PR24

Cost Adjustment Claim: Drainage

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A cost adjustment claim to reflect the additional costs of operating and maintaining a drainage system in an area where multiple exogenous factors interact to increase drainage costs, including 40% higher than average urban rainfall and the highest proportion of combined sewers in the industry.

United Utilities

Water for the North West

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Cost Adjustment Claim Submission

Cost Adjustment claim submission	
Title:	*Combination of exogenous factors driving increased drainage costs across the North West*
Price Control:	Wastewater Network Plus
Claim Value:	£152.6 million
Cost adjustment headline:	Ofwat's proposed base cost model suite for PR24 does not adequately capture the effect of United Utilities Water's (UUW) unique operating circumstances, including 40% higher than average urban rainfall and the highest proportion of legacy combined sewers in the industry, on the cost to convey wastewater. While we welcome Ofwat's proposal to *potentially* include urban rainfall in a subset of sewage collection and wastewater network plus models, we consider this only a partial representation of UUW's compounding cost drivers. UUW considers that urban rainfall should be included in *all* sewage collection and wastewater network plus cost models, and that the effect of urban rainfall should also be considered alongside (and in combination with) the proportion of combined sewers. As Ofwat's proposed models (April 2023) do not sufficiently capture these factors, UUW proposes a net symmetrical adjustment of £152.6 million to the modelled allowance if such models are not adjusted in line with our proposals set out within our econometric base cost model consultation response[1].
Description:	*It should be noted from the outset that this is a* ***conditional cost adjustment claim****. In our main PR24 submission and Future Ideas Lab Paper[2], we present compelling evidence that the best option for customers is to set an environmentally adjusted PCL for internal sewer flooding that reflects the operating circumstances of a given region. If an appropriate environmentally-adjusted PCL is adopted, UUW will withdraw this cost adjustment claim. If, however, the sewer flooding PCL is not adjusted in this way, we consider this cost adjustment claim to be the next best option for customers. While this claim will not enable us to achieve Ofwat's view of upper quartile performance (as that would require several billions of pounds of investment in surface water separation), the costs included in this claim would better reflect the differential costs of operating and maintaining drainage assets between different regions. Appendix A provides more details of our position, and our proposal for an environmentally adjusted PCL for internal sewer flooding.* This document sets out the case for an upward cost adjustment of £152.6 million to reflect the additional costs of conveying surface water in a region where: (a) urban rainfall is 40% higher than the national average for England and Wales. Ranked by rainfall, 17 out of the top 26 cities in England and Wales are in the North West, resulting in higher volumes of surface water runoff entering the sewers in the North West; and (b) the proportion of combined sewers is the highest in the industry, with over 54% combined as a proportion of legacy public sewers versus an industry

[1] UUW (2023) *Base Cost Modelling Submission.* Available here

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

average of 33%. Combined sewers are highly responsive to rainfall and have less hydraulic capacity during storms, increasing the risk of sewer flooding.

UUW considers that these exogenous factors are largely outside of management control and are material drivers of expenditure, yet their impact is not fully accounted for within Ofwat's botex models. This is especially significant as the interaction between these exogenous factors compounds their individual impact. Ofwat's proposed base cost models therefore do not adequately reflect the impact of exogenous factors upon drainage costs, with the implication that customers of some other WaSCs are paying too much for the level of service they receive.

We therefore set out the case for an upward adjustment of the base allowance. To calculate the level of adjustment required, we supplemented Ofwat's model suite[3] with an interaction term that reflects the interrelationship between urban rainfall and combined sewers. Statistical analysis demonstrated that the interaction term has a material and statistically significant impact upon modelled botex, and there is no deterioration in model performance as a result of its inclusion.

We did not introduce the term into Ofwat's models that include an urban rainfall variable (models SWC4-SWC6 and WWNP5-WWNP8), instead basing the claim on models SWC1-SWC3 and WWNP1-WWNP4 with the interaction term added. We did use Ofwat's recommended model suite to calculate the implicit allowance resulting from the proposed partial adoption of an urban rainfall factor. Following the removal of the implicit allowance and proportional adjustments to ensure the claim is symmetrical, the net adjustment is £152.6 million.

There are several additional factors that compound the effect of the above but are not reflected in the value of the claim. This is to ensure the claim has a clear focus upon the most significant factors and thereby limit the impact on customer's bills. UUW thus proposes absorbing the impact of these factors to limit the impact on customer's bills. These other factors include:

(c) low permeability soils and below industry average potential evapotranspiration (PET) compound to increase the overland flow of surface water into the sewer network;

(d) food service establishment (FSE) density is significantly higher than the national average – FSEs have been demonstrated to be a major cause of flooding events due to the discharge of fats, oil and grease (FOG) into the sewer network increasing the risk of blockages. Although we actively engage with food service establishments to mitigate any adverse impacts, we cannot influence the number and location of FSEs; and

(e) unique local topographies interact with surface water runoff to increase system surcharging and flood risk, especially in areas of high cellar density.

Collectively, these factors would likely result in an additional efficient cost adjustment to base expenditure of tens or hundreds of millions of pounds. However, by not seeking - at this stage - to reflect all of these factors within the determination of the claim value, UUW is demonstrating a level of stretch and ambition in its plan and only seeking an adjustment for the highest priority factors that have the largest impact on the provision of drainage services.

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

1. Cost adjustment case summary

Gate	Summary	Location reference
Need for cost adjustment	• UUW provides services to a region in which multiple exogenous factors interact to make our drainage system both more susceptible to flooding and overflow activations. These factors include: (a) urban rainfall 40% higher than the industry average (b) the highest proportion of legacy combined sewers in the industry (54% vs industry average of 33%) (c) low soil permeability and below industry average potential evapotranspiration (PET) (d) an above average density of food service establishments (118.2 per 100,000 population vs national average of 90.8 per 100,000 population) and (e) unique local topographies	*Section 4.1*
	• These exogenous factors are largely outside of management control. Nevertheless, UUW has taken multiple steps to mitigate flood and spill risk, including: implementation of our pioneering system of dynamic network management (DNM), transformation of our blockage resolution model, installation of over 1600 flood mitigation devices and a programme of sustained engagement with high risk food service establishments. Despite these efforts, an upward adjustment to the modelled allowances remains necessary to allow UUW to further mitigate the impact of these exogenous factors upon the services we deliver to customers.	*Section 4.2*
	• The combined interaction of these exogenous factors drives higher base costs through multiple mechanisms with the implication that UUW will incur higher costs in moving towards a common PCL. These mechanisms include: (a) higher surface water flows into the system necessitate larger diameter assets which cost more to operate and maintain (b) more frequent and longer duration storm events necessitate greater reactive expenditure on incident response and (c) a higher flood risk exposure means UUW must spend more on mitigating flood risk than other companies.	*Section 4.3*
	• To adequately capture the effect of these material drivers, we set out the case for a symmetrical cost adjustment. To calculate the level of adjustment required, we supplemented Ofwat's proposed model suite with a factor that reflects the combined effect of urban rainfall and combined sewers. Following the removal of the implicit allowance resulting from Ofwat's partial adoption of an urban rainfall factor, the net modelled adjustment for UUW is £152.6 million. We also set out the impact that an upward adjustment to our modelled cost allowance would have on cost allowances for other companies.	*Section 4.4*
Cost efficiency	• UUW's proposed costs are highly efficient. Indeed, multiple layers of efficiency have been incorporated into the claim, including: – We have derived this claim using a modelled approach aligned to Ofwat's PR19 allowance calculations, which incorporates an upper quartile catch-up and frontier shift efficiency challenge. This means that our adjustment value is in line with the efficiency benchmark and includes an element of productivity growth throughout AMP8; and – A number of factors that compound the effect of urban rainfall and combined sewers, including FSE density, soil permeability and PET, are not	*Section 5*

	reflected in the modelled value in order to simplify this cost adjustment claim and to limit the impact to customer bills.	
Need for investment	• As we are requesting an adjustment to our cost baselines and not proposing discrete investment/interventions, we do not consider this section applicable. Ofwat also deemed the equivalent section to be N/A during its PR19 Final Determination assessment of UUW's claim.	*Section 6*
Best options for customers	• Customer research demonstrates that sewer flooding performance is a key priority for our customers. We are therefore committed to stretching ourselves to the limits of what is achievable within the constraints imposed by our unique operating circumstances. • It is for this reason that we will propose that the PCLs for internal sewer flooding are set at the maximum level of performance modelled to be achievable within the constraints imposed by the unique operating circumstances in the North West. UUW considers that PCLs adjusted for a region's operating circumstances represents the best option for customers, meaning that customers across the country are paying for an equivalently efficient and stretching level of service. Appendix A sets out more detail regarding how UUW considers the regulatory framework can be adjusted to reflect the regional challenges wastewater companies face, specifically through the adoption of PCLs that are adjusted to companies' regional operating circumstances. • If, however, our PCLs are not adjusted for our unique operating circumstances, we present compelling evidence to demonstrate that UUW will incur higher costs in moving towards a common level of flooding incidents (without any normalisation for key environmental factors) because of those circumstances. We consider the next most appropriate outcome for customers would therefore be for an interaction term reflecting urban rainfall and combined sewers to be included within all sewage collection and wastewater network plus models. • If this does not occur, we consider this cost adjustment claim to be the next best option for customers.	*Section 7*
Customer protection	• This claim would ensure that customers are protected by cost allowances being better allocated based on the key exogenous factors that affect the cost of providing drainage services. Customers would only pay more in areas where the need for higher cost was greatest, and customers would avoid overpaying in areas where the drainage environments are favourable. • Customers are also protected from partial or non-delivery of this investment through a number of performance commitments, including internal sewer flooding, external sewer flooding, storm overflows, pollution and sewer collapses. These measures have over and underperformance payments associated with them. Failure to deliver the additional botex will result in underperformance payments on this suite of PCs.	*Section 8*

2. Preface: Strategic context

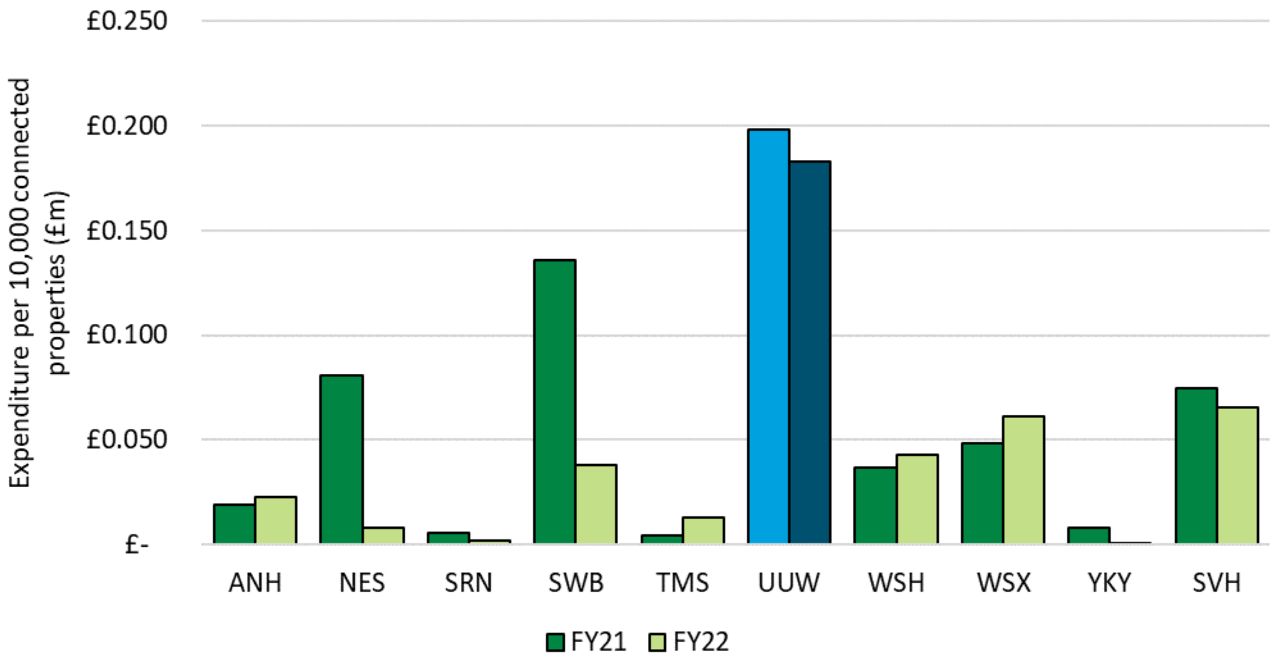
2.1 Historical expenditure and approach to setting PCLs

2.1.1 This claim must be understood within the wider context of UUW's drainage ambitions and Ofwat's approach to cost modelling and setting performance commitment levels (PCLs) for sewer flooding.

