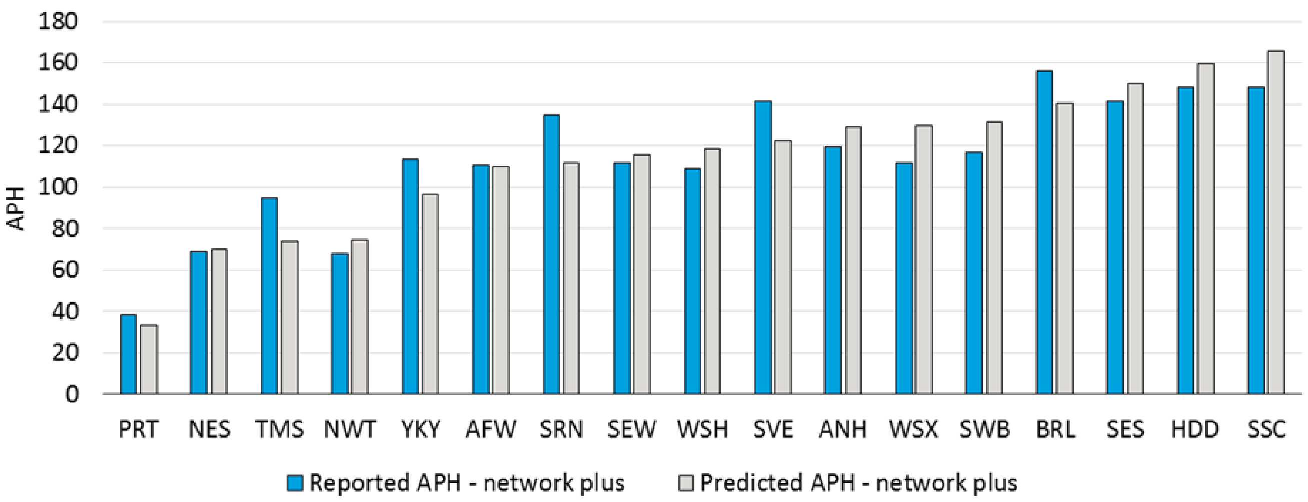
C: The Report is published.

9.2.16 We have also identified cases in the industry data share where APH appears to be materially overstated, through comparison to an equivalent and independently verifiable proxy (energy consumption divided by distribution input, see Appendix C for derivation and proof). Figure 23 illustrates reported and 'predicted' APH[86] using APR data over the period 2011-12 to 2022-23. It is clear that while the majority of companies' predicted APH is largely in line with reported APH, a number of companies report APH that is substantially higher than expected. This type of unexplained inconsistency is a key reason why UUW is so concerned at the use of APH in cost assessment at PR24.

[85] Ofwat (2022) *Final Methodology. Appendix 9: Setting expenditure allowances*. Available here.

[86] Estimated using the proxy variable.

Figure 23: Reported average pumping head versus a 'predicted' pumping head measure



Source: UUW analysis of APR data

No company provides any evidence that suggests APH data is of high quality

9.2.17 The poor data quality underpinning average pumping head is a widely known issue within the sector. Ofwat notes: "*We are still concerned about the quality of APH data*"[87]. This led Ofwat to commission a review by Turner & Townsend and the WRc[88]. This report found a number of inconsistencies in company reporting and made some recommendations for improvement. While the industry did subsequently hold a meeting in November 2022 on average pumping head data quality, this session did not agree best practice principles for calculating APH and we are not aware of any further conversations or progress made since then. Indeed, this session highlighted that a range of different estimation methods are still used, with no firm plans to improve this or move to more measured data. As such, we are not confident that APH data is of sufficient quality to use within cost assessment at this moment in time.

9.2.18 It is striking to us that no company acknowledges the data quality issue in their CAC. In fact, Anglian suggests that all data quality issues have been entirely eliminated: *"As a result of this renewed focus on APH and its data quality and a separate exercise by Ofwat to assure the cost data used in recent months, the concerns which led it the PR19 claim being dismissed have now been addressed."* It is not clear how Anglian has arrived at this conclusion. The Turner & Townsend report found substantial differences in average pumping head calculations between companies. We are not aware of any progress made in measurement techniques or improving consistency across companies since its publication. In fact, in its claim, SES states that 34% of its APH estimate has been calculated by reference to measured data in 2022-23. This is still strikingly low, and is considered by SES as a significant improvement.

9.2.19 No company provides any evidence of robustness analysis that considers what effect different values of pumping head would have on its claim. Given the uncertainty surrounding the quality of pumping head data, we would expect to see extensive evidence that demonstrates that changes in pumping head data do not have any undue impacts on the results.

The variable produce logically implausible and unintuitive results

9.2.20 We consider that there is clear evidence that the data consistency issues noted in the previous sections are driving implausible and unintuitive results. In some cases, the use of average pumping head results in some companies receiving a downwards adjustment and other companies receiving an upwards adjustment that is greater than the entirety of their power expenditure over a typical five year period. This section sets out the evidence supporting this finding.

[87] Ofwat (2023) *Econometric base cost models for PR24.* Available here.

[88] Turner & Townsend and the WRc (2022) *Average pumping head: data quality improvement.* Available here.

9.2.21 As we evidenced between paragraphs 9.2.30 and 9.2.34, pumping head primarily captures the energy requirement associated with moving water against gravity. SVE's claim supports this: *"Average Pumping Head (APH) is a direct measure of pumping and therefore energy usage."* Ofwat also recognises this: *"APH is a direct measure of pumping requirements. It captures the volume of water pumped and the pressure at which it is pumped"*[89]. Anglian also evidences this relationship: *"Average Pumping Head (APH) is a direct measure of pumping and therefore energy usage"*[90]. Therefore, pumping head is primarily a measure of power expenditure.

9.2.22 We can show that the use of pumping head drives unrealistic changes in power-related cost allocations, which suggests the data underlying pumping head does not appropriately reflect power costs. We consider that this is due to poor data quality. Additionally, the fact that the use of pumping head results in an adjustment that strips away more than 100 percent of several companies' power costs means that their subsequent allowances will be unrealistically low. As such, these companies will receive an unduly low allocation of cost and it is likely that the service to their customers will be affected as a result.Additionally, the fact that the use of pumping head results in an adjustment that strips away more than 100 percent of several companies' power costs means that their subsequent allowances will be unrealistically low. As such, these companies will receive an unduly low allocation of cost and it is likely that the service to their customers will be affected as a result.

9.2.23 Table 26 illustrates average annual wholesale water power expenditure by company over the period 2011-12 to 2022-23, and the five year equivalent value of this. Using a five year average allows us to compare to the AMP8 adjustments suggested within the cost adjustment claims – these cost adjustments are additional to the modelled allowances, which already include an implicit allowance relating to power expenditure.

9.2.24 This comparison reveals that Anglian's proposed symmetrical adjustment is in some cases resulting in companies receiving an upwards adjustment greater than their typical spend on power over an entire AMP. These instances are highlighted in red. This is clearly implausible and is resulting in an over allocation of cost to these companies. Conversely, some companies are receiving a downwards adjustment that is greater than their typical power expenditure over an AMP. This results in a negative implicit allowance for power i.e. using more power results in lower costs. Clearly, this is a logically impossible and unintuitive result. No company provides any evidence that would justify removing the entirety of several companies' implicit allowances for power from base allowances.

9.2.25 It is revealing that Thames Water has not submitted a cost adjustment claim relating to average pumping head. The extent of the proposed adjustment to Thames' allowances suggests that Thames faces significant issues relating to topography in its region. However, to our knowledge Thames did not seek a related cost adjustment claim at PR19 and is not seeking one at PR24. This could imply that Thames does not face significant topographical issues in its region, and the allocation of costs is being driven by inconsistent data and/or spurious correlations within the model suite. In any case, even if there were particular topographical issues in the Thames region, an allocation of costs 204 percent larger than actual expenditure is clearly implausible.

9.2.26 Furthermore, in its CAC, Anglian suggests that operating within a sparser area requires more pumping activity, all else equal: *"Other things being equal, a sparser region with few dense areas in it means that more pumping will be required to bring water across relatively longer distances."* It then presents a chart that demonstrates Thames Water operates within the most densely populated region, and Anglian itself operates in one of the most sparsely populated regions. This comment is inconsistent with the very large upwards allocation Thames receives as a result of average pumping head. It suggests that the substantial benefit that Thames receives from having to pump water only short distances due to its high population density is offset by substantial topographical challenges e.g. high frictional losses or unusually high lift. These substantial topographical challenges would need to drive additional costs of

[89] Ofwat (2023) *Econometric base cost models for PR24.* Available here.

[90] Anglian (2023) *Average pumping head cost adjustment claim.* Available here.

£736.2m *beyond* the net benefit Thames receives from serving a densely populated region. Again, this is clearly implausible.

9.2.27 Additionally, the fact that the use of pumping head results in an adjustment that strips away more than 100 percent of several companies' power costs means that their subsequent allowances will be unrealistically low. As such, these companies will receive an unduly low allocation of cost and it is likely that the service to their customers will be affected as a result.

Table 26: The use of average pumping head produces logically implausible cost reallocations

Company	Average annual power expenditure (2022-23 CPIH)	Average power expenditure over a 5 year period	Anglian's proposed adjustment (additional to botex allowances)	Anglian's adjustment as % of 5 year average
ANH	37.6	188.0	130.5	69%
NES	29.6	148.0	-49.5	-33%
NWT	37.7	188.4	-196.6	-104%
SRN	17.2	86.0	-111.4	-130%
SWB	21.3	106.6	95.3	89%
TMS	72.0	360.2	736.2	204%
WSH	29.6	147.8	-109.7	-74%
WSX	10.4	51.9	-5.4	-10%
YKY	35.3	176.4	-206.8	-117%
AFW	27.8	138.9	-45.5	-33%
BRL	10.0	49.8	-21.4	-43%
PRT	2.7	13.4	-32.6	-244%
SES	6.4	32.2	40.2	125%
SEW	20.0	99.9	57.9	58%
SSC	13.4	66.8	85.8	128%
SVE	74.7	373.5	-202.1	-54%
HDD	3.1	15.4	-6.1	-40%

Source: Analysis based on APR data and companies' CAC submissions

9.2.28 We consider that it is patently improper for cost assessment to reflect a factor for which there is strong evidence of inconsistency across the industry, and which is giving such clearly implausible and unintuitive results. The net effect is that some companies will receive a material over allocation of cost and others will receive a material under allocation of cost. This can be contrasted with booster pump density data, which is much more precise and it is almost impossible for differences in company reporting methodologies to impact upon the reported value.