2.1.2 At PR19, Ofwat presented graphs of industry botex allocated to 'sewage collection' to conclude that *'it is far from clear that on a per kilometre basis United Utilities spends unusually high amounts on operating or maintaining its underground assets'.*

2.1.3 UUW considers that it is more appropriate to take a rounded view of expenditure, including comparing total enhancement expenditure on 'reducing flood risk for properties'; an allowance for which is included within Ofwat's wastewater network plus base cost models and by extension, within this claim. Indeed, UUW has had by far the largest total expenditure on 'reducing flood risk for properties' per 10,000 sewer connections (Figure 1) within AMP7 to date and expenditure 27.9% above the industry average over the period 2011-12 to 2021-22. As will be outlined in Section 4.2: 'Management Control', UUW has invested significantly in deployment of our industry-leading dynamic network management (DNM) initiative, utilising a network of over 17,500 sensors to proactively identify and resolve blockages before flooding can occur, as well as implementing a large-scale property-level flood mitigation programme.

Figure 1 - Expenditure on 'reducing flood risk for properties' per 10,000 sewer connections for FY21 and FY22. Source: Ofwat, PR24 wastewater cost assessment master dataset. Available here.

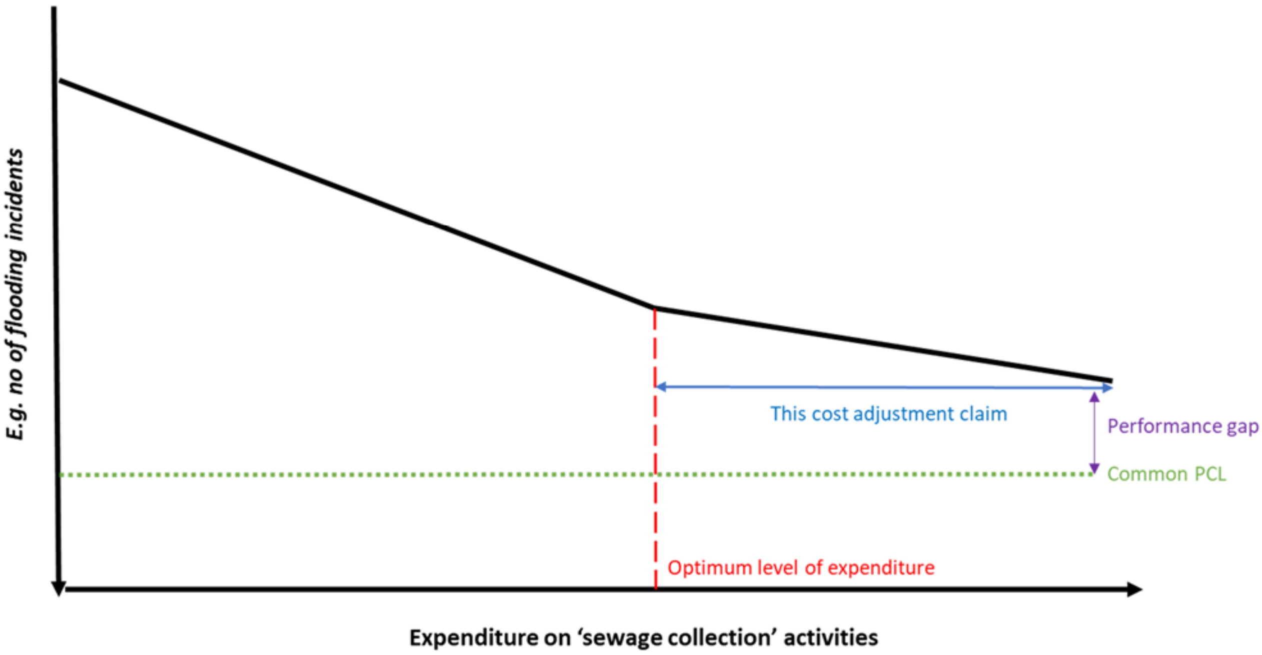


2.1.4 Further, we consider our expenditure on sewage collection to be efficient within the constraints imposed by the unique operating circumstances in the North West. Indeed, as published in our Future Ideas Lab paper[4], we set out an econometric modelling approach to predict performance based upon companies' regional operating circumstances. If measured in this way, in FY23 UUW achieved an upper quartile level of performance for internal sewer flooding; for example, *where the UQ is subject to an appropriate environmental adjustment that reflects urban rainfall, combined sewers and FSE density*.

[4] UUW (2022) *Future Ideas Lab: What lessons can we learn from cost assessment at PR19?* Available here

2.1.5 Given these operational constraints, we consider we are spending an appropriate level of botex on sewage collection. Increasing base expenditure beyond this point would not yield a cost beneficial improvement in performance. Significant and sustained enhancement expenditure, far beyond that witnessed historically (e.g. to substantially reduce the proportion of combined sewers by surface water separation), would be required to move to the common PCL position. Above our current level of botex expenditure on sewage collection, we judge that the performance improvements delivered by a given unit of expenditure begin to plateau, and thus expenditure above this optimum level becomes inefficient and uneconomic for our customers. Such a relationship is demonstrated theoretically in Figure 2, whereby above the 'optimum level of expenditure', the performance gains decrease.

Figure 2 - A theoretical graph used to demonstrate that as the expenditure on 'sewage collection' increases above the 'optimum level of expenditure', the performance improvements (black line) from a given unit of expenditure decreases.



2.1.6 It is for this reason that we consider an internal sewer flooding PCL that takes into account our unique operating circumstances to be a more appropriate outcome for both UUW and our customers. UUW will therefore be proposing that our AMP8 PCLs are set at the maximum level of performance modelled to be achievable *within the constraints imposed by our unique operating circumstances*. While this represents an extremely stretching position, we believe that it is possible to achieve this level of performance economically without the need for a further uplift to the modelled botex allowance (this approach is set out in appendix A).

2.1.7 If, however, our PCLs are not adjusted for our unique operating circumstances, this cost adjustment claim will be necessary to allow UUW to reasonably recover the higher costs that will be incurred as a result of operating in a challenging environment for providing drainage services. Owing to the cost-performance relationship outlined above, the claim will only allow UUW to make incremental improvements and will not enable us to achieve an upper quartile level of performance (Figure 2). This is because the cost models are based upon re-allocation of historical actual expenditure levels. Therefore, as no company with UUW's exogenous characteristics has achieved performance consistent with Ofwat's upper quartile target, the costs of hitting the upper quartile target will not be reflected within the historical dataset and therefore cannot be reallocated by the cost models, even if a factor reflecting urban run-off and combined sewer was to be adopted.

2.1.8 In order to achieve the common sewer flooding PCL, a fundamental reconfiguration of our system would be necessary, including large-scale separation of combined sewer systems. These activities would inevitably cost several billions. While we will be proposing large-scale investment in downstream storage solutions to reduce overflow spill frequency through our WINEP (section 2.2.2), this conventional investment will have a negligible impact on flooding risk – therefore necessitating further billions of pounds of investment in upstream surface water separation to achieve a common internal sewer flooding PCL.

2.1.9 Within this context, we recommend that Ofwat consider our proposals for environmentally adjusted PCLs for internal sewer flooding which will be set out within our PR24 business plan. PCLs adjusted to account for the exogenous circumstances across operating regions would ensure customers across the country are paying for an equivalently stretching level of service. Appendix A sets out more detail regarding how UUW considers the regulatory framework can be adjusted to reflect the regional challenges wastewater companies face, specifically through the adoption of PCLs that are adjusted to companies' regional operating circumstances. Further detail regarding how our proposed PCLs for internal flooding were set will be set out in our main PR24 business plan submission.

2.1.10 However, should Ofwat not support our proposal for an environmentally adjusted PCL for internal sewer flooding, we set out the compelling evidence for the need for an upward adjustment to the modelled botex allowance in this document.

2.2 Other investment programmes and absence of double counting

WINEP and Advanced WINEP

2.2.1 Within our PR24 business plan, we will be submitting a regulatory enhancement case to deliver upon our environmental obligations and reduce spills at storm overflows as outlined in the Water Industry National Environment Plan (WINEP). We do not consider that this enhancement expenditure overlaps with this cost adjustment claim, as this claim pertains to the additional botex required for managing existing drainage services in our region, which will not support the delivery of additional hydraulic capacity to reduce spill frequency. Indeed, the storage solutions delivered through the WINEP will increase future expenditure requirements for asset maintenance and operation rather than having a mitigating influence.

2.2.2 Furthermore, our proposed WINEP solutions have a minor impact on reducing flood risk and therefore will not have an impact on our expenditure to reduce flood risk for properties. Grey storage solutions simply prevent spills from storm overflows to watercourse by capturing them within a tank and **therefore do not provide upstream flood alleviation beyond that offered by the existing storm overflow.** Alongside these traditional solutions, we are proposing an ambitious programme of blue-green or hybrid solutions to attenuate rainwater, including the removal over 160 ha of impermeable area. However, as the WINEP is optimised for spills drivers, the locations proposed demonstrate limited overlap with our highest areas of hydraulic flooding risk. Best estimates of modelled annualised flood risk reduction as a by-product of the WINEP overflows investment are therefore small: 2.77 internal sewer flooding incidents and 3.44 external sewer flooding incidents.

2.2.3 Alongside our main WINEP submission, we will also be submitting our c. £[✂]'Advanced WINEP'. The Advanced WINEP accelerates a sample of future drivers into AMP8 to demonstrate how rainwater management is critical to delivering multiple benefits and efficient spend, when partnership funding can be leveraged to change grey to green**.** The programme is therefore entirely comprised of hybrid or blue-green solutions and is specifically targeted at delivering wider environmental outcomes alongside spill reduction, including hydraulic flooding benefits. However, the scale of the reduction is ultimately limited by the geographical area to which the Advanced WINEP is constrained as an innovative new framework for delivering upon regulatory enhancement. It is therefore estimated that the annualised flood risk benefit is 4.84 internal sewer flooding incidents and 0.93 external sewer flooding incidents.

2.2.4 We therefore do not consider it necessary to adjust the value of this claim to reflect these flooding benefits. However, we do recognise that our WINEP programme is still subject to change. If these benefits change materially between submission of this cost adjustment claim in June 2023 and submission of our PR24 business plan in October 2023, the value of this claim will be adjusted accordingly.

Rainwater management enhancement case

2.2.5 Finally, in alignment with our long-term ambitions set out within the Drainage and Wastewater Management Plan (DWMP), we will be submitting a c.£[✂]enhancement case for rainwater management. This will set out our plans for large-scale investment in Sustainable Drainage Systems (SuDS), to secure long-term resilience against the effects of climate change. However, this investment is only aimed at protecting against the risk of future performance deterioration due to climate change. The scale of the operational change and total investment necessary to fundamentally reconfigure our network and control rainwater at source means that rainwater management investment must be staggered across multiple AMPs. It will thus take multiple AMPs for any benefits to be realised at a regional scale.

2.2.6 Thus, this cost adjustment case solely concerns the additional maintenance and short-term flood mitigation measures needed to cope with the unique operating circumstances of the North West whilst our longer-term vision to reduce rainwater entering combined systems is enacted. We therefore anticipate that the value of this claim may diminish in future price control periods as combined sewers are gradually separated and urban rainfall is better attenuated.

3. Introduction

3.1 Overview

3.1.1 This document sets out a claim for an upward cost adjustment of £152.6 million to reflect the additional costs of operating and maintaining a drainage system in an area in which multiple exogenous factors interact to increase volumes of surface water entering the sewer network.

3.1.2 Ofwat's current botex models[5] do not adequately capture the effect of UUW's unique exogenous factors, including 40% higher than average urban rainfall and the highest proportion of legacy combined sewers, on the costs to operate and maintain our wastewater system. Whilst we welcome Ofwat's proposal to *potentially* include urban rainfall in a subset of sewage collection and wastewater network plus models, we consider this only a partial representation of UUW's compounding cost drivers.

3.1.3 Specifically, we consider that the effect of rainfall cannot be considered independently of the proportion of combined sewers. As combined sewers convey both foul and surface water flows, they have less hydraulic capacity than separate systems during periods of heavy rainfall, making them a greater risk of service impact (such as sewer flooding). Clearly, this effect will be particularly pronounced in areas of higher urban run-off, whereby the presence of combined sewer compounds the impact of storm events. The interaction between these two factors is, in our view, the largest single impact on drainage cost and performance, and (unless Ofwat agrees to setting environmentally adjusted sewer flooding PCL targets) should be reflected in all sewage collection and wastewater network plus models. If Ofwat imposes a simplistic common target for flooding incidents, the absence of this interaction factor results in an inequitable stretch across the industry, with the implication that customers of companies operating in a relatively benign environment may pay too much for the service they receive.

3.1.4 While we are sympathetic to Ofwat's view that companies have been seen to deliver good performance and cost efficiency simultaneously, we consider that the exogenous operating circumstances present in the North West place an unattainable stretch on UUW when Ofwat's botex models exclude these factors. We are therefore proposing a symmetrical cost adjustment. As part of this, we provide evidence demonstrating how an upward adjustment to the modelled cost allowance would affect cost allowances for other companies.

3.1.5 At PR19, UUW submitted a cost adjustment claim for drainage. Whilst Ofwat largely accepted the principle of the argument, namely that 'higher volumes of surface water runoff enter the sewers in the North West…compared with most other regions'[6], the claim was rejected due to two key reasons outlined in Table 1. Since PR19, we have undertaken numerous activities to materially improve our evidence base and we present such compelling evidence against the assessment criteria outlined in Appendix 9 of the PR24 Final Methodology. Furthermore, Ofwat's publication of its base cost models has allowed us to submit a claim that is of a higher quality and fully supported by econometric modelling analysis, including the removal of any implicit allowance from the claim value. Table 1 details the reasons for rejection at PR19 alongside the evidence we have since gathered to address these claims.

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

[6]Ofwat (2019) *PR19 final determinations. United Utilities – Cost efficiency additional information appendix.* Available here

Table 1 - Ofwat's reasons for rejection of UUW's drainage cost adjustment claim at PR19 alongside how we have since addressed these

Ofwat's reasons for rejection at PR19	How we have addressed these in this claim
"Owing to the relief provided by combined sewer overflows (CSOs), we are not persuaded that higher surface water runoff necessarily means that larger assets are needed to manage the resulting flows"	Analysis of PR14 business plan data, the latest available industry-wide data, demonstrates that UUW has the highest proportion of sewers > 626 mm in diameter and the second highest proportion of sewers > 321 mm in diameter. Further, Ofwat should now recognise, given the current focus and future expectations on CSO spill frequency, that CSOs cannot be assumed to be provide the level of "relief" against the need for larger assets that Ofwat claimed at PR19. It is also important to note that the significant enhancement investment required to reduce CSO spill frequency, will in future lead to increased maintenance requirements. Indeed, in its econometric modelling consultation, Ofwat states, *"The greater the volumes of inflow into drainage and sewerage networks, the larger network and storage assets need to be"*[7], suggesting this argument has since been accepted.
"It is far from clear that on a per kilometre basis United Utilities spends unusually high amounts on operating or maintaining its underground assets. In fact, as can be seen in figures(), PR19 business plan data indicates than in the last two years United Utilities' unit costs have been at or just below the industry average"	A full overview of our response is provided in the preface. In summary: • Ofwat presented graphs of industry botex allocated to 'sewage collection' to reach this conclusion. UUW considers that it is more appropriate to take a rounded view of expenditure. Indeed, UUW has had - by far - the largest total expenditure on 'reducing flood risk for properties' per 10,000 sewer connections in AMP7 to date (Figure 1) and expenditure was 27.9% above the industry average over the period 2011-12 to 2021-22. • Further, we consider our expenditure on 'sewage collection' activities to be efficient within the constraints imposed by our unique operating circumstances. It would not be an efficient use of resources to spend significantly above the industry average on 'sewage collection', to improve our sewer network in an attempt to achieve a level of sewer flooding incidents that is not attainable within our unique operating circumstances, i.e. a common internal sewer flooding PCL. It is for this reason that we are proposing an environmentally adjusted PCL for sewer flooding as the best option for customers (as set out in Appendix A).

3.1.6 Our claim is underpinned by robust engineering, operational and economic rationale as informed by work UUW commissioned at PR19[8], the outputs from our 'flooding hackathon' and submissions to the Future Ideas Lab[9].The flooding hackathon was a multi-disciplinary sprint that brought together subject matter experts, developers, interface designers and others to improve our understanding of the risk drivers for flooding using new and pre-existing datasets, including open data where available. The results demonstrated that a multiplicity of factors that compound to result in UUW incurring additional costs to operate and maintain sewerage infrastructure and to mitigate flood risk. The outputs of our flooding hackathon have been shared with Ofwat through a number of sessions leading up to the Price Review submission.

3.1.7 We have calculated UUW's proposal for an adjustment to the allowance by reference to a model suite that reflects the issues we face in a region with high volumes of urban rainfall and a high prevalence of combined sewers. This model suite is identical to Ofwat's consultation model suite but introduces an 'interaction term', which reflects the inter-relationship between urban rainfall and combined sewers, into sewage collection models SWC1-SWC3 and wastewater network plus models WWNP1-WWNP4. The claim value of £152.6 million therefore represents the difference between the modelled allowance

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

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

[9] UUW (2022) *Future Ideas Lab: What lessons can we learn from cost assessment at PR19?* Available here

resulting from models with and without this factor, minus the implicit allowance £48.3 million associated with Ofwat's proposed adoption of an urban rainfall factor in a *subset* of its models (models SWC4-SWC6 and WWNP5-WWNP8).

3.2 Structure of this document

3.2.1 We have structured this document according to Ofwat's assessment gates for cost adjustment claims as outlined in the PR24 Final Methodology Appendix 9[10]. The claim is therefore divided as follows:

a) Section 4 'need for investment' outlines the compelling evidence that Ofwat's proposed econometric models do not adequately capture the unique operating circumstances of the North West and this has material implications for company expenditure:

(i) Section 4.1 outlines the key exogenous factors that affect drainage performance in the North West;

(ii) Section 4.2 outlines how such factors are largely outside of management control and demonstrates that UUW has invested efficiently to manage such risks;

(iii) Section 4.3 demonstrates how such exogenous factors are material drivers of expenditure and as such, UUW will incur higher costs in moving towards common PCLs than other companies; and

(iv) Section 4.4 provides evidence that the cost claim is not included in Ofwat's modelled allowance, including an explanation for why our proposed explanatory variable, namely an interaction term for urban rainfall and combined sewers, is superior to the explanatory variable in Ofwat's cost models.

b) Section 5 'cost efficiency' demonstrates that our cost estimates are efficient, including an explanation for how the cost estimates were derived and the efficiency assumptions applied. Third party assurance of the robustness of the cost estimates was also provided by PwC. An extract from their report is provided in paragraph 5.1.8.

c) Section 6 'need for investment' details why we do not consider this criteria to be appropriate for this case as per Ofwat's guidance set out in Appendix 9.

d) Section 7 'best option for customers' explains why UUW considers the best option for customers of all companies to be PCLs for internal sewer flooding that are adjusted to the operating circumstances of that region.

e) Section 8 'customer protection' demonstrates that customers of UUW are fully protected via a range of performance commitments should UUW fail to fully deliver upon the additional expenditure set out in this claim.

[10] Ofwat (2022) *Appendix 9 Setting expenditure allowances.* Available here

4. Need for adjustment

4.1 Unique circumstances

4.1.1 UUW provides services in a unique operating environment, whereby a number of compounding factors interact to increase operation and maintenance costs.

4.1.2 The value of this claim has been determined through the introduction of an interaction term into Ofwat's cost model suite that reflects the combined impact of two key exogenous factors, namely:

(i) urban rainfall; and

(ii) proportion of combined sewers

4.1.3 We apply these terms when deducing the claim value as we consider that Ofwat has a consistent dataset for both factors across all operating regions and therefore a symmetrical cost adjustment can be achieved. Furthermore, these variables, and specifically the interaction between them, were found to be robust and highly statistically significant in econometric models.

4.1.4 There are also several additional factors that compound the effect of the above but are not reflected in the value of the claim, primarily due to inconsistent data and/or concerns regarding the impact on customers' bills. UUW thus proposes to absorb the impact of these factors to limit the impact on customers' bills and focus the cost adjustment claim. These other factors include:

(i) soil permeability and potential evapotranspiration (PET)

(ii) food service establishment (FSE) density; and

(iii) local topography and cellar density

4.1.5 We outline the impact of these exogenous factors below to reflect the additional layer of stretch that UUW is taking on. Indeed, Table 2 shows that no other company has the same combination of unfavourable exogenous factors as UUW.

Table 2 - UUW has a unique combination of exogenous factors

Company	High proportion of combined sewers (> 40%)	Urban Rainfall > industry average (9.5 m3 per 10,000 connected props)	PET < industry average (600.34 mm)	Low soil permeability*	High FSE density?**
ANH	×	×	×	×	×
NES	✓	×	✓	✓	✓
SRN	×	×	×	×	×
SVE (inc. HDD)	×	×	×	×	×
SWB	✓	✓	×	×	×
TMS	×	×	×	×	✓
UUW	✓	✓	✓	✓	✓
WSH	✓	✓	✓	×	×
WSX	×	×	×	×	×
YKY	✓	✓	✓	×	✓

**Visual representation based on the dominant soil type characteristics across the UK (Figure 5). Low soil permeability characteristics: Slowly permeable seasonally wet acid loamy and clayey soils; slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils; slowly permeable wet very acid upland soils with a peaty surface; blanket bog peat soils; loamy and clayey floodplain soils. Source: Cranfield University Soilscapes Data*
***Where high is considered to be 107-232 outlets per 100,000 population and medium to high 87-106 outlets / 100,000 population based on PH (2018 data)*

4.1.6 While these factors will be considered here separately for ease of understanding, it must be emphasised that it is their interaction that compounds to disadvantage UUW. The impact of these unique factors on company expenditure will be explored in more detail in Section 4.3: Materiality.

Urban Runoff

4.1.7 The North West has 40% more urban rainfall than the industry average and therefore greater volumes of surface water enter the sewer network.

4.1.8 UUW's position to the west of the UK results in a high exposure to prevailing winds from the south west bringing warm air that is laden with moisture from the Atlantic Ocean. This air cools as it is forced to rise over high ground of the west Pennines resulting in large totals of orographic rainfall[11]. Indeed, as acknowledged by Ofwat at PR19[12], ranked by average annual rainfall, 17 out of the top 26 cities in England and Wales fall within UUW's operating area.