9.2.29 Overall, we cannot reconcile the use of pumping head with Ofwat's principles of base cost assessment, which stipulates that cost assessment should be based upon good quality data[91]. Additionally, another of Ofwat's principles states that cost assessment should 'focus upon exogenous drivers'. The Turner & Townsend report found that the pumping head variable is materially under the influence of company control via the approach to estimation and we have presented evidence (Figure 23) that suggests some companies are overestimating average pumping head. As such, we consider that the inclusion of average pumping head would be inconsistent with Ofwat's principles of cost assessment.

[91] Ofwat (2022) *Final Methodology. Appendix 9: Setting expenditure allowances*. Available here.

Average pumping head is a poor predictor of maintenance requirements

9.2.30 Topography creates two sources of cost pressure:

- Consuming energy to pump water against gravity; and,
- Maintaining pumping-related assets.

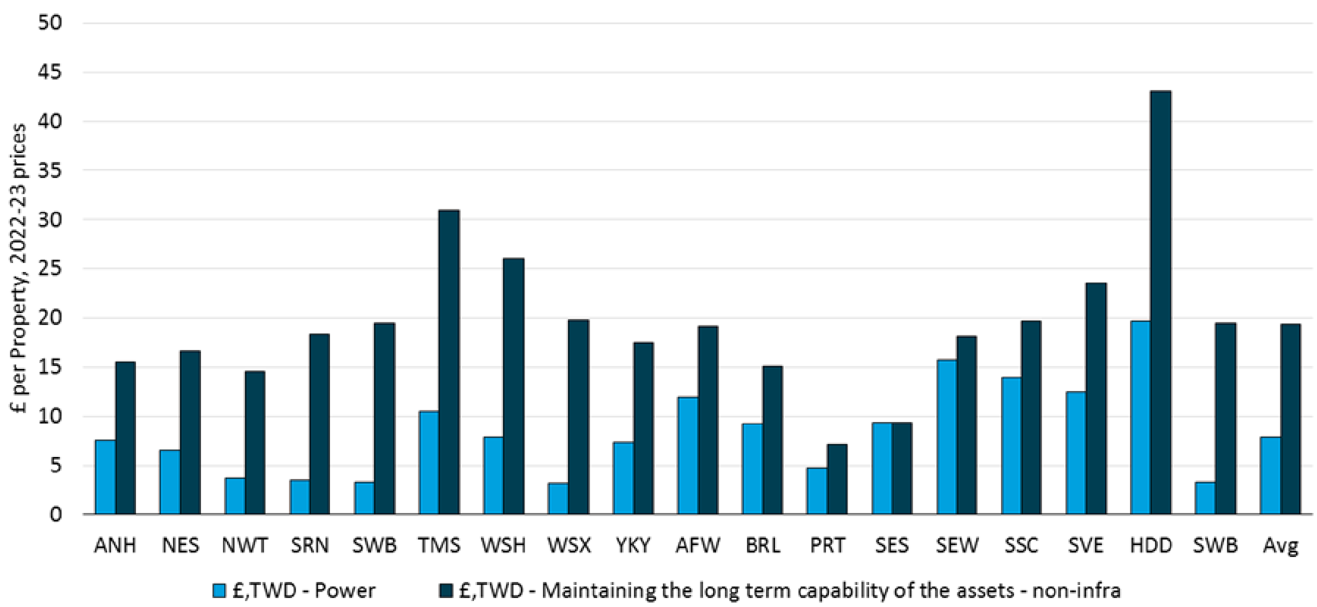
9.2.31 Conceptually, average pumping head is an intuitively appealing way to reflect energy requirements. Simplistically, this is because it focuses upon the height water must be pumped to, which is highly correlated with the overall energy that is required. However, it is a poor predictor of asset maintenance requirements and operational complexity of the network. These factors are primarily driven by the overall number and complexity of assets in operation. While the size of the individual asset may drive a small portion of maintenance costs, ultimately a 1,000KWh capacity pump will have relatively lower maintenance and operational complexity than ten 100KWh capacity pumps located in different parts of the network. As SVE states:

"Boosters per length is a measure of asset intensity within the network. This is the 'true' topography proxy – lots of small boosters are necessary to move water through hilly terrain."

9.2.32 As Turner & Townsend note, it is possible for a small number of pumps to contribute a majority of overall pumping head. SVE highlights this in its claim: "*On average, just 30% of pumps contribute 90% of APH.*" South Staffs also provides specific evidence of this in its claim, as we discuss in paragraph 9.2.44.

9.2.33 It is also clear that maintenance tends to form a much larger proportion of industry cost than pumping. Figure 24 sets out treated water distribution power and non-infrastructure maintenance costs per customer, averaged over the period 2011-12 to 2022-23. While there will be an element of non-pumping power costs and non-pumping station maintenance within these cost categories, we consider the majority of the costs in this figure will relate to pumping. It's clear that for most companies, maintenance costs form the majority of pumping-related costs.

Figure 24: Power and non-infrastructure maintenance per property (treated water distribution)



Source: UUW analysis using APR data

9.2.34 As such, we consider that it is entirely legitimate for booster pump density to be the primary explanatory variable for topography because its underlying cost driver – maintenance – is the more material driver of costs. However, this is not acknowledged by ANH, SES or SEW. None of these companies provides any evidence to support their position that booster pump density be dropped entirely. They also don't provide any evidence that average pumping head is capable of reflecting efficient asset maintenance requirements.

Specific comments on SVE's network complexity claim

9.2.35 The engineering and operational rationale underpinning Severn Trent's claim is unclear. SVE carries out what it terms 'control group analysis' to examine whether the chosen set of models reflect its particular circumstances of network complexity and concludes that they do not. However, it doesn't sufficiently describe the underlying issue it is seeking remuneration for. Without compelling engineering or operational rationale to support the claim, it isn't clear that the negative detriment SVE perceives within the model suite isn't in fact an appropriate outcome.

9.2.36 For example, it does not sufficiently explain what it means by 'network complexity' and doesn't evidence the cost impact of excluding this cost driver from the models. This means that it is impossible to understand the extent to which it's detrimented. It also doesn't quantify the effect of omitted variable bias and in particular, doesn't quantify how the triangulation of models with different measures of topography acts to offset any omitted variable bias caused by only including a single topography variable. Combined with the lack of compelling engineering rationale, this means it is not possible to determine whether its proposed adjustment is appropriate and in line with prior expectations.

9.2.37 We also have concerns about the way in which SVE has valued its claim:

- SVE states that including booster pump density and APH in separate models can cause an issue because the relative distribution across companies can affect cost allocations. To support this it notes that: *"The PR24 models suggest the Boosters / length has a slightly more stronger coefficient than APH, meaning that companies with slightly 'heavier' APH to boosters/length (including ourselves) will be slightly disadvantaged."* This misrepresents how the coefficients on econometric models should be interpreted. The coefficients are calculated by reference to a relationship between the underlying explanatory variable and cost. APH and booster pump density are fundamentally different explanatory variables – a one percent increase in APH cannot be compared with a one percent increase in booster pump density. Therefore, comparing the coefficients in this way is not a valid basis for a cost adjustment claim.
- It also states that only including one of APH or booster pump density within a model will result in omitted variable bias. This is not an invalid statement, but it ignores the fact that subsequent triangulation of models with one topography variable will act to offset any impact of omitted variable bias in any one model on the ultimate allowance. As stated above, it does not attempt to quantify or reflect this factor in its claim.

9.2.38 Therefore, we do not consider that SVE has presented compelling evidence to justify including two measures of topography within a single model. As such, we consider that the claim valuation method is invalid and the claim should be rejected.

Specific comments on SSC's topography cost adjustment claim

9.2.39 SSC states that it operates a small number of very large capacity pumping stations, and that the use of number of booster pumping stations per length of main causes an under allocation of power and maintenance costs as a result.

9.2.40 However, a smaller number of pumping stations will result in lower maintenance costs, all else equal. It should also provide significant scope for pumping efficiency benefits. This is recognised by SSC:

"a denser population would likely allow a company to take account of economies of scale by minimising the number of sites but having sites of a larger capacity."[92]

[92] SSC (2023) *Topography cost adjustment claim.* Available here.

9.2.41 Indeed, SSC provides evidence on page 8 that its areas of high population density tend to overlap with areas of high lift. While this will tend to increase pumping head, it should act to reduce overall maintenance costs and it provides scope for SSC to benefit from higher pumping efficiency.

9.2.42 Throughout the claim, SSC suggests that booster pumping stations is a poor reflector of maintenance requirements but it doesn't provide any evidence or analysis to support this assertion. It suggests that having a smaller number of larger capacity assets will lead to relatively higher maintenance costs. However, UUW's operational experience suggests the opposite is the case.

9.2.43 Therefore, we are not convinced that SSC faces higher 'in-the-round' costs i.e. the claim does not contain any evidence that disproves the notion that its higher pumping requirements are offset by reduced maintenance requirements.

9.2.44 SSC also demonstrates that the majority of its average pumping head figure is generated by just two pumping stations:

"…Our Hampton Loade works accounts for 55% of the APH value by itself, with Seedy Mill comprising a further 14% for a total combined value of 69% from only two sites."[93]

9.2.45 This means that there is clear potential to benefit from maintenance and pumping efficiencies. It also serves to demonstrate the lack of correlation between average pumping head and maintenance requirements.