4.1.9 Furthermore, Ofwat's own 'urban rainfall calculations (October 2022) dataset[13] (BN4505) demonstrates that, when normalised per 10,000 sewer connections, UUW's urban rainfall is 40% higher than the industry average (Figure 3). Therefore, as high rainfall coincides with the urban conurbations of the North West, it can be deduced that more rainwater falls onto hard, impermeable urban surfaces and so enters the sewer system relative to in other companies' areas. High rainfall results in higher flooding risk and drives the increased activation of overflows to alleviate such risk.

4.1.10 We note that we do not consider the difference between ourselves and Welsh Water to be entirely reflective of differences in urban rainfall. Instead, our analysis has found urban rainfall in Welsh areas may be systematically overstated due to potential differences in the way geographical areas are measured between the two countries. We present evidence of this in Appendix B. While we consider that the addition of an urban rainfall variable to the recommended model suite is a positive development and we consider the calculation to be pragmatic and generally appropriate, we do consider that any resulting comparative analysis should be viewed in context of the underlying systematic differences between England and Wales set out in Appendix B.

Figure 3 - Urban rainfall (million m3) (wastewater – LAD) per 10,000 connected properties. Source: Ofwat, urban rainfall calculations. Available here.

[11] Orographic rainfall is formed when air is forced to cool when it rises over hills or mountains.

[12] Ofwat (2019) *PR19 final determinations. United Utilities – Cost efficiency additional information appendix.* Available here

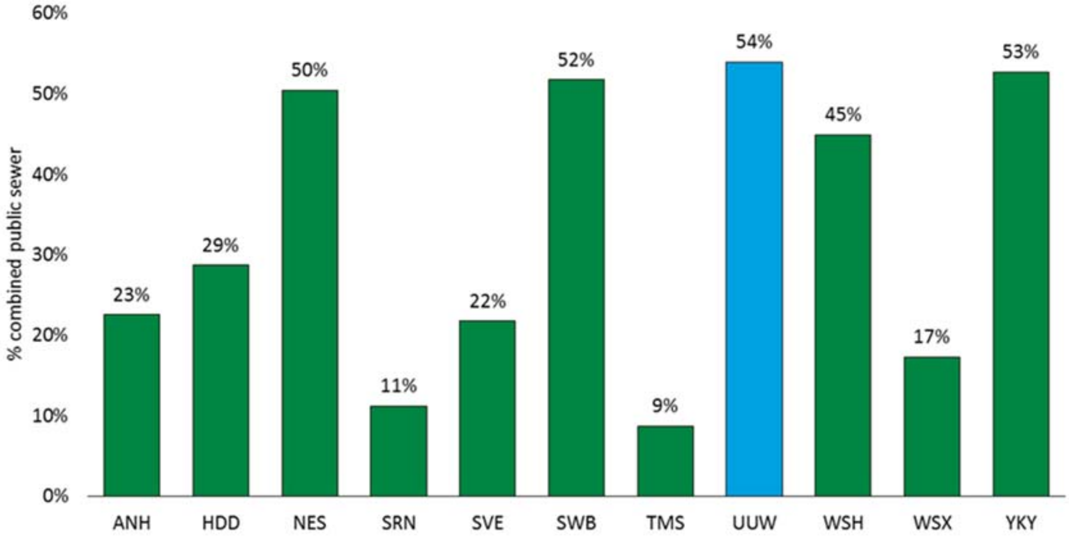
[13] Ofwat (2022) *Urban rainfall calculations.* Available here

Proportion of combined sewers

4.1.11 UUW has the highest percentage of combined public sewers in the industry. Combined sewers convey both foul and surface water flows, resulting in a reduced hydraulic capacity in periods of high rainfall and increased risk of sewer flooding relative to other companies.

4.1.12 UUW has the highest percentage of combined public sewers in the industry at 54% (Figure 4) compared to an industry average of 33%. Combined sewers are highly responsive to rainfall and have less hydraulic capacity during storms, increasing the risk of sewer flooding. Indeed, analysis completed as part of UUW's flooding hackathon demonstrated that, per kilometre of sewer, the likelihood of internal surcharge incidents, internal overland incidents and external incidents are 26.5%, 52.1% and 2.7% higher, respectively, in combined sewers compared to foul-only sewers.

Figure 4 - UUW has the highest % of combined public sewers in the industry. Source: Ofwat, PR24 wastewater cost assessment master dataset. Available here.



4.1.13 Engineering and operational rationale therefore dictates that there is a strong interrelationship between rainfall and combined sewers: combined sewers have a lower hydraulic capacity during periods of heavy rainfall, amplifying the effect of urban rainfall on sewer flooding and storm overflow risk. Indeed, the hackathon was able to demonstrate that WaSCs with higher proportions of combined sewers have higher numbers of flooding incidents as urban rainfall increases.

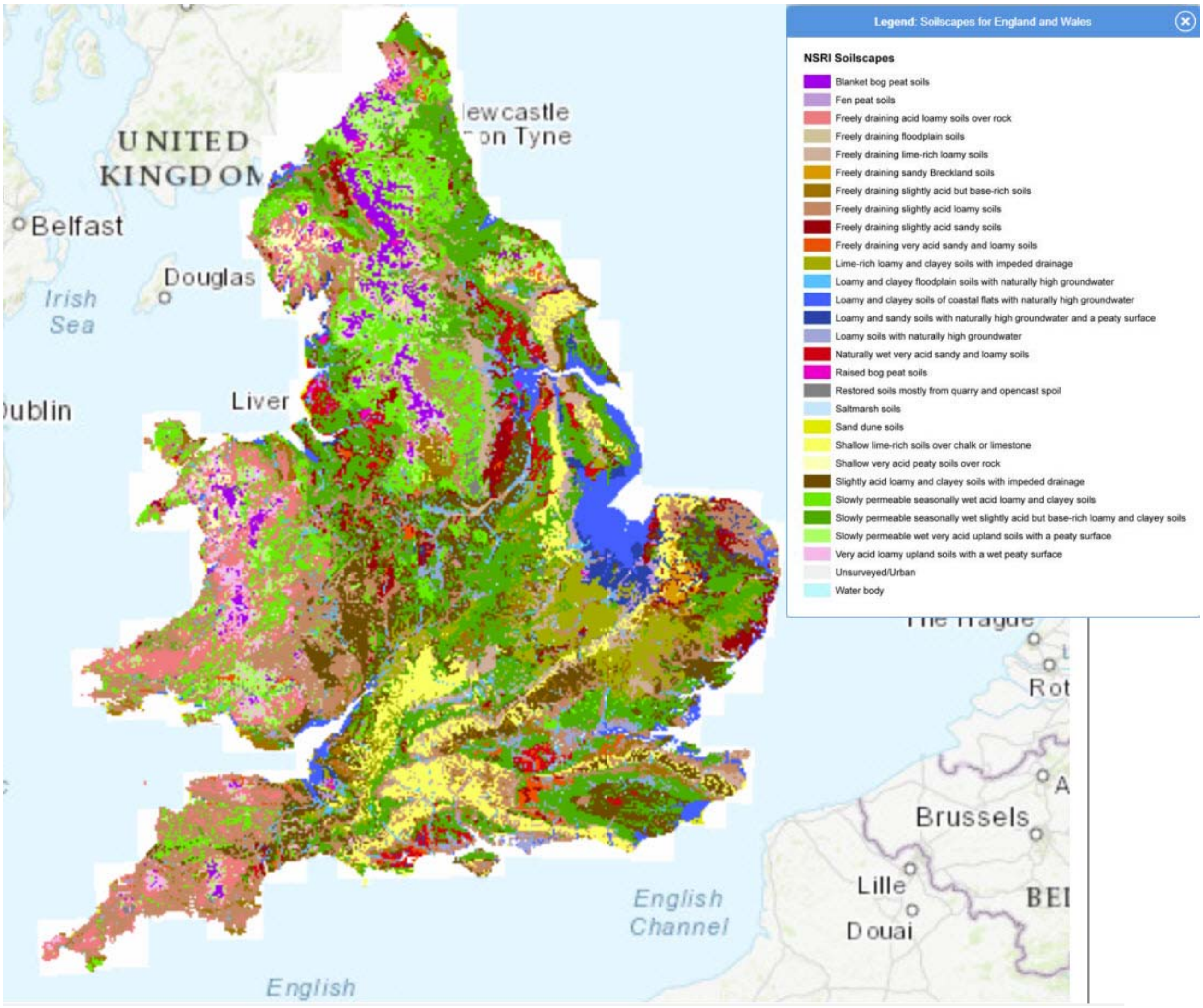
Soil Permeability and potential evapotranspiration

4.1.14 The North West has large areas of low permeability soils and potential evapotranspiration (PET) that is below the industry average. These two factors reduce the ability of water to be lost from the system via infiltration and evaporation/transpiration, respectively. Therefore, this suggests that more of the rainfall falling in the North West flows overland into the sewer network.

4.1.15 Compounding the effect of urban rainfall is soil permeability and potential evapotranspiration (PET). Much of the North West has large swathes of slowly permeable soils with a low infiltration potential. Indeed, analysis of Soilscapes data, a freely accessible dataset published by Cranfield University[14], demonstrates that significant areas of the North West, including surrounding major urban centres such as Manchester, are covered by slowly permeable seasonally wet loamy and clayey soils (Figure 5). In contrast, the operating areas covered by Welsh Water and South West Water, regions that are similarly exposed to Atlantic depressions, are dominated by freely draining loamy soils. The implication is that rainfall that falls in UUW's operating region is more likely to flow overland into our sewer network.

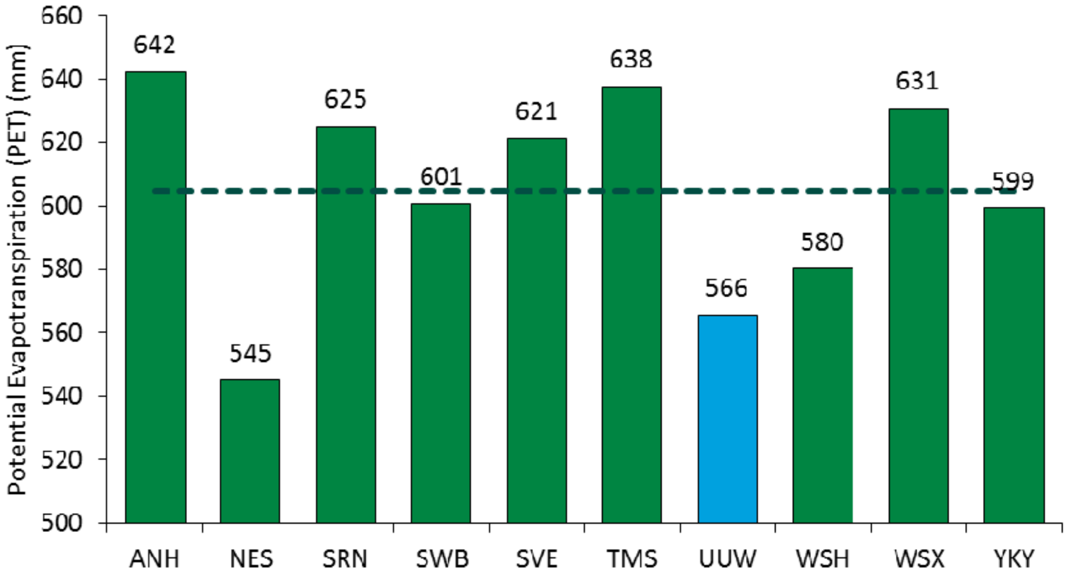
[14] Cranfield Soil and Agrifood Institute (N/A) *Soilscapes.* Available here

Figure 5 - Large areas of the North West are covered by 'slowly permeable seasonally wet acid loamy and clayey soils' (bright green) and 'slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils' (dark green). Source: Cranfield University Soilscapes Data. Available here



4.1.16 Furthermore, UUW has a below average PET (Figure 6). PET is a measure of the rate of the maximum potential loss of water via evaporation from the land surface and transpiration by plants. A low PET thus means that less water is being lost from the surface via these routes and is therefore available to run overland into UUW's sewer network.