9.2.46 Additionally, SSC acknowledges that its chosen asset configuration (a small number of large pumps) generates significant operational benefits:

"Both sites supply treated water to strategic storage assets located at high elevations, in order that customers in those areas can be supplied predominantly via gravitational flows from those service reservoir assets. This is the most resilient approach as it does not materially rely on a larger number of smaller distributed pumping assets that the boosters per length of mains driver assumes."[94]

9.2.47 However, its claim suggests that the use of booster pumps leaves it at a disadvantage. We would argue that the use of booster pumps is entirely appropriate because it reflects the operational benefits SSC highlights within its claim.

9.2.48 Therefore, on balance we consider that the sole use of pumping head to represent topographical-related costs will tend to overstate SSC's efficient costs. This is because: SSC's asset configuration means that maintenance requirements are likely to be low; the scope for pumping efficiency is likely to be high; and it benefits from significant operational resilience. However, SSC does not acknowledge this within its claim and does not provide any evidence that values these offsetting benefits.

9.2.49 The failure of average pumping head to reflect asset configurations such as that highlighted by SSC is a key reason UUW considers that an asset-based measure such as booster pumping stations should continue to be used within cost assessment, even once average pumping head's data quality has improved. The use of both measures within a triangulated model suite would allow cost assessment to reflect both power and maintenance requirements and any economies of scope between these two cost drivers e.g. the maintenance benefits achieved from operating a small number of large pumps.

9.2.50 For this reason, it is entirely inappropriate to consider average pumping head and booster pumping stations as substitutable measures of topography. We view them as wholly complementary. Arguing for the sole inclusion of average pumping head within cost assessment is speculative and ignores the fact it is a patently unsuitable way to reflect maintenance requirements.

[93] ibid

[94] ibid

Specific comments on ANH's cost adjustment claim

9.2.51 As we evidence above, booster pump density is a good measure of asset maintenance requirements. However, Anglian considers it should be dropped entirely:

"…[Booster pump density] is, at the very least, a much poorer measure of topography: we indeed would contend it is not a measure of topography at all."

9.2.52 We consider that Anglian's submission fundamentally misunderstands the engineering significance of booster pump density. As SVE states:

"Boosters per length is a measure of asset intensity within the network. This is the 'true' topography proxy – lots of small boosters are necessary to move water through hilly terrain."

9.2.53 Booster pump density is therefore able to reflect the efficiencies that can be realised by having a small number of large pumps and the cost pressures caused by having a large number of small pumps – we provide more detail of this effect between paragraphs 9.2.39 and 9.2.50 above.

9.2.54 Anglian does not provide any evidence that it has considered this effect in its claim. In fact, it considers that the *"Has the company accounted for cost savings and/or benefits from offsetting circumstances, where relevant?"* test is not relevant. As evidenced above, average pumping head is a poor predictor of maintenance requirements. Therefore, solely considering average pumping head within a model suite is only considering one side of the coin – it will hand considerable advantage to companies with a small number of large pumps because the models will not reflect the offsetting benefits associated with this asset configuration. Ideally, booster pump density and APH would both be used within a triangulated model suite. However, until such time as the issue of APH data quality has been resolved, we consider that booster pump density remains the most appropriate topography variable.

Specific comments on SES's pumping cost adjustment claim

9.2.55 SES argues that WRP models exclude a pumping driver and that therefore they receive an under allocation of cost. However, the WRP models aggregate the costs of water resources, raw water distribution and water treatment to account for substitution effects across these value chain elements. As we discuss in section 2.3, this recognises that companies with a higher proportion of groundwater sources will tend to have lower treatment costs. However, SES does not provide any evidence that suggests its water resources power costs are materially greater than the cost saving it receives from treating water from groundwater sources.

9.2.56 SES states that it receives a negative adjustment when booster pumping stations is used within cost assessment and that this is inappropriate. However, in our view, SES's submission is misunderstanding the engineering rationale underpinning the use of booster pumping stations – it primarily captures asset configuration and the potential to benefit from economies of scale, maintenance efficiencies and pumping efficiencies. SES has below average booster pump density which suggests it has a small number of large assets. This allows it to benefit from significant offsetting benefits and ultimately, lower costs. In this way, it is not unrealistic for SES to receive a negative adjustment when booster pump density is used within cost assessment.

9.2.57 Finally, SES states:

"we propose to deliver further efficiency improvements over AMP8". However, it doesn't quantify this improvement or attempt to offset it from the claim value.

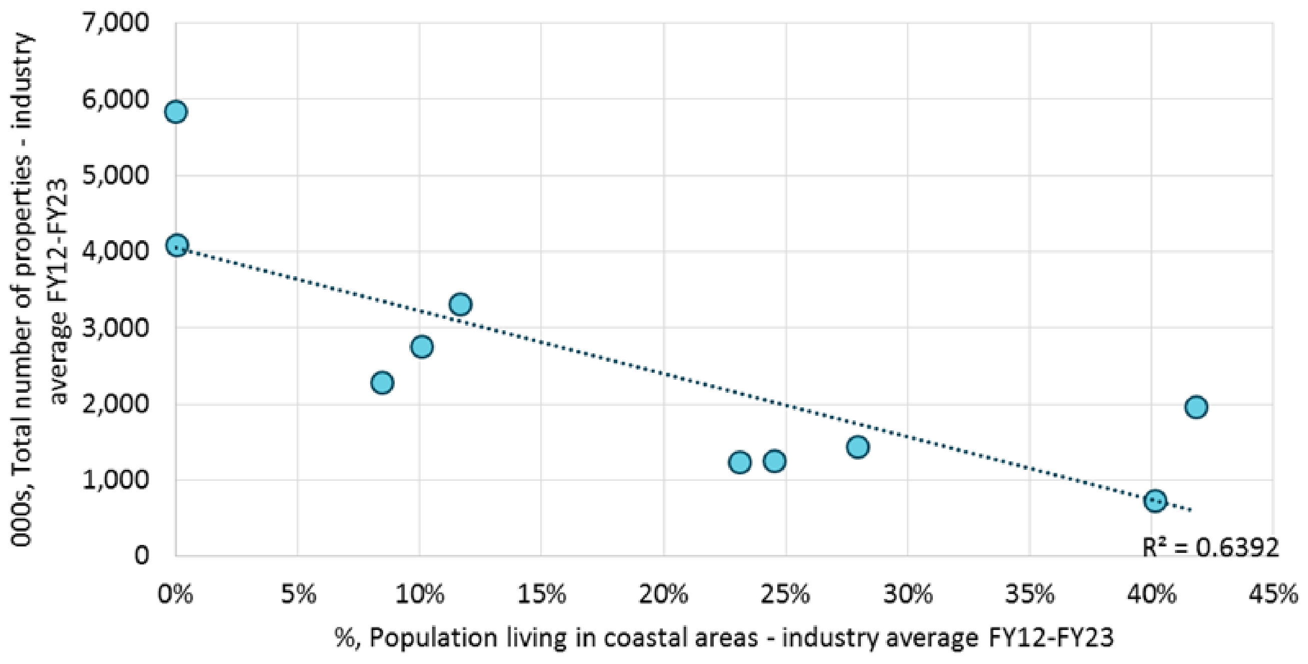
9.3 Southern Water - Coastal population

9.3.1 Southern's coastal population claim argues that operating wastewater assets in coastal areas drives higher ongoing costs. It submitted a related 'coastal population' variable to Ofwat's econometric model consultation, which captured the percentage of each company's population that lived in proximity to the coastline.

9.3.2 In its response to the econometric model consultation, UUW did not support the adoption of this variable. We noticed that it would have resulted in a slight upward increase in our base cost allocation, despite us having a lower than average coastal population. We also noticed that Thames received an upwards cost allocation despite having no coastline and Wessex would have received a negative adjustment despite having an above average coastal population. At the time, Southern did not provide any evidence to justify why such apparently unintuitive reallocations were appropriate.

9.3.3 However, we consider that the evidence provided in its claim addresses our previous concerns. Southern highlights the strong negative correlation between coastal population and company scale, which we have validated, as shown in Figure 25. It also provided compelling engineering and operational rationale to support why operating in coastal locations drives higher costs.

Figure 25: There is a clear negative correlation between scale and % population in coastal areas



Source: UUW analysis of Ofwat's cost assessment dataset

9.3.4 Econometric theory is clear that we would expect downwards bias on a coefficient that is negatively correlated with the error term i.e. the coefficient is smaller than it would be in the absence of bias. In the case where coastal population is excluded from the model, then coastal population forms part of the error term and due to its negative correlation with scale, biases the scale coefficient downwards. This artificially reduces the power of the scale coefficient, which effectively under remunerates larger companies and over remunerates smaller companies.

9.3.5 Therefore, the apparently unintuitive reallocation of cost away from companies with a high coastal population and towards companies with low coastal populations is simply the result of removing an implicit bias from the model suite that favours smaller WaSCs. We consider this argument to be compelling and supported by empirical theory and evidence, as set out in Southern's claim.

9.3.6 Additionally, Southern highlights that there is a tangible improvement in model performance when the coastal population variable is included:

"The evidence shows that the coastal variable has the expected sign and a plausible magnitude, it is statistically significant and improves the overall quality of the models (e.g., the R-squared appreciably improves and the range of efficiency score narrows for each and every model specification)."[95]

[95] Southern Water (2023) *Coastal population CAC.* Available here.

9.3.7 This is consistent with the notion that including the coastal population variable is removing bias from the modelled estimates.

9.3.8 We have closely examined the way in which Southern has developed its coastal population variable and consider its methodology to be robust. We did notice a general trend across most companies whereby the percentage of coastal population was shrinking slightly over the period covered by the models. However, information from the Office for National Statistics (ONS) suggests this trend is to be entirely expected given lower than average population growth in coastal towns:

"71% of coastal towns had both slower population and employment growth than the England and Wales average over the 2009 to 2018 period"[96].

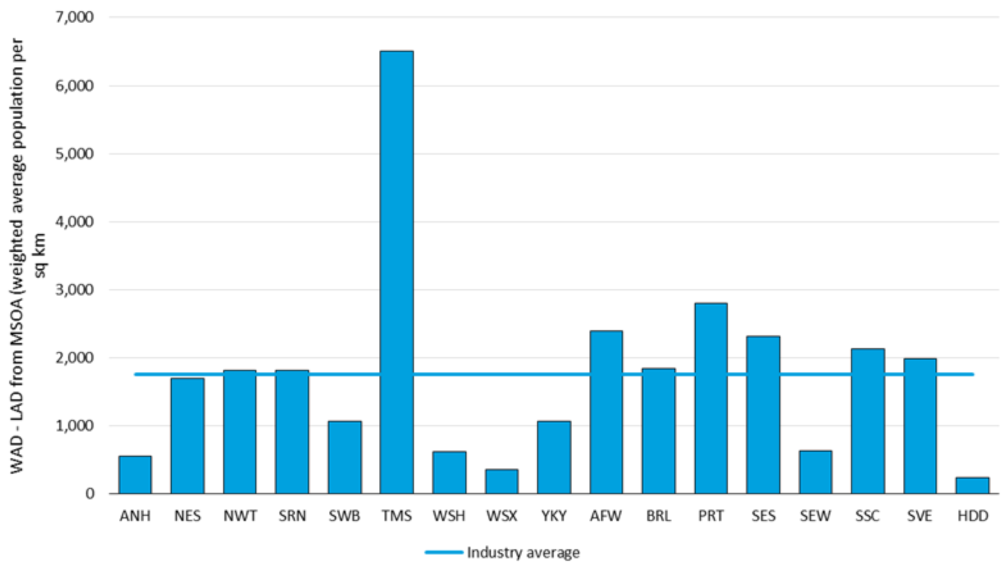
9.3.9 As such, we support Southern's claim. The variable is transparent, replicable and calculated using robust third party data. It is clear that omitting the variable will lead to material bias within cost assessment. We consider that the coastal population variable should be added to the model suite, and have implemented this approach in our proposals.

9.4 South East Water - Economies of scale at WTW

9.4.1 We support the use of exogenous variables to capture population density, as Ofwat proposed in its model suite e.g. weighted average density (WAD). The use of exogenous variables reflects the underlying cost driver but removes incentives to structure assets in an inefficient way. Exogeneity of explanatory variables is one of our key principles of cost assessment[97]. We note that Ofwat has also identified a focus upon exogenous cost drivers as a key principle in its approach to cost assessment[98].

9.4.2 It isn't clear why SEW considers that the existing, exogenous measures of population density do not reflect its circumstances. As Figure 26 shows, it has a below average population density according to the weighted average density (MSOA to LAD) variable – this aligns to SEW's view of its regional circumstances as set out in the claim. However, several other companies serve more sparsely populated regions i.e. there is no evidence to suggest that SEW is a significant outlier relative to other companies.

Figure 26: Weighted average density (LAD from MSOA) by company



Source: UUW analysis of Ofwat's cost assessment dataset

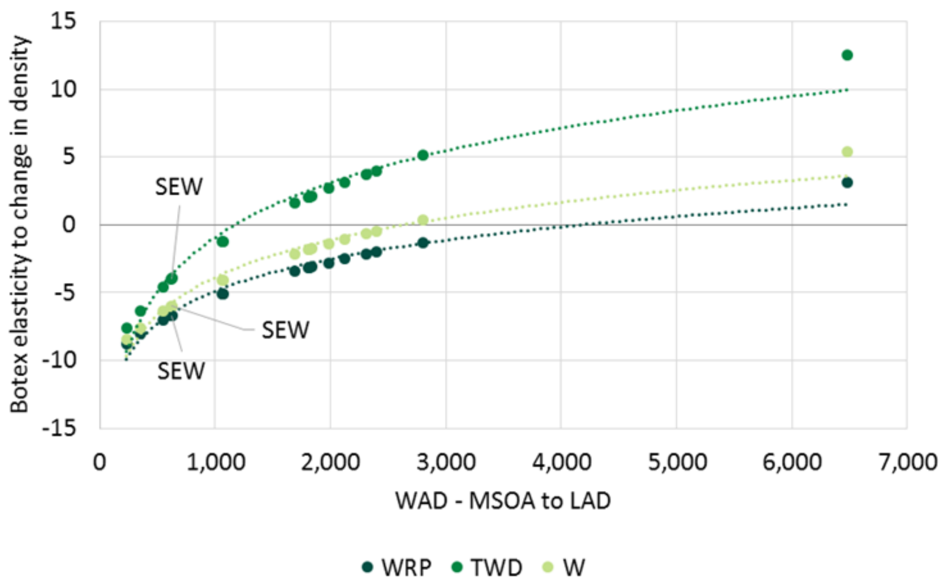
[96] ONS (2020) *Coastal towns in England and Wales*. Available here.

[97] UUW (2021) *The principles of regulatory cost assessment*. Available here.

[98] Ofwat (2022) *Final methodology: setting expenditure allowances appendix.* Available here.

9.4.3 We can examine the effect of this variable upon SEW within the model suite. Figure 27 illustrates the modelled elasticity of density with respect to base expenditure. The elasticity reflects the extent to which a change in population density causes a change in botex. Density is modelled using a quadratic term in Ofwat's recommended water models, which imposes a U-shaped relationship between density and cost. This reflects the fact that areas of high population sparsity can drive higher costs and areas of high population density can also drive higher costs. It is clear from Figure 27 that the model is expecting that SEW's relative sparsity will drive higher costs – the fact it sits well below zero means that it sits at the high left-hand side of the U-shaped relationship. As such, we consider this to be evidence that the exogenous variables (WAD) are reflecting SEW's circumstances appropriately i.e. the model reflects that high sparsity is driving higher costs. As we discuss below, we do not consider that SEW presents sufficient compelling evidence to refute this finding.

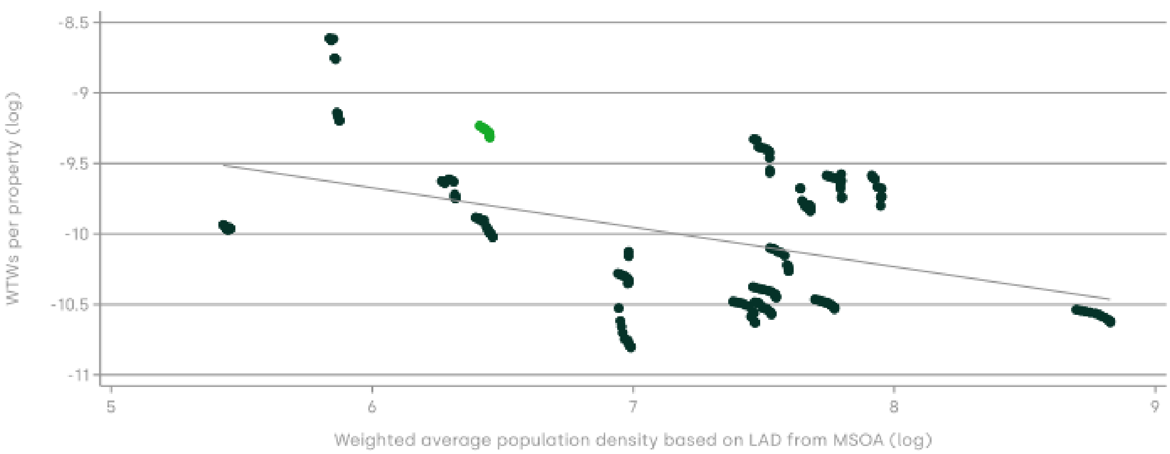
Figure 27: The modelled elasticity of density relative to base costs



Source: UUW analysis of Ofwat's cost assessment dataset

9.4.4 SEW presents graphs that suggest it sits above the line of best fit that would be expected between number of treatment works per population and density. It considers this to be proof that it is detrimented by existing measures of density. See Figure 28 for example.

Figure 28: Figure 4.6 replicated from SEW's CAC



Source: South East Water

9.4.5 However, it's clear that SEW is by no means an outlier relative to other companies in the industry. It doesn't satisfactorily explain why the existing measures of population density aren't reflecting its circumstances, particularly given no other company has submitted a similar claim. Therefore, it is not clear that Ofwat's models aren't making sufficient allocation for a company of its circumstances.

9.4.6 Secondly, SEW is making a comparison between a variable that is entirely exogenous (WAD) and a variable that is endogenous (WTW per property), at least in the long-term. If SEW is an outlier in this relationship, it is because it has more WTW per property than would be expected by looking at the industry as a whole.

9.4.7 However, it provides no evidence that exogenous factors have led it to adopt its chosen asset structure i.e. it is unclear why it has so many WTWs per property relative to the industry average for a company serving an area of its population density. Without compelling evidence that its asset configuration is efficient and driven by circumstances outside of management control, there is a clear risk that this cost adjustment is seeking remuneration for poor historical investment decisions and the associated higher ongoing costs.

9.4.8 We have further concerns with the way SEW has valued its claim. SEW argues it operates in a unique environment that is not reflected by the cost models i.e. the industry average. It then bases its claim value and associated symmetrical adjustment on internal company data. This data reflects SEW's past management decisions on asset configuration, electricity and chemical purchase strategies etc. It then uses this data to reallocate costs across the industry, leading some companies to receive significant negative adjustments.

9.4.9 We consider that this is not an acceptable basis on which to make a symmetrical adjustment. This is because SEW provides no evidence that its chosen asset configuration is an efficient response to its regional circumstances nor that its approach to managing water treatment costs in general is efficient. Without clear and compelling evidence that its internal costs are efficient, there is a significant risk that any subsequent symmetrical adjustment compels other companies in the industry to subsidise sub-optimal asset configuration and ongoing management practices.