Figure 6 - Annual average potential evapotranspiration (PET) (2001-22) by company. The dashed black line represents the industry average. Source: Available here.



4.1.17 Therefore, together, low permeability soils and below average PET compound the effect of above average urban rainfall by allowing less of the rainfall falling on a surface to be removed via infiltration and evapotranspiration, respectively. The result is that a greater proportion of rainfall is therefore available to runoff into sewer systems.

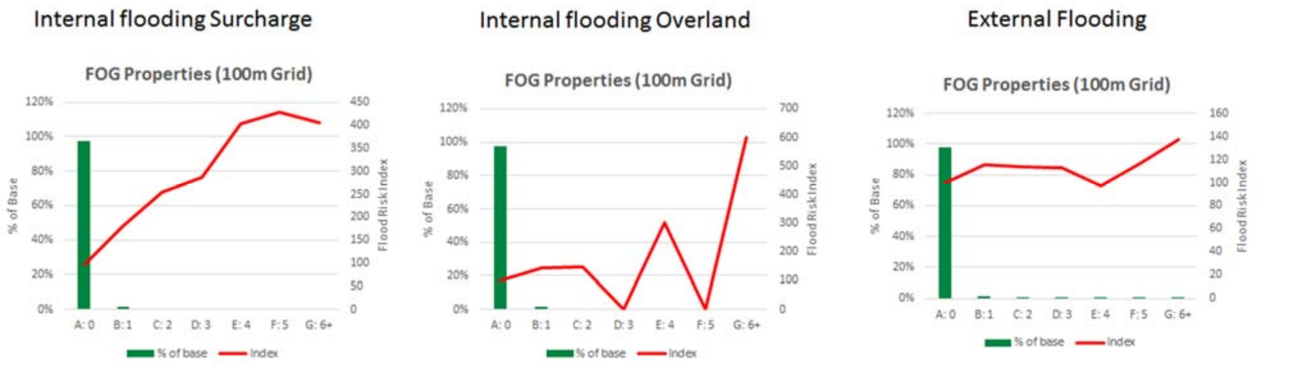
Food service establishment (FSE) density

4.1.18 FSE density in the North West is well above the national average, increasing the risk of flooding caused by fat, oil and grease (FOG) blockages.

4.1.19 The North West has a higher FSE density (118.2 per 100,000 population) than the national average (90.8 per 100,000 population)[15]. Our flooding hackathon demonstrated that the risk of internal flooding risk significantly increased with the number FOG discharging premises located within a 100 m grid square (Figure 7). As a result, it can be concluded that UUW faces a higher risk of flooding caused by FOG discharges from FSEs than most other companies, necessitating higher expenditure on blockage clearance as well as engagement with, and monitoring of, FSEs.

[15] Public Health England (2018) *Fast food outlets: density by local authority in England.* Available here.

Figure 7 - Flood risk increases as FOG property (i.e. FSE) density increases for surcharge, overland flow and external flooding mechanisms. Source: UUW internal data (flooding hackathon)



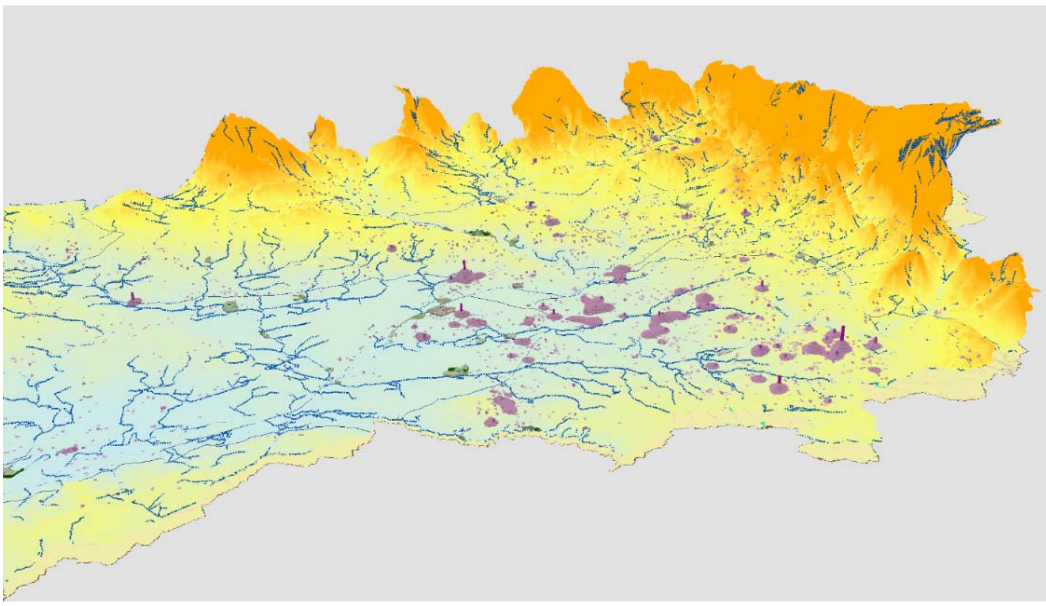
The x-axis displays the FOG property density within a 100 m grid square, grouped into bins of increasing density. The green bar shows the percentage of grid squares that fall within each category. The red line shows the flood risk index increasing with the FOG property density.

Local topography

4.1.20 The interaction of runoff with unique local topographies acts to exacerbate the risk of flooding in certain urban centres.

4.1.21 UUW considers that unique local topographies can further increase runoff into local systems. Specifically, our flooding hackathon demonstrated that Manchester's geography and its topography as a 'bowl' holds water and directs it towards our network (Figure 8). Manchester is situated at the base of the Pennines and therefore, when moist air from the Atlantic hits the Pennines, the moisture condenses to produce orographic rainfall that then flows back into the 'bowl' over saturated ground. Once this rainwater enters the network, as the base of the bowl is flat, hydraulics dictate that the system remains surcharged for longer following rainfall and pumping stations and wastewater treatment works (WwTWs) remain at high level. As a result, the entire system has much less spare capacity for an extended period of time, increasing the risk of service deterioration.

Figure 8 - A 3D topographic representation of the Manchester Drainage Area



The Manchester drainage area has a 'bowl' topography whereby orographic rainfall generated by the Pennines is forced to runoff and enter the sewerage system in the urban centre of Manchester. Purple areas represent internal flooding clusters.

4.1.22 Additionally, Manchester has a high cellar density (Figure 9). Our flooding hackathon demonstrated that increased cellar density significantly increases risk of internal flooding via both surcharge and overland flow mechanisms (Figure 10). The high cellar density in Manchester therefore exacerbates the effect of topography on flood risk, as cellar locations coincide with low spots on the network in flat base of the 'bowl'.

Figure 9 - Cellar density across the UK. Red clusters correspond to areas of high cellar density. Source: 2001 census data. Available here.

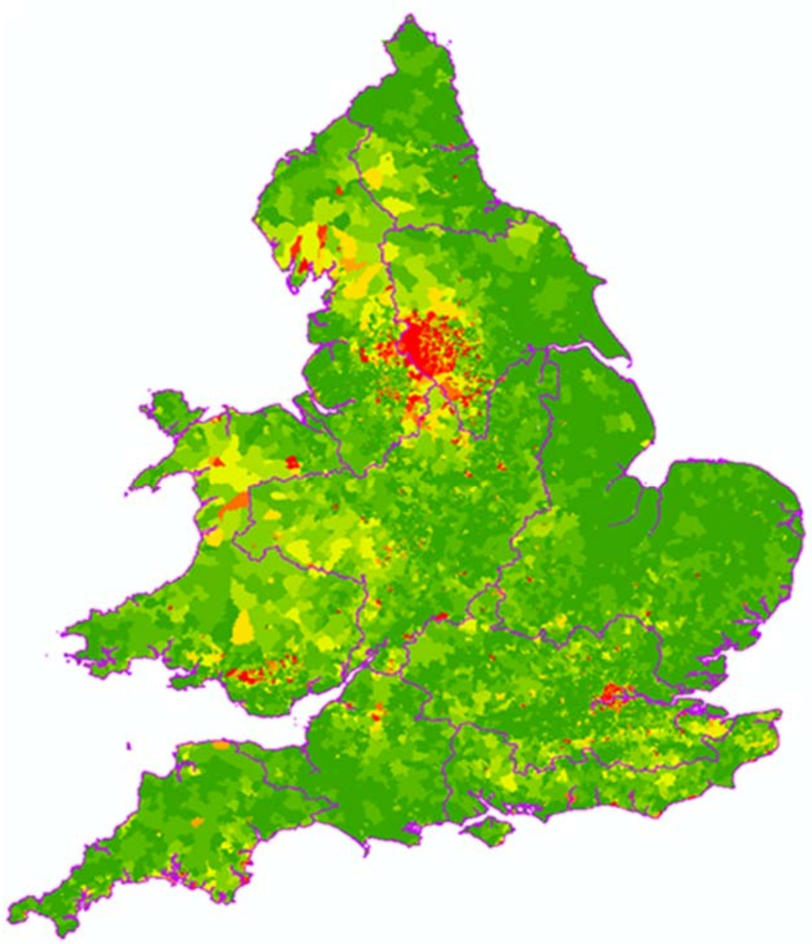
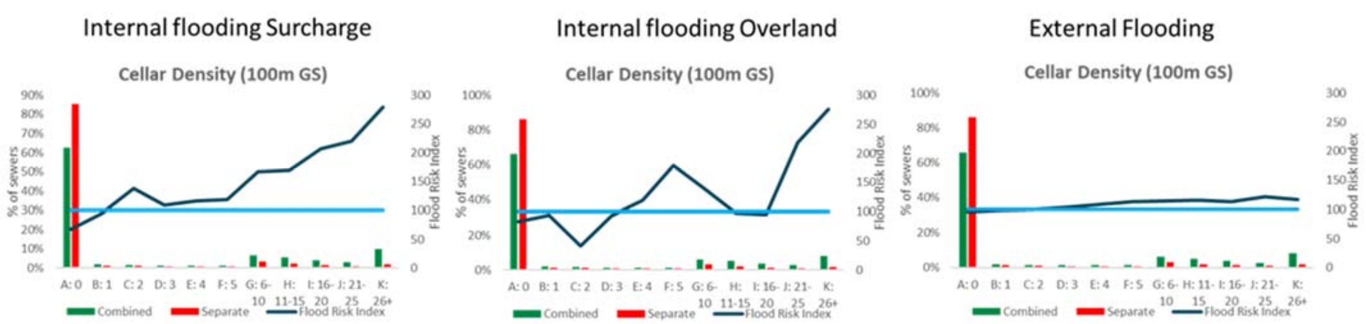


Figure 10 - Our flooding hackathon demonstrated that Internal flooding surcharge and internal flooding (overland) risk indices increase as cellar density increases. Source: UUW internal data (flooding hackathon)



The x-axis displays the cellar density within a 100 m grid square, grouped into bins of increasing density. For each bin, the bars show the proportion of combined (green) and separate (red) sewers. The dark blue line shows the flood risk index (right-hand axis) increasing with the cellar density, relative to the average (i.e. 100) (light blue line). For example, a flood risk index of 300 represents a 3x increase in overall risk based on the number of cellars.