9.4.10 It is important to note that it is possible to test SEW's economies of scale variable (WTW per property) within the model suite. We found that WTW per property's coefficient has a negative and statistically significant sign across all models, which is unintuitive relative to SEW's argument – the coefficient suggests that the more WTWs per property a company has, the lower costs are. This is entirely contrary to SEW's CAC. SEW does not acknowledge this result and does not present evidence to suggest why the key tenet of its claim does not appear to be robust when tested at an industry level. We consider that it would be inappropriate to make a symmetrical adjustment when key pieces of evidence appear contradictory and this is not appropriately explained within the document.

9.4.11 Finally, SEW presents evidence that alternate measures of treatment works level economies of scale are negatively correlated with scale. In the case where such variables are excluded from the model, they will be captured in the error term (assuming the existing measures of population density are not already capturing the underlying relationship). Econometric theory suggests that the negative correlation between these variables and the scale term will serve to depress the value of the scale coefficient. This will actually tend to benefit smaller companies, all else equal, because the model places less weight upon the effect of company size on cost. This benefit is not acknowledged by SEW in its claim.

9.4.12 We note that UUW considers it is detrimented by the approach to population density typically taken in cost assessment. This is because we serve a highly dense southern region (Merseyside and Greater Manchester) and a highly sparse northern region (Cumbria). However, the fact that population density is calculated as a weighted average across the region means that these two extremes are not appropriately captured at a company level – in effect, UUW is considered as relatively average, despite incurring above average costs in our southern and northern regions. We have not submitted a cost adjustment claim at PR24 because we have not yet been able to identify and develop evidence that would meet Ofwat's assessment criteria of 'compelling'. We do not consider that SEW's evidence meets this threshold either.

9.5 Anglian Water – Lack of large works

9.5.1 Anglian's claim suggests that its sparsely populated region has led it to operate a large number of smaller works, which means it is unable to benefit from economies of scale to the same extent as other companies. It does not consider the PR19 economies of scale variables (percentage of load treated in bands 1-3 and percentage of load treated above band 6) to appropriately capture its circumstances, in part due to the arbitrary thresholds these variables impose.

9.5.2 It considers that Ofwat's new Weighted Average Treatment Works Size (WATS) variable provides a much more compelling way to reflect economies of scale at wastewater treatment works. This is because it doesn't impose arbitrary thresholds on the relationship between cost and cost driver. We strongly agree with this position, as we set out between paragraphs 2.4.29 and 2.4.33. As a result, our proposed model suite makes sole use of the WATS driver to reflect economies of scale at wastewater treatment works.

9.5.3 We consider that the adoption of the WATS variable within Ofwat's recommended model suite[99] means that Anglian's claim is unnecessary and would result in a double count. We note that Anglian states that should WATS be used by Ofwat, then it will withdraw its claim. We therefore consider the claim is not needed and do not provide further comment.

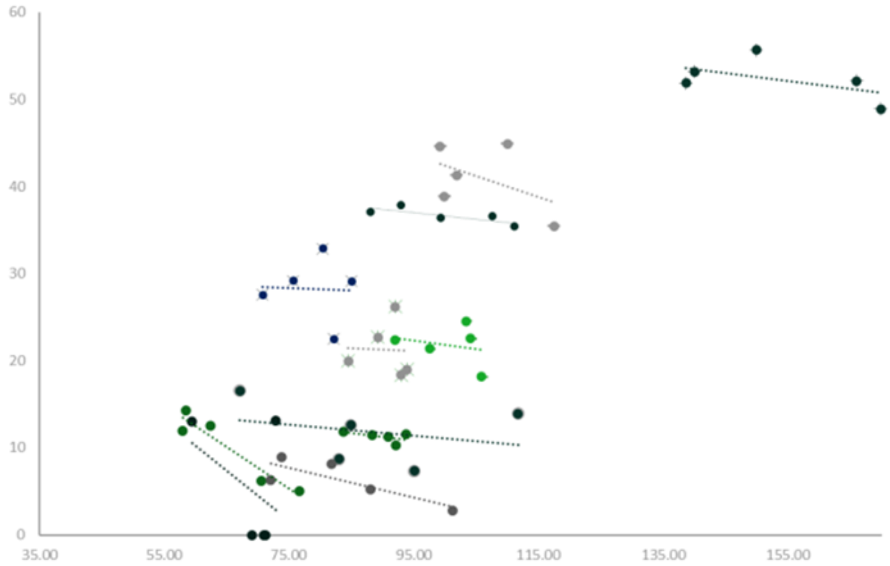
9.6 South West Water – Leakage

South West states that its upper quartile performance drives additional base costs. The key assumption underlying its claim is that maintaining lower leakage levels drives additional ongoing base costs. Because leakage is not reflected within the model suite, it claims that the modelled base allowance will not provide adequate cost allocation for a company with its overall level of leakage.

9.6.1 However, it does not provide compelling evidence to support this assumption. The key piece of evidence that South West presents in support of this assumption is set out in Figure 29, which replicates Figure 4.1 in South West's claim. The graph portends to show a 'within-company' negative correlation between leakage base expenditure and leakage levels. This would be expected in the case where maintaining lower levels of leakage requires additional base expenditure i.e. the marginal cost of maintaining leakage levels increases as overall leakage falls. At first glance, this relationship appears to provide support for South West's claim.

[99] Ofwat (2023) *Econometric base cost models for PR24.* Available here.

Figure 29: Figure 4.1 replicated from South West Water's claim



Source: South West Water

9.6.2 However, it is important to note that South West's analysis excludes seven companies that do not exhibit the negative relationship South West is expecting to see: *"Note: For presentational clarity, the chart shows only the 11 companies (out of 17) that present a negative relationship between leakage levels and expenditure."*[100] South West does not provide any evidence that supports its decision to exclude these companies or explain why these companies might not be exhibiting the relationship that South West assumes to exist. Absent such evidence, the analysis presented in Figure 29 to support the cost adjustment claim appears to be selective. Such an approach creates a clear risk that the analysis that flows from this is biased in one direction.

9.6.3 We are not aware of any other evidence within South West's claim that supports the assumption that lower levels of leakage are associated with higher ongoing maintenance expenditure. South West does not attempt to substantiate its industry-level analysis by providing internal data on leakage maintenance costs at different levels of leakage. Instead, it states that: *"It is accepted that there is a higher base cost necessary to maintain lower levels of leakage"*. However, without further explanation, elucidation or evidence, we do not consider this to represent compelling evidence in support of the key tennet underlying its claim – less leakage equals higher ongoing base expenditure. Therefore, it isn't clear that the unadjusted base allowances are insufficient to allow South West to maintain current leakage levels.

9.6.4 To be clear, our position that there is a lack of evidence within the claim supporting the notion that lower leakage levels increase base expenditure does not support the idea that *reducing* leakage is costless. We are clear that improving leakage performance is associated with substantial increases in expenditure. Such expenditure is unequivocally enhancement by nature, as set out in the Regulatory Accounting Guidelines: *"Enhancement expenditure is generally where there is a permanent increase or step change in the current level of service to a new "base" level and/or the provision to new customers of the current service level"*[101] This is recognised by South West in its claim.

9.7 Yorkshire Water – Combined sewers

9.7.1 Yorkshire's claim highlights the fact that it has a high prevalence of combined sewers relative to the industry average. It notes that a number of different factors compound the effect of combined sewers

[100] South West Water (2023) *Cost adjustment claim initial submission.* Available here.

[101] Ofwat (2023) *Regulatory Accounting Guidelines 4.11.*

which disproportionately increases the detrimental impact of each. Yorkshire considers that this effect has a substantial effect on cost and performance.

9.7.2 UUW strongly agrees with this position. We note that the evidence set out within Yorkshire's cost adjustment claim is entirely aligned with UUW's own, independently-derived evidence base. This is set out in Table 27. As such, we consider the engineering, operational and economic rationale underpinning Yorkshire's claim to be compelling.

Table 27: Comparison of Yorkshire's evidence to UUW's

Yorkshire's evidence	Corroborated by UUW?	UUW source
Heavy rainfall events can lead combined sewers to 'back up' and cause customer flooding incidents	Yes	UUW's internal sewer flooding 'hackathon'[102] found an increased risk of internal flooding incidents in areas of high combined sewer prevalence. This was corroborated at an industry level in UUW's Future Ideas Lab submission[103].
Food Service Establishments (FSEs) increase the risk that fats, oils and grease (FOG) enters the sewer network and lead to blockages.	Yes	UUW's internal sewer flooding 'hackathon' found an increased risk of internal flooding incidents in areas of high FSE density. This was corroborated at an industry level in UUW's Future Ideas Lab submission.
The prevalence of cellared properties increases the risk of internal sewer flooding incidents because it acts as a 'low-point' on the network	Yes	UUW's internal sewer flooding 'hackathon' found an increased risk of internal flooding incidents in areas of high cellar density. The underlying data supporting this was set out in Figure 10 of UUW's drainage cost adjustment claim[104].
Age and material of the network	Yes	UUW's 'hackathon' found a clear link between sewer age and internal sewer flooding risk. Lack of suitable data meant we were not able to corroborate this at an industry level.
Heavy rainfall in urban areas acts to reduce hydraulic capacity of the sewer system and can lead to increase flooding risk.	Yes	UUW's 'hackathon' found urban rainfall to be a material driver of internal sewer flooding risk. Our Future Ideas Lab apper also found urban rainfall impacted performance at an industry level. Our drainage cost adjustment claim presented evidence that urban rainfall impacts costs at an industry level.
The above factors combine to make the individual effect disproportionately worse: "These factors work in tandem to materially impact company cost and performance in sewerage networks…An event (e.g. an internal sewer flood) Is often the culmination of factors"	Yes	UUW's 'hackathon' found the interaction between each element to be an important driver of internal flooding risk. Our Future Ideas Lab paper found that an interaction term (which captures the inter-relationship between urban rainfall and combined sewers on performance) had a statistically significant and material impact on performance. Our drainage cost adjustment presents evidence that an interaction term also has a material effect on costs.