4.1.23 The result of these factors is that Manchester has an especially high flood risk. Indeed, in FY21, a particularly wet year, 47.2% of UUW's internal flooding events occurred in the Manchester drainage area. To mitigate this risk, over 1100 property-level flood mitigation devices have been installed in the Manchester drainage area since 2017 at a cost of over £9 million.

4.1.24 However, owing to the logistical difficulty of accounting for any unique local topographies across the industry and the insufficient confidence in the accuracy of cellar data nationally, we do not propose such factors for inclusion within Ofwat's botex models.

Higher costs in the round

4.1.25 As outlined in Table 2, UUW provides services to an operating region in which multiple exogenous factors interact to increase ongoing operation and maintenance costs. We have looked across a comprehensive range of drivers of maintenance costs and flood risk and UUW sits unfavourably for each factor. Indeed, we fail to identify a single factor that has a mitigating influence for UUW relative to other companies. These material drivers compound to disadvantage UUW and will increase the costs incurred in moving towards a common PCL above those incurred by other companies. Section 4.3: Materiality explores the relationship between our exogenous factors and cost in more detail.

4.1.26 One argument could be that higher runoff into our sewer network could afford UUW an advantage with regards to improved flushing and blockage clearance. However, research conducted by WRc on behalf of UUW demonstrates that this assumed relationship does not always hold true[16]. This report concluded that, in some circumstances, high rainfall can actually increase blockage numbers. Therefore, any inferred advantage from UUW's unique operating circumstances cannot be considered to offset the compounding impact of the material drivers, resulting in higher costs in the round.

4.2 Management control

4.2.1 The above factors are all entirely, or largely, outside of management control:

- **Urban rainfall** – Management cannot control the amount of rainfall falling within a region, nor the degree of urbanisation. We do, however, exert some degree of control over the way in which rainwater is managed. Part of our long-term ambition is therefore to increase attenuation of rainwater, within both urban areas and the wider catchment, through measures such as SuDS and natural flood management (NFM). However, the scale of the operational change and total investment necessary to fundamentally reconfigure our network and control rainwater at source means that rainwater management investment must be staggered across multiple AMPs. Urban rainfall is therefore outside of short-term management control.
- **Proportion of combined sewers** – Our combined sewers are legacy assets inherited at privatisation. We could not control the asset base we inherited and whilst we are looking to increase surface water separation, this is an expensive and complex process to conduct at scale. Indeed, Defra's consultation on the Government's Storm Overflows Discharge Reduction Plan[17] states *"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".* We therefore consider that separation at the scale necessary to reduce the combined sewer variable in this claim would be prohibitively expensive and disruptive for our customers and therefore this variable is outside of short to medium term management control.
- **Local topography** – Topography is entirely outside of management control.

[16] WRc (2023) *Understanding the Impact of Rainfall and Drainage Area Features on Blockages.* Available upon request.

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

- **Soil permeability and PET** – Both factors are entirely outside of management control.
- **FSE density** – Numbers and location of FSEs are outside of management control, although we do have an active programme of engagement with FSEs to improve their understanding of appropriate FOG disposal practices and thereby decrease discharges to the network.

4.2.2 While acknowledging these exogenous factors fall outside of management control, we have nevertheless invested significantly in managing the risk, including:

- Deployment of our industry leading Dynamic Network Management (DNM) initiative. The DNM approach allows UUW to manage our wastewater network more proactively and is believed to be the largest integrated solution of its kind globally. DNM has involved the installation of over 17,500 intelligent sensors, alongside enhanced monitoring on more than 1,500 point assets, across 160 drainage areas. By improving the monitoring capabilities in our network and applying predictive analytics and machine learning to spot deviations from 'normal' flow signatures, we have been able to identify and resolve key causes of flooding and spills, such as blockages, before customers are even aware of the problem/before a spill can occur. The proactive alerts generated by this network of sensors have detected over 2100 sewer blockages since August 2021.
- Introduction of a robust blockage resolution model, including: mandating post blockage clearance CCTV surveying to better understand root cause and raise further works accordingly; a targeted planned cleaning programme in areas identified as susceptible to repeat blockages and enhanced targeting of proactive CCTV surveying and defect resolution as part of our Flying Start initiative for AMP7. We have also implemented a 'high risk asset plan', performing proactive walkovers of assets susceptible to blockage formation, such as interceptor traps[18] and pitch fibre sewers[19].
- Installation of over 1,600 flood mitigation devices, such as flood barriers and non-return valves, over the first three years of AMP7 at properties where flooding has previously occurred, significantly reducing the incidence of repeat flooding. Additionally, we have invested heavily in our 'hydraulic flood risk resilience' schemes to reduce the impact of hydraulic incapacity through cut and pump solutions as well as planned installation of 9,945 m^3 of storage by the end of AMP7.
- Partnering with ECAS to conduct over 8,500 site visits to high-priority FSEs since October 2019, providing education and advice regarding grease removal equipment and kitchen best practice. This work has resulted in the installation of over 500 grease traps, preventing an estimated 1,242 tonnes of FOG from entering UUW's sewer network.
- Launching regional 'What not to Flush' and 'Stop the Block' customer campaigns, as well as conducting more targeted engagement with communities in 'hotspot' areas, including the distribution of fat traps. As a result, we outperformed our bespoke 'raising customer awareness to reduce the risk of flooding' performance commitment by 13.4% in FY22.
- Promoting, driving and supporting planning for flood risk reduction throughout all levels of planning, from a strategic level at Regional Flood and Coastal Committees to operational Making Space for Water meetings in all regional council areas.
- Maturing our partnerships framework through place-based plans such as the Integrated Water Management Plan for Manchester developed through the trilateral partnership with the EA and Greater Manchester Combined Authority (GMCA).

[18] Interceptors traps can be found on drains serving pre-1937 properties, often terraced, and are owned or maintained by whoever is responsible for the drain on which they are found. They are designed like a u-bend, maintaining a constant water level and preventing any odours venting from the public sewer. The nature of the design allows rags, solids and silt to build up, meaning blockages are common.

[19] Pitch fibre is a material that was a popular lower cost alternative to traditional clay pipes in the 1950s-70s. However, this material is highly susceptible to breaking and collapsing.

4.2.3 Throughout, we have taken all necessary steps to control costs and take advantage of any spend to save opportunities. For example, the large-scale deployment of DNM is allowing us to scale back our planned serviceability programme in some locations, such that it is no longer necessary to clean blockage-prone locations on a pre-defined cyclic basis but rather cleaning is only carried out when we are alerted to a deviation in flow signature. Further, transitioning to an operating model that is driven by sensor alerts as a means of identifying a problem, rather than customer contact, has reduced reactive callouts by 10% and 25% for infrastructure and non-infrastructure jobs, respectively.

4.3 Materiality

4.3.1 As acknowledged in Ofwat's Econometric Base Cost Models Consultation[20]: "*The greater the volumes of inflow into drainage and sewerage networks, the larger network and storage assets need to be, and the greater the amount of pumping and capital maintenance costs are needed to avoid sewer flooding incidents and discharges of wastewater from storm overflows, and maintain good asset health*". While this is stated specifically with regard to urban rainfall, UUW contends that the impact of combined sewers exacerbates the above costs as combined sewers have less hydraulic capacity than separate systems during periods of heavy rainfall. As a direct result of our exogenous factors, UUW will therefore incur additional costs in moving towards common PCLs.

4.3.2 This section outlines evidence to support the relationship identified above between our exogenous factors and cost, specifically via the following example mechanisms:

a) Higher surface water flows into the system necessitate larger diameter assets. Larger assets cost more to operate and maintain;

b) Higher sewer flooding risk exposure increases expenditure on incident response;

c) UUW must spend more than other companies on managing flood risk

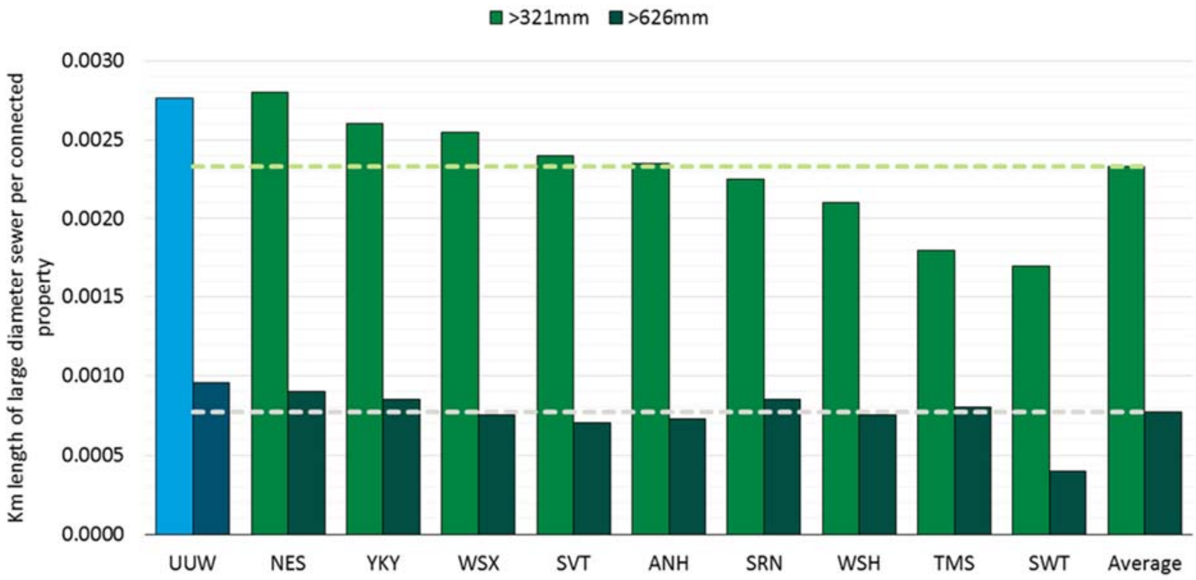
Larger assets drive higher costs

4.3.3 Large volumes of surface water entering the system necessitates a larger asset base to cope with such inflows. UUW has the highest proportion of sewers > 626 mm in diameter in the industry. Large assets require greater expenditure on inspection, rehabilitation and cleaning.

4.3.4 Larger flows into the system necessitate larger assets to avoid upstream hydraulic overloading. Analysis of PR14 business plan data, the latest available industry-wide data, demonstrates that UUW has the highest proportion of sewers > 626 mm in diameter and the second highest proportion of sewers > 321 mm in diameter (Figure 11). This is despite UUW having the lowest proportion of surface water sewers, which are typically larger in diameter, suggesting that the discrepancies in the size distribution profile would be even more pronounced if combined sewers only were considered. We consider that the use of PR14 data is appropriate as there is no evidence to suggest that the size distribution of assets among companies has changed significantly in the past two AMPs.

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

Figure 11 - UUW has above average proportions of sewers >321 mm and >626 mm in diameter based on PR14 business plan data (with UUW error corrected as per PR19 claim). Source: PR14 business plan data.



This is the latest available industry data. It can reasonably be assumed that the size distribution of assets has not changed significantly across the industry since PR14 owing to the long lives of infrastructure assets.

4.3.5 A review of our competitively tendered contracts and cost database unequivocally demonstrates that larger diameter sewers cost more to maintain. For example, sewer cleaning rates from our framework suppliers demonstrate that unit rates increase as sewer diameter increases, especially so in sewers above 900 mm in diameter (Figure 12). Sewer cleaning is fundamental in optimising available storage capacity by reducing siltation and preventing blockage formation, particularly in flat locations such as the base of the 'Manchester bowl'.

Figure 12 - Average sewer cleaning rates across our framework contractors by sewer diameter. The cost per m increases with sewer diameter. Source: UUW contractor rates.

[✂]

4.3.6 A similar relationship is also observed for structural assessments (Figure 13) and sewer rehabilitation (Figure 14). Both of these activities are imperative in maintaining good asset health, especially as combined sewers experience more variable flows and are therefore subject to increasing stresses and strains. However, it can be clearly seen that the cost of structural assessments and sewer repair increase with the diameter of the sewer. As UUW has a greater proportion of larger sewers, and owing to the stresses placed upon combined sewers in accommodating a wide range of flows, it therefore costs UUW more to maintain good asset health.

Figure 13 - Average cost of a structural assessment across our framework contractors by sewer diameter. The cost per m increases with sewer diameter. Source: UUW contractor rates.

[✂]

Figure 14 - Average cost of a sewer repair across our framework contractors by sewer diameter. The cost per m increases with sewer diameter and this is compounded by depth. Source: UUW contractor rates.

[✂]

4.3.7 Thus, as UUW has a greater proportion of larger diameter assets than other companies (and with our high proportion of combined sewers), UUW requires additional costs to maintain the same level of sewer serviceability. In increasing sewer serviceability activities in order to manage drainage services in our region, UUW will therefore incur disproportionately high costs.

4.3.8 Additionally, as CSOs act as relief points on the network during periods of high rainfall, operational rationale dictates that, due to our higher urban runoff rate and percentage of combined sewers, current frequency of CSO spills should be expected to be higher than for other companies. As a direct result of our unique circumstances, UUW must therefore install more storage than most other companies to meet customers' and regulators' expectations regarding spill reduction – this storage will also require maintenance in future periods.

4.3.9 Additional storage brings with it additional maintenance requirements that are not accounted for in Ofwat's botex models, including the need for cyclic cleaning and desilitation, as well as inspection of powered assets. Indeed, a review of tank cleaning rates shows that above $500m^3$ the cost of tank cleaning increases rapidly as the costs of enabling works, including traffic management and confined space entry procedures (Figure 15); 51% of UUW's tanks exceed this size.

Figure 15 - Average cost of tank cleaning across our framework contractors by tank volume. The cost increases with volume. Source: UUW contractor rates.

[✂]

4.3.10 For instances in which UUW must inspect tanks that exceed $5000m^3$, costs for cleaning increase exponentially, as a result of the need to implement even more complex traffic management, lifting and safety procedures (Figure 16). Indeed, for an instance in which UUW need to clean a 21,205 m^3 tank, the cost estimate is over £600,000.

Figure 16 - Costs of cleaning tanks >5000 m3 can be exceptionally high as a result of the complex traffic management and H&S procedures. Source: UUW contractor rates.

[✂]

4.3.11 Therefore, it is clear that as a result of the need to store and convey more surface water, UUW has larger than average assets. The cleaning, inspection and rehabilitation of these larger assets is more costly and therefore, as a direct result of our unique operating circumstances, UUW incur higher costs that are not accounted for within Ofwat's cost models. UUW therefore requires an upward adjustment to the botex allowance for maintenance of these larger than average assets.

4.3.12 In addition to our existing maintenance needs, this will be exacerbated by the future maintenance that will result from the significant enhancement investment required to meet customer's and regulators' expectations regarding CSO spill reductions. Reducing CSO spill frequency will substantially increase UUW's grey storage volume, and specifically their associated maintenance needs, relative to other companies.

More frequent storms increase incident response costs

4.3.13 As a result of the exposure of the North West to incoming westerly Atlantic depressions[21], UUW is highly susceptible to periods of intensive rainfall; an effect that is amplified by the lower hydraulic capacity of combined sewers during such rainfall events. It can therefore be concluded that UUW has greater costs associated with incident response than regions that are less susceptible to such storms.

4.3.14 For example, Storm Desmond and Storm Eva, two severe storms that hit the North West in short succession in December 2015, resulted in reactive costs on the wastewater network of over £ [✂] that were incurred on activities such as overtime, pump hire, generator hire, clean-up and tankering. Over the long-term, these two storms alone are estimated to have cost UUW £[✂], via expenditure associated with pipebridge replacement, replacement of damaged electrical equipment, insurance claims and repair of civil infrastructure such as access roads. As a result of the increased exposure to these types of storm events, we must spend more of our base allowance on incident response than Ofwat's cost models account for.

Higher flood risk requires more expenditure on mitigation

4.3.15 As a result of the interaction between the exogenous factors outlined in this claim, UUW has a higher sewer flooding risk exposure than most other operating regions. We must therefore spend more than other companies on the installation, inspection and maintenance of flood mitigation devices. Expenditure on flood mitigation programmes will increase further in moving towards a common PCL.

4.3.16 Over the first three years of AMP7, as a direct result of our higher flood risk, we have invested significantly in flood mitigation, installing over 1600 flood mitigation devices, such as flood barriers and non-return valves, at customers' properties. Additionally, we have invested £36 million in our 'hydraulic flood risk resilience' schemes to reduce the impact of hydraulic incapacity through cut and pump solutions as well as planned installation of 9945 m^3 of storage by the end of AMP7.

4.3.17 Indeed, as outlined in Figure 1 in the preface for this document, UUW has had by far the largest total expenditure per 10,000 sewer connections on 'reducing flooding risk for properties' over the first two years of AMP7 and expenditure 27.9% above the industry average over the period 2011-12 to 2021-22. Thus, UUW incurs more costs on the installation of flood mitigation measures, as well as their inspection, maintenance and replacement, than Ofwat's current cost models allow for. In moving towards a common PCL, these costs will only increase further.

Materiality: Summary

4.3.18 UUW presents compelling evidence that exogenous factors are material drivers of expenditure. As outlined in Section 4.1, these factors are not distributed evenly across operating regions. As a result, relative to other companies, UUW will experience higher ongoing baseline costs on sewage collection

[21] Burt and Howden (2013) *North Atlantic Oscillation Amplifies Orographic Precipitation and River Flow in Upland Britain.* Available here

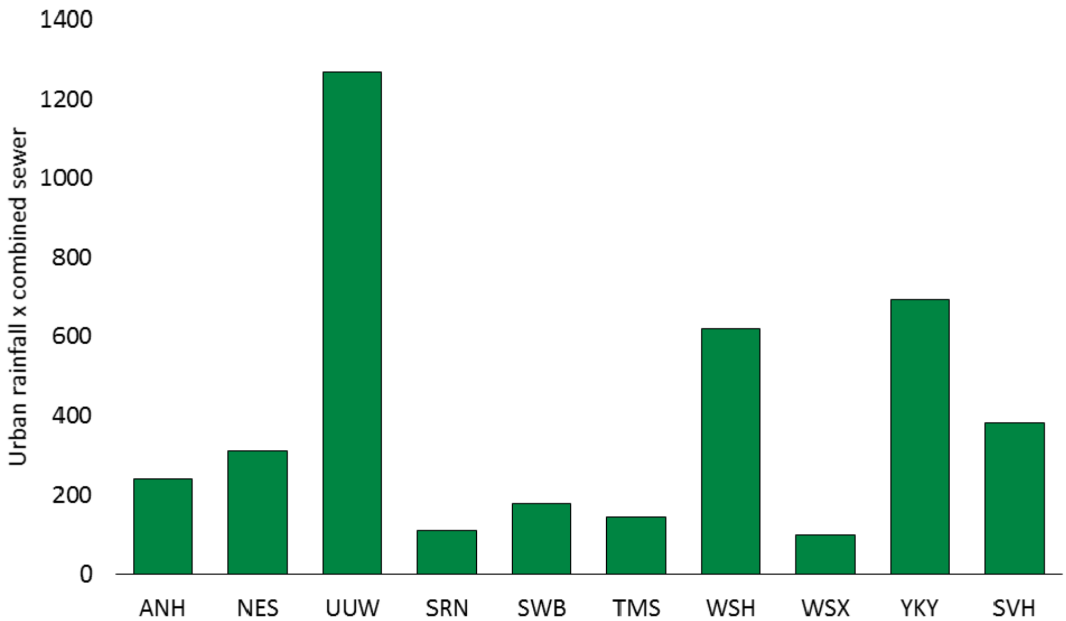
activities and additional growth in expenditure on 'reducing flood risk for properties' in moving towards a common PCL.

4.4 Adjustment to allowances (including implicit allowance)

4.4.1 As we set out in 4.2.1, there are key exogenous factors that drive additional costs and performance challenges in the North West. In UUW's submission to Ofwat's econometric model consultation, UUW proposed a set of sewage collection models that reflected these exogenous factors and which drew upon UUW's prior work in this area. In Ofwat's consultation model suite, Ofwat has included urban rainfall across a subset of its sewage collection and wastewater network plus models. It did not choose to reflect combined sewer prevalence or the interaction effects between urban rainfall and combined sewers.

4.4.2 We have calculated the value of this cost adjustment claim by reference to a model suite that reflects the issues that prevail, namely high volumes of urban rainfall and a high prevalence of combined sewers. This model suite is identical to Ofwat's consultation model suite but includes an 'interaction term' across all sewage collection models SWC1-SWC3 and wastewater network plus models (WWNP1-WWNP4). We do not use models SWC4-SWC6 or WWNP5-WWNP8 because these models include an urban rainfall term – we do use these models as part of Ofwat's full recommended model suite to calculate the implicit allowance. The interaction term was calculated by multiplying urban run-off with the percentage of combined sewers (Figure 17). This variable is uncorrelated with scale; the correlation between the interaction term and number of properties is 0.09 and length of sewers 0.16.

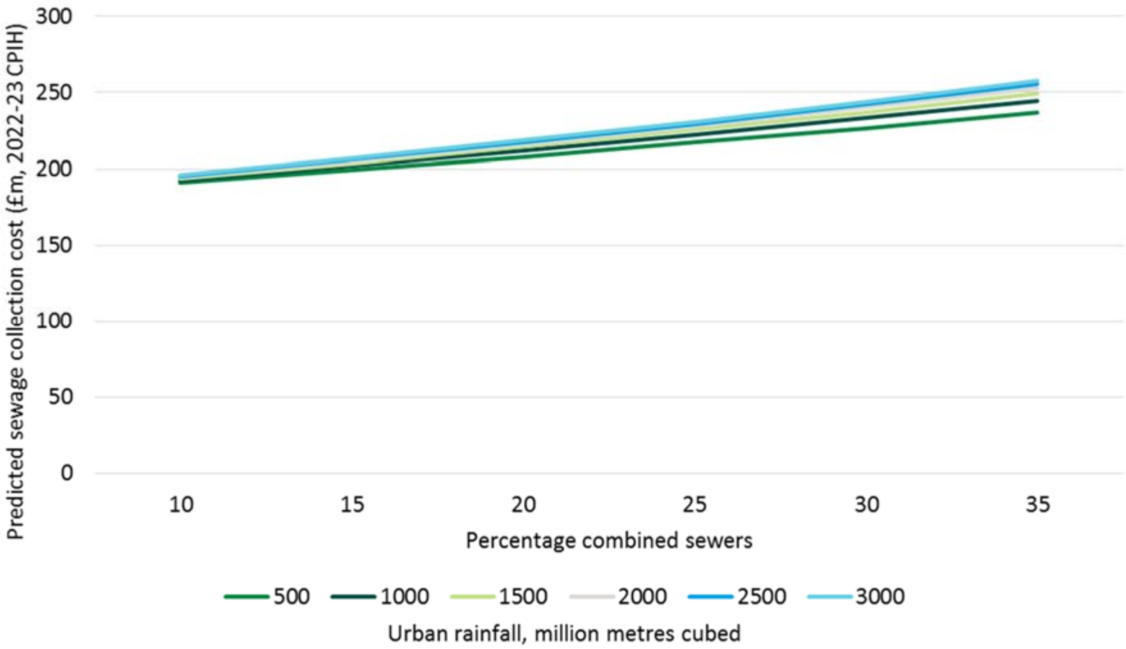
Figure 17 - Creating a combined variable allows us to consider the joint effect of urban run-off and combined sewers



4.4.3 We consider that this interaction term represents the most appropriate way to reflect the engineering, operational and economic rationale set out in Section 4.1 than a standalone urban rainfall or combined sewers variable. This is because the interaction term is better able to capture the sensitivity of combined sewers to urban rainfall, and also avoids overstating the impact of high run-off in areas with significant amounts of surface water separation (i.e. low levels of combined sewers). For example, in an alternative model where urban rainfall and combined sewers are included as individual independent variables, the interpretation of the coefficient on the urban rainfall variable would be 'the marginal effect of urban rainfall on cost, holding all other factors constant - including combined sewers'. However, this does not align with our engineering priors, which demonstrate an inter-relationship between these variables i.e. the impact of one variable upon cost depends upon the relative size of the other. The use of an interaction term allows us to introduce this inter-relationship into the cost assessment framework.