Source: UUW analysis of Yorkshire's claim

[102] The sewer flooding 'hackathon' brought together a team made up of internal and external subject matter experts and data scientists. The team examined a large number of datasets to understand the key drivers of internal sewer flooding. We discuss this project and its findings in more detail in *"UUW_CAC_002 Drainage cost adjustment claim"*. We have also previously presented this work to Ofwat.

[103] UUW (2022) *What lessons can we learn from cost assessment at PR19?* Available here.

[104] UUW (2023) *UUW_CAC_002 Drainage cost adjustment claim.* Available here.

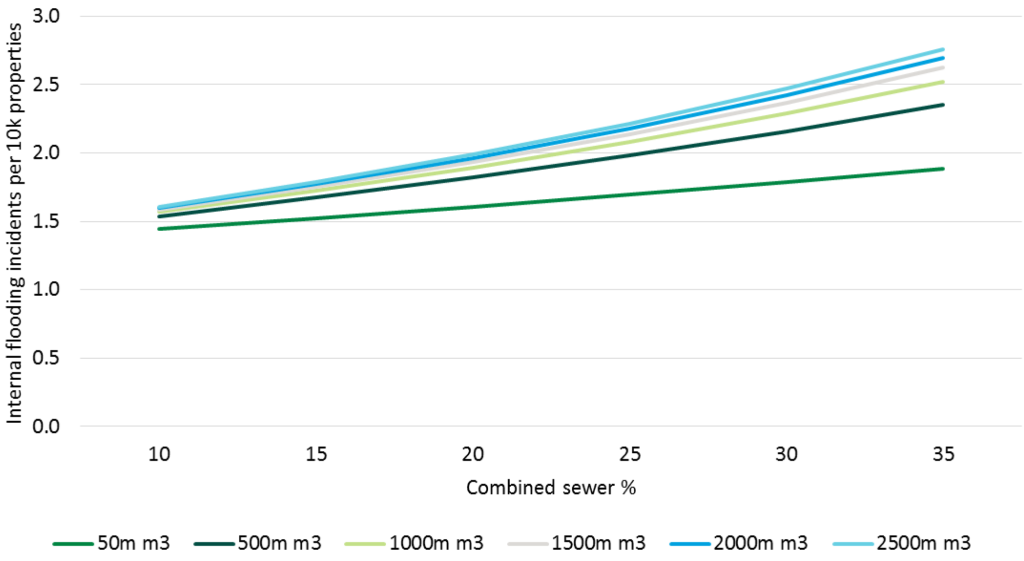
9.7.3 Within its claim, Yorkshire notes that combined sewer prevalence is not under the short-term influence of company management and highlights the relatively small change in combined sewers over the period covered by the dataset. We agree with this position. Removing combined sewers is a significant undertaking – it involves fundamentally restructuring the local sewer network (which can reach depths in excess of ten metres). As such, it is extremely costly and disruptive to those living and working within the local area.

9.7.4 Importantly, the fact that combined sewer prevalence has not materially changed in the period since 2011-12 demonstrates that the base cost models will not reflect activity that reduces the extent of the combined sewer network. We separately and independently identified the static nature of combined sewer prevalence within Appendix A of our drainage cost adjustment claim (Appendix A relates to our early submission version of the drainage cost adjustment claim. The equivalent section in supplementary document *UUW44 - Cost adjustment claims submission – update to claims* is Appendix E).

9.7.5 We agree with Yorkshire's position that combined sewers and urban rainfall cannot be treated as proxies or substitutes, and that each has a distinct influence on flooding performance: *"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)"*.

9.7.6 This inter-relationship led us to adopt the interaction term within our performance and cost modelling approach. The relationship predicted by the interaction term is entirely aligned with Yorkshire's statement above i.e. that companies with similar urban rainfall levels can have different levels of sewer flooding if combined sewer prevalence is different (and vice versa). This is illustrated in Figure 30, which was generated using the internal sewer performance models submitted as part of the Performance Commitment technical document submission[105].

Figure 30: Combined sewers and urban rainfall have a mutually compounding effect on internal flooding incidents



9.7.7 We note that Yorkshire's claim valuation methodology differs slightly from that employed within UUW's cost adjustment claim:

- Yorkshire includes percentage of combined sewers as a separate explanatory variable, alongside an urban rainfall variable.
- UUW includes an interaction term, which multiplies combined sewers by urban rainfall.

[105] UUW30 '*Internal sewer flooding technical document'.*

9.7.8 Both of these are entirely valid and complementary methods. They are subtly different – including urban rainfall and combined sewers as separate independent variables means the model will estimate the effect of combined sewers on cost, holding all other variables (including urban rainfall) constant. Including these variables as an interaction term means that the impact of combined sewers on costs depends upon the level of urban rainfall (and vice versa). In our view, the interaction term approach aligns best with the bottom-up evidence and engineering rationale that combined sewers and urban rainfall have a compounding effect on cost and performance.

9.7.9 However, we are clear that the two methods are not inconsistent with each other. Indeed, we view them as complementary. This is evidenced by our submission to Ofwat's consultation on base econometric modelling for PR24, where we submitted a sewage collection model with combined sewers and urban rainfall as separate independent variables alongside a model with an interaction term that captured the joint effect of these variables.

9.7.10 We note that the symmetrical adjustments suggested by Yorkshire are broadly in line with those suggested by UUW.

9.7.11 Within our business plan, UUW presents evidence to suggest the most economic outcome for customers is for internal sewer flooding performance targets to be adjusted to reflect exogenous regional factors. One of these regional factors is the prevalence of combined sewers. In the event that this approach to setting performance targets is adopted by Ofwat, then it may not be necessary for costs to be adjusted as suggested in this claim.

9.8 Sutton and East Surrey – Retail Scale

9.8.1 SES considers that it is materially disadvantaged by the inclusion of an economies of scale variable across only a subset of Ofwat's retail models. This is because it is a relatively small company and as such, it does not perceive a constant returns to scale assumption to be reflective of reality.

9.8.2 Unlike in wholesale operations, we are clear that economies of scale within retail operations is under management control e.g. through the outsourcing of retail functions or merger activity. This appears to be implicitly recognised within SES's claim where it suggests higher costs are justified because it is able to provide better customer service: *"There are consumer benefits from SES Water's relatively small-scale, local retail operations even though this increases our efficient costs of operation. We are able to better understand, and pay greater attention to, local stakeholder and our customer requirements, and maintain operations, such as our local call centre, that are highly valued by customers because they provide a bespoke and locally focused service that results from the company serving a relatively small supply area."* By contrast, Southern Water states that it has relocated its customer service centre to Yorkshire to reduce costs: *"Our HR strategy has been to locate such roles outside our area to lower wage regions where this is beneficial to customers, in order to mitigate the exposure to higher wages in the South East. This has included relocating our retail customer service contact centre to Yorkshire."*

9.8.3 We consider this to be evidence that SES has actively targeted a point on the cost-service relationship such that it retains its local focus as a small company and tolerates higher costs because it will be able to provide better service as a result. We note that residential retail's service quality is incentivised through C-Mex. As such, there is a clear risk that reflecting economies of scale within cost assessment disincentives companies from seeking scale efficiencies. This is because smaller companies would receive additional allowances through cost assessment but (according to SES) would be better able to earn outperformance reward in relation to performance targets. Therefore, reflecting retail scale in any form within cost assessment creates the risk that smaller companies are, in effect, double funded. We have previously represented against the inclusion of retail scale within cost assessment for this reason (e.g. within our response to Ofwat's econometric model consultation).

9.8.4 As a result of the risk that the claim distorts incentives to act efficiently, we do not consider the claim to be valid.

Appendix A Model Selection

A.1.1 This appendix sets out the details of UUW's model selection process described in section 2.7. We set out brief descriptions of key aspects below:

- We do not include any models with an average pumping head head explanatory variable within our robustness tests. This is because we have fundamental concerns with the quality and consistency of average pumping head data. Unless we are confident in the underlying data, we cannot be sure that the results of any model robustness tests aren't spurious.
- We do not select models WRP3 and WRP4 in part because the coefficients on treatment complexity vary materially relative to the other water resources plus models and overall model fit is poorer. Similarly, we don't select TWD2 and W3 and W4 partly because the model fit is slightly worse than other candidates.
- We do not select model SWC3 in part because it fails the RESET test. While we only place low weight on the RESET test result, both other sewage collection models pass.
- We test and discount a model with a Biological Oxygen Demand (BOD) driver due to statistical insignificance.
- We reject models SWT1 and SWT2 in part because the restrictions imposed upon the estimation of a relationship between treatment works economies of scale and cost cannot be justified in the presence of a superior explanatory variable (WATS). We reject models WwNP2 and WwNP3 in part for the same reason.
- We reject models WwNP1 and WwNP5 in part because these do not include a treatment complexity cost driver.
- We accept all Bioresources models, despite all failing our model selection criteria. This is to offset the risk of any one poor model unduly affecting results. This should not be interpreted as tacit support for an approach which relies solely on Bioresources models to set allowances.
- We reject models BRP3-BRP6 in part due to a lack of statistical significance. However, we accept BRP2 despite a lack of statistical significance because it contains an important and valid cost driver for Bioresources. This aligns with our principle that engineering and operational rationale should be prioritised over statistical performance.
- We do not present evidence of robustness testing of wastewater models with and without the AMP5 dummy for brevity. We found that the AMP5 dummy when included in sewage collection and bioresources models had an unintuitive positive coefficient. We consider this is in part due to the effect of the private sewer programme in AMP5 and significant investment by Thames Water in growth at its sludge treatment centres. We have therefore already screened out any wastewater models where the AMP5 dummy had an unintuitive sign.

Table 28: Water model selection

	WRP1	WRP2	WRP3	WRP4	WRP5	WRP6	TWD1	TWD2	TWD3	W1	W2	W3	W4	W5	W6
Use within final suite?	yes	yes	no	no	yes	yes	yes	no	yes	yes	yes	no	no	yes	yes
Engineering and/or economic justification	[amber]	[amber]	[amber]	[amber]	[amber]	[amber]	[green]	[green]	[green]	[green]	[green]	[green]	[green]	[green]	[green]
Transparency and relevance	[green]	[green]	[green]	[green]	[green]	[green]	[green]	[green]	[green]	[green]	[green]	[green]	[green]	[green]	[green]
Statistical validity	[green]	[amber]	[red]	[red]	[green]	[amber]	[green]	[amber]	[green]	[green]	[green]	[amber]	[amber]	[green]	[green]
Number of properties (log)	1.077***	1.075***	1.067***	1.066***	1.032***	1.030***				1.062***	1.053***	1.048***	1.040***	1.036***	1.030***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}				{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
Percentage of water treated in complexity bands 3-6	0.003*		0.002		0.003*					0.002*		0.002		0.002*	
	{0.066}		{0.223}		{0.058}					{0.063}		{0.230}		{0.064}	
Weighted average density – MSOA to LAD (log)	-1.394**	-1.354*					-2.679***			-1.835***	-1.685***				
	{0.028}	{0.056}					{0.000}			{0.000}	{0.001}				
Weighted average density – MSOA to LAD (log) squared	0.085**	0.082*					0.214***			0.129***	0.119***				
	{0.037}	{0.072}					{0.000}			{0.000}	{0.000}				
AMP5 dummy	-0.078	-0.076	-0.086	-0.083	-0.084	-0.081	-0.068**	-0.058*	-0.058*	-0.062	-0.051	-0.065*	-0.054	-0.063*	-0.051
	{0.177}	{0.139}	{0.138}	{0.110}	{0.138}	{0.110}	{0.040}	{0.085}	{0.079}	{0.107}	{0.177}	{0.093}	{0.153}	{0.098}	{0.168}
Weighted average treatment complexity (log)		0.24		0.196		0.253					0.310*		0.27		0.306*
		{0.313}		{0.439}		{0.282}					{0.055}		{0.116}		{0.052}
Weighted average density – MSOA (log)			-5.028**	-5.044**				-5.616***				-5.012***	-4.604***		
			{0.023}	{0.037}				{0.000}				{0.001}	{0.002}		
Weighted average density – MSOA (log) squared			0.302**	0.302**				0.394***				0.318***	0.292***		
			{0.024}	{0.038}				{0.000}				{0.000}	{0.001}		
Properties per km of main (log)					-6.840*	-6.749*			-15.29***					-11.47***	-10.71***
					{0.072}	{0.082}			{0.000}					{0.000}	{0.000}
Properties per km of main (log) squared					0.736*	0.724			1.930***					1.331***	1.242***
					{0.099}	{0.111}			{0.000}					{0.000}	{0.000}
Length of main (log)							1.053***	1.013***	1.056***						
							{0.000}	{0.000}	{0.000}						
Number of booster pumping stations per km of main (log)							0.365***	0.331***	0.371***	0.332***	0.352***	0.347***	0.368***	0.259**	0.272**
							{0.000}	{0.001}	{0.000}	{0.005}	{0.004}	{0.005}	{0.004}	{0.026}	{0.031}
Constant	-5.455***	-5.663***	10.029	10.014	5.38	5.108	3.974***	15.88***	25.87***	-2.04	-2.644*	11.542**	9.845*	16.19***	14.46***
	{0.001}	{0.005}	{0.220}	{0.271}	{0.491}	{0.525}	{0.003}	{0.001}	{0.000}	{0.184}	{0.086}	{0.045}	{0.087}	{0.001}	{0.003}
Sample size	204	204	204	204	204	204	204	204	204	204	204	204	204	204	204
R squared	0.903	0.898	0.896	0.893	0.905	0.902	0.961	0.957	0.963	0.963	0.965	0.962	0.964	0.964	0.966
Ramsey RESET test	0.581	0.488	0.848	0.793	0.396	0.281	0.102	0.131	0.574	0.263	0.142	0.321	0.164	0.293	0.137
Efficiency score distribution	1.570	1.557	1.620	1.613	1.550	1.539	0.468	0.632	0.597	0.670	0.682	0.719	0.719	0.701	0.665

Table 29: Wastewater model selection (part 1)

	SWC1	SWC2	SWC3	SWT1	SWT2	SWT3	SWT4	SWT5	SWT6	SWT7	WwNP1	WwNP2	WwNP3	WwNP4	WwNP5
Use within final suite?	yes	yes	No	no	no	yes	no	no	no	yes	no	no	no	yes	no
Engineering and/or economic justification	green	green	green	amber	amber	green	amber	amber	amber	green	red	amber	amber	green	red
Transparency and relevance	green	green	green	green	green	green	green	green	green	green	green	green	green	green	green
Statistical validity	green	green	amber	red	amber	green	red	red	amber	green	green	green	green	green	green
Sewer length (log)	0.796***	0.884***	0.855***												
	{0.000}	{0.000}	{0.000}												
Pumping capacity per km of sewer (log)	0.354***	0.600***	0.552***								0.392***	0.404***	0.379***	0.316***	0.432***
	{0.006}	{0.000}	{0.000}								{0.000}	{0.000}	{0.000}	{0.001}	{0.000}
Properties per length of sewer (log)	1.116***														
	{0.000}														
Weighted average density – MSOA to LAD (log)		0.226***													
		{0.009}													
Weighted average density – MSOA (log)			0.378***												
			{0.001}												
Load (log)				0.740***	0.834***	0.847***	0.907***	0.918***	0.986***	0.936***	0.657***	0.735***	0.722***	0.723***	0.724***
				{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
Percentage of load treated in bands 1-3				0.036				0.038**				0.022**			
				{0.163}				{0.027}				{0.028}			
Percentage of load with ammonia consent lower than 3mg/l				0.004***	0.004***	0.004***		0.004***	0.004***	0.004***	0.005***	0.005***	0.005***	0.005***	
				{0.001}	{0.001}	{0.001}		{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	
AMP5 dummy				-0.092**	-0.093**	-0.088**	-0.11***	-0.090**	-0.091**	-0.086**	-0.003	-0.005	-0.005	-0.005	-0.018
				{0.031}	{0.031}	{0.027}	{0.005}	{0.042}	{0.041}	{0.037}	{0.891}	{0.799}	{0.820}	{0.794}	{0.364}
Percentage of load treated at WwTW larger than 100,000 PE					-0.01***				-0.01***				-0.003*		
					{0.000}				{0.000}				{0.081}		
Weighted average treatment work size (log)						-0.25***	-0.21***			-0.22***				-0.1***	
						{0.000}	{0.007}			{0.000}				{0.007}	
Percentage of load with BOD consent lower than 20mg/l							0.002								0.004***
							{0.262}								{0.000}
Percentage of population living in coastal areas								0.009**	0.009***	0.006**					
								{0.014}	{0.009}	{0.019}					
Sludge produced (log)															
WwTW per property (log)															
Constant	-7.97***	-6.50***	-7.53***	-4.60***	-5.08***	-3.44***	-4.52***	-7.04***	-7.19***	-4.95***	-2.95***	-4.03***	-3.58***	-2.85***	-3.88***
	{0.000}	{0.000}	{0.000}	{0.001}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
Sample size	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
R squared	0.919	0.894	0.894	0.854	0.867	0.906	0.893	0.89	0.898	0.92	0.942	0.948	0.944	0.951	0.936
Ramsey RESET test	0.184	0.104	0.079	0.026	0.204	0.5	0.258	0	0.313	0.692	0.43	0.454	0.633	0.826	0.601
Efficiency score distribution	0.245	0.305	0.328	0.721	0.640	0.387	0.456	0.459	0.358	0.199	0.200	0.191	0.191	0.156	0.213

Table 30: Wastewater model selection (part 2)

	WwNP6	WwNP7	WwNP8	WwNP9	WwNP10	WwNP11	WwNP12	BIO1	BIO2	BIO3	BIO4	BIO5	BIO6	BRP1	BRP2
Use within final suite?	no	no	no	no	no	no	no	yes	yes	yes	yes	yes	yes	yes	yes
Engineering and/or economic justification															
Transparency and relevance															
Statistical validity															
Sewer length (log)															
Pumping capacity per km of sewer (log)	0.434***	0.433***	0.409***	0.358	0.362	0.339	0.222								
	{0.000}	{0.000}	{0.002}	{0.203}	{0.200}	{0.237}	{0.381}								
Properties per length of sewer (log)															
Weighted average density – MSOA to LAD (log)								-0.161				-0.261			-0.002
								{0.252}				{0.237}			{0.975}
Weighted average density – MSOA (log)									-0.13				-0.374		
									{0.580}				{0.286}		
Load (log)	0.751***	0.704***	0.750***	0.674***	0.757***	0.749***	0.777***							0.924***	0.922***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}							{0.000}	{0.000}
Percentage of load treated in bands 1-3	0.007				0.023**			0.066**	0.067**		0.079**				
	{0.720}				{0.048}			{0.035}	{0.029}		{0.021}				
Percentage of load with ammonia consent lower than 3mg/l				0.005***	0.005***	0.005***	0.005***							0.002	0.002*
				{0.000}	{0.000}	{0.000}	{0.000}							{0.114}	{0.097}
AMP5 dummy	-0.019	-0.016	-0.019	-0.003	-0.006	-0.005	-0.008							-0.048	-0.048
	{0.319}	{0.419}	{0.304}	{0.874}	{0.760}	{0.781}	{0.644}							{0.107}	{0.112}
Percentage of load treated at WwTW larger than 100,000 PE		0.001				-0.004*									
		{0.697}				{0.086}									
Weighted average treatment work size (log)			-0.029				-0.098***							-0.191***	-0.190***
			{0.613}				{0.008}							{0.000}	{0.000}
Percentage of load with BOD consent lower than 20mg/l	0.004***	0.005***	0.004***												
	{0.000}	{0.000}	{0.000}												
Percentage of population living in coastal areas				0.001	0.002	0.002	0.004								
				{0.880}	{0.840}	{0.852}	{0.625}								
Sludge produced (log)								1.203***	1.158***	1.158***	1.143***	1.056***	1.050***		
								{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}		
WwTW per property (log)										0.304					
										{0.252}					
Constant	-4.251***	-3.687***	-3.926***	-3.177**	-4.327***	-3.934**	-3.539**	-0.745	-0.659	1.06	-1.665*	0.935	2.034	-4.552***	-4.523***
	{0.003}	{0.000}	{0.000}	{0.034}	{0.003}	{0.020}	{0.011}	{0.486}	{0.649}	{0.266}	{0.098}	{0.298}	{0.270}	{0.000}	{0.000}
Sample size	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
R squared	0.936	0.936	0.936	0.942	0.948	0.945	0.953	0.724	0.718	0.681	0.721	0.679	0.674	0.938	0.938
Ramsey RESET test	0.676	0.626	0.713	0.24	0.386	0.586	0.829	0.575	0.444	0.918	0.255	0.259	0.477	0.899	0.73
Efficiency score distribution	0.211	0.217	0.206	0.197	0.196	0.185	0.145	0.757	0.783	0.823	0.818	0.785	0.816	0.291	0.291

Table 31: Wastewater model selection (part 3)

	BRP3	BRP4	BRP5	BRP6	BRP7	BRP8	BRP9
Use within final suite?	no	no	no	no	yes	yes	no
Engineering and/or economic justification							
Transparency and relevance							
Statistical validity							
Sewer length (log)							
Pumping capacity per km of sewer (log)							
Properties per length of sewer (log)							
Weighted average density – MSOA to LAD (log)			0.031			-0.102	
			{0.668}			{0.128}	
Weighted average density – MSOA (log)	0.028			0.075			-0.038
	{0.798}			{0.500}			{0.731}
Load (log)	0.926***	0.959***	0.957***	0.953***	0.974***	0.926***	0.976***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
Percentage of load treated in bands 1-3							
Percentage of load with ammonia consent lower than 3mg/l	0.002				0.002*	0.005***	0.002*
	{0.172}				{0.081}	{0.007}	{0.092}
AMP5 dummy	-0.049	-0.058**	-0.058**	-0.056**	-0.047	-0.027	-0.046
	{0.105}	{0.036}	{0.037}	{0.041}	{0.118}	{0.335}	{0.130}
Percentage of load treated at WwTW larger than 100,000 PE							
Weighted average treatment work size (log)	-0.197***	-0.178***	-0.191***	-0.197***	-0.179***	-0.152***	-0.170***
	{0.000}	{0.001}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
Percentage of load with BOD consent lower than 20mg/l		0.001	0.001	0.001			
		{0.587}	{0.679}	{0.693}			
Percentage of population living in coastal areas					0.003	0.005**	0.004
					{0.217}	{0.017}	{0.253}
Sludge produced (log)							
WwTW per property (log)							
Constant	-4.739***	-5.108***	-5.179***	-5.419***	-5.360***	-4.408***	-5.205***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
Sample size	120	120	120	120	120	120	120
R squared	0.938	0.934	0.934	0.935	0.941	0.945	0.941
Ramsey RESET test	0.634	0.807	0.735	0.799	0.965	0.474	0.415
Efficiency score distribution	0.303	0.297	0.297	0.309	0.264	0.216	0.245

Table 32: Residential retail model selection

	BD1	BD2	BD3	ROC1	ROC2	RTC1	RTC2	RTC3	RTC4	RTC5	RTC6
Use within final suite?	yes	yes	yes	yes	no	no	no	no	yes	yes	yes
Engineering and/or economic justification											
Transparency and relevance											
Statistical validity											
Revenue per household (log)	1.105***	1.152***	1.014***			0.679***	0.726***	0.672***	0.555***	0.608***	0.546***
	0	0	0			0	0	0	0	0	0
Percentage of households with default (Equifax variable ep_lpcf62)	0.051***					0.025***			0.023***		
	0.003					0.002			0.003		
Covid dummy (2019-20 = 1)	0.402***	0.380***	0.396***			0.181***	0.162***	0.169***	0.177***	0.158***	0.171***
	0	0	0			0	0	0	0	0	0
Covid dummy (2020-21 = 1)	0.226***	0.179**	0.210***			0.063**	0.036	0.047*	0.056**	0.03	0.046*
	0.004	0.02	0.008			0.02	0.234	0.085	0.042	0.315	0.099
Average number of County Court Judgements per household (Equifax variable eq_apcf2) (log)		0.773**					0.23			0.177	
		0.019					0.159			0.276	
Percentage of households classed as income deprived (IMD) - interpolated			0.075***					0.026*			0.028*
			0.002					0.077			0.076
Percentage of properties receiving water and wastewater services				0.002**	0.003***						
				0.031	0						
Number of properties (log)					-0.066*	-0.104***	-0.101***	-0.090***			
					0.067	0	0.001	0.004			
Constant	-5.177***	-4.741***	-4.399***	2.894***	3.741***	0.405	0.551	0.534	-0.277	-0.147	-0.036
	0	0	0	0	0	0.244	0.118	0.183	0.566	0.747	0.934
Sample size	170	170	170	170	170	170	170	170	170	170	170
R squared	0.661	0.657	0.668	0.117	0.13	0.702	0.667	0.646	0.655	0.645	0.64
Ramsey RESET test	0.258	0.233	0.179	0.965	0.136	0.609	0.5	0.432	0.375	0.064	0.287
Efficiency score distribution	1.028	1.019	0.797	0.740	0.697	0.458	0.536	0.599	0.550	0.553	0.644

Appendix B How models respond to individual year effects

B.1.1 This section sets out a stylised example to show how changes in underlying data feed through into cost allowances, when these are set using a regression-based approach. This is based upon the simulation approach developed by Reckon106.

B.1.2 We use the following assumptions within this simulated analysis:

- There are three companies. Each company is a different size but each is equally efficient and operates in an identical region.
- Scale and cost are perfectly related e.g. one additional unit of scale leads to one additional unit of cost.
- There are five years within the underlying dataset.
- Costs are set using a pooled Ordinary Least Squares (OLS) approach.
- There are two scenarios: in the first, costs are constant over each of the five years in the underlying dataset (columns a-c); and in the second, there is a cost shock in the final year (columns d-f).
- The cost shock causes an equivalent 10 percent increase to each company's expenditure.

B.1.3 Table 33 sets out the results of the simulation analysis:

- Column c sets out the predicted costs from a pooled OLS regression, with column a as the dependent variable and column b as the explanatory variable. This results in predicted costs aligning with actual costs.
- Column f sets out the predicted costs following a cost shock in year five. It's clear that the increase in costs in year five is reflected in cost prediction. However, the model does not pass through this cost increase in full. In fact, column g makes it clear that the model passes through an proportion of the cost increase, where that proportion is determined by the weight of year five within the historical period covered by the dataset.
- In this example, year five is one fifth of the total number of years. This means that one fifth of the cost shock in year five is passed through to predicted costs by the model – the cost shock is 10 percent and predicted costs increase by two percent as a result.
- Therefore, if the relationships contained within this historical dataset was used to forecast costs to a future period, these forecasts would only contain an element of the cost increase seen in year five. If the cost increase is expected to continue, then the resulting allowances would be insufficient.

[106] Reckon (2022) *Opportunities for a more coherent regulatory approach for Ofwat's funding of base expenditure and enhancement*. Available here.

Table 33: Simulation analysis of 10% increase in costs in one year

Company	Year	Cost 1	Scale 1	Predicted cost 1	Cost 2	Scale 2	Predicted cost 2	Difference
		a	**b**	**c**	**d**	**e**	**f**	**g**
				a = constant + intercept * b			d = constant + intercept * e	(f / c) - 1
A	1	10	10	10	10	10	10.2	2%
A	2	10	10	10	10	10	10.2	2%
A	3	10	10	10	10	10	10.2	2%
A	4	10	10	10	10	10	10.2	2%
A	5	10	10	10	**11**	10	10.2	2%
B	1	40	40	40	40	40	40.8	2%
B	2	40	40	40	40	40	40.8	2%
B	3	40	40	40	40	40	40.8	2%
B	4	40	40	40	40	40	40.8	2%
B	5	40	40	40	**44**	40	40.8	2%
C	1	20	20	20	20	20	20.4	2%
C	2	20	20	20	20	20	20.4	2%
C	3	20	20	20	20	20	20.4	2%
C	4	20	20	20	20	20	20.4	2%
C	5	20	20	20	**22**	20	20.4	2%

Appendix C 'Predicted' pumping head derivation

C.1.1 In this appendix, we provide the basis by which we calculate 'predicted' pumping head and why 'predicted' pumping head is equivalent to reported pumping head.

C.1.2 This proof relies on the following three equations:

1) $Pumping\ Energy\ Consumed = Pumping\ Efficiency \times Potential\ Energy$

2) $Potential\ Energy = Pumped\ Volume \times Water\ Density \times Gravitational\ Constant \times Height$

3) $Average\ Pumping\ Head = \frac{Height * Pumped\ Volume}{Total\ Company\ Volume}$

By substituting 2) into 1):

4) $$Pumping\ Energy\ Consumed = Pumping\ Efficiency * Pumped\ Volume * Water\ Density * Gravitational\ Constant * Height$$

Equation 3) can be rearranged:

5) $Height * Pumped\ Volume = Average\ Pumping\ Head * Total\ Company\ Volume$

By substituting 5) into 4):

6) $$Pumping\ Energy\ Consumed = Pumping\ Efficiency * Water\ Density * Gravitational\ Constant * Average\ Pumping\ Head * Total\ Company\ Volume$$

For this analysis water density, pumping efficiency and the gravitational constant can be treated as constants. Therefore, the pumping energy consumed is proportional to average pumping head:

7) $\frac{Pumping\ Energy\ Consumed}{Total\ Company\ Volume} = Constant * Average\ Pumping\ Head$

8) $\frac{Pumping\ Energy\ Consumed}{Total\ Company\ Volume} \propto Average\ Pumping\ Head$

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