4.4.4 The effect of the interaction term can be intuitively understood through a graph. Figure 18 illustrates how the effect of combined sewers on sewage collection costs changes as the volume of urban rainfall changes. At lower levels of urban rainfall, the marginal effect of combined sewers on costs is lower whereas at higher levels of urban rainfall, the marginal effect increases. We consider that the range of marginal effects set out in Figure 18 represents a credible range of the impact of combined sewers and urban rainfall on sewage collection costs.

Figure 18 - The effect of the interaction term in model SWC2



4.4.5 We added this interaction term into Ofwat's recommended model suite. For the purposes of this claim, we did not consider Ofwat's models that include an urban rainfall variable (models SWC4-SWC6 and WWNP5-WWNP8), as these models are reflected in our implicit allowance calculations.

4.4.6 Table 3 shows the model results. It is clear that the interaction term has a material and statistically significant impact upon modelled botex, and there is no deterioration in model performance as a result of its inclusion.

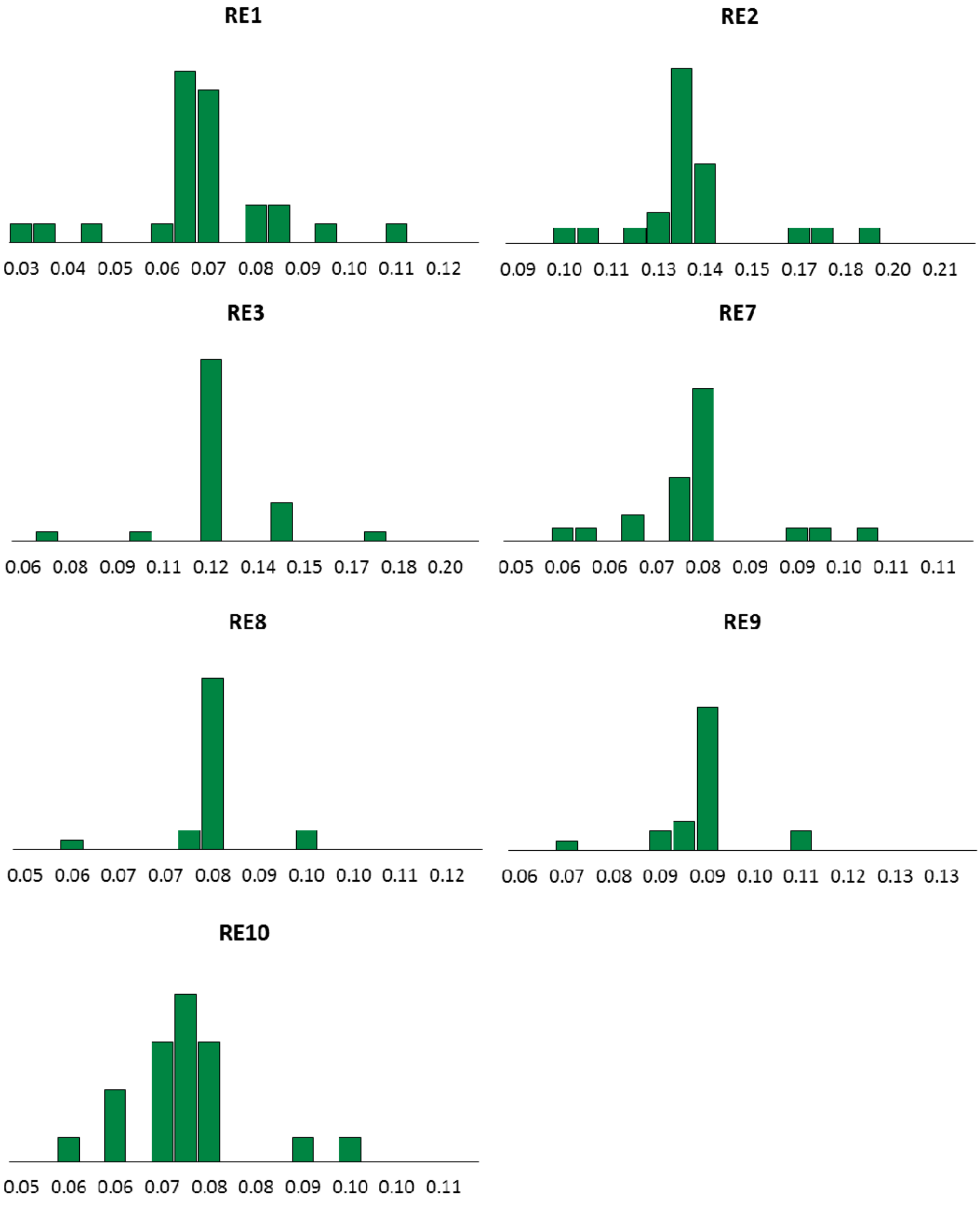
Table 3 - Model suite we used to value the cost adjustment claim

	SWC1	SWC2	SWC3	WWNP1	WWNP2	WWNP3	WWNP4
ln(sewer length)	0.849***	0.922***	0.900***				
	{0.000}	{0.000}	{0.000}				
ln(pumping capacity per km)	0.426***	0.711***	0.657***	0.453***	0.487***	0.464***	0.383***
	{0.002}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
ln(property density)	1.028***						
	{0.000}						
% combined sewers x ln(urban rainfall)	0.066**	0.138***	0.137***	0.080***	0.088***	0.097***	0.074***
	{0.028}	{0.000}	{0.001}	{0.002}	{0.000}	{0.000}	{0.001}
ln(WAD – MSOA to LAD)		0.275***					
		{0.002}					
ln(WAD – MSOA)			0.435***				
			{0.000}				
ln(load)				0.692***	0.791***	0.787***	0.745***
				{0.000}	{0.000}	{0.000}	{0.000}
pctbands13					0.025***		
					{0.000}		
% load with ammonia consent less than 3mg/l				0.005***	0.005***	0.005***	0.005***
				{0.000}	{0.000}	{0.000}	{0.000}
% STWs larger than 100k						-0.004***	
						{0.000}	
ln(WATS)							-0.078***
							{0.000}
Constant	-8.357***	-7.526***	-8.713***	-3.548***	-4.919***	-4.543***	-3.432***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
R squared	0.921	0.913	0.913	0.96	0.967	0.966	0.966
RESET test	0	0.189	0.271	0.154	0.214	0.888	0.837

4.4.7 We have also found this variable to be robust to changes in the underlying dataset. We systematically dropped companies and years and re-estimated the models. Figure 19 shows how the coefficient on the interaction term responds to these changes. The tight grouping around the coefficient's central value demonstrates that the variable is robust to underlying changes in the dataset. This is strong evidence that the variable reflects underlying engineering priors and is not affected by outlier observations.

4.4.8 Therefore, the strong engineering, operational rationale underpinning this variable (as set above) combined with its robust model performance supports its use within our claim valuation.

Figure 19 - The interaction term's coefficient is robust to changes in the underlying dataset



4.4.9 How we calculated the claim value and proposed symmetrical adjustment

4.4.10 There are four stages to UUW's calculation of the proposed symmetrical adjustment:

(1) Gross claim. First, we calculated an allowance using models SWC1-SWC3 and WWNP1-WWNP4 in Ofwat's recommended model suite. These models do not include an urban rainfall variable and so the resulting allowance acts as the base comparator. We then calculated the allowance from the models set out in Table 3 above. The difference between them represents the AMP8 allowance for all companies as a result of including the interaction term in Ofwat's model suite. We used an upper quartile catch-up efficiency challenge combined with a frontier shift assumption of 0.6% to generate these allowances. We provide justification for these assumptions in Section 5.

(2) Implicit allowance. Ofwat's recommended model suite contains an urban rainfall factor across a subset of models. This means that it contains an implicit allowance for urban rainfall. To calculate this implicit allowance, we calculate the difference in total allowances between Ofwat's consultation model suite and a version of the model suite with no urban rainfall variable.

(3) Gross claim minus implicit allowance. We subtract the implicit allowance from the raw adjustment to calculate a net raw adjustment.

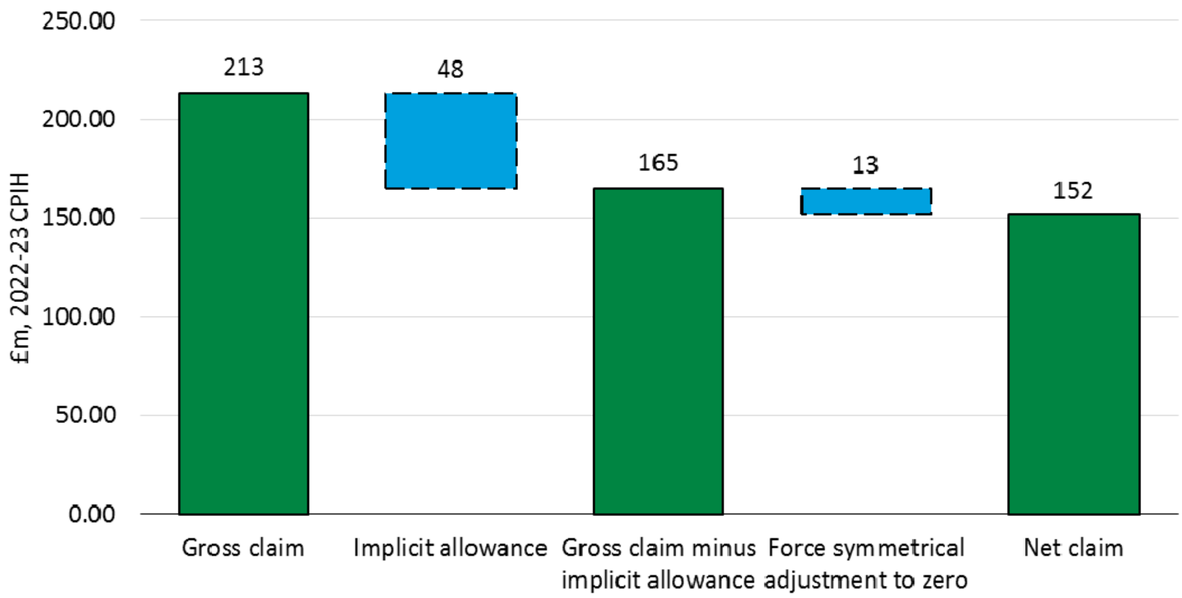
(4) Net symmetrical adjustment. We alter the 'net raw adjustment' to ensure that the overall industry adjustment equals zero. To do this, we subtract the net raw adjustment for each company from the average raw adjustment for all companies. This has the effect of adjusting all companies' allowances downwards.

Table 4: UUW's proposed symmetrical adjustment for drainage (£ millions)

Company	Gross claim	Implicit Allowance	Net claim minus implicit allowance	Net Symmetrical Adjustment
ANH	-9.75	-16.9	7.2	-5.6
NES	18.10	-3.1	21.2	8.4
NWT	213.15	48.3	164.9	152.1
SRN	-0.39	11.4	-11.8	-24.5
SVH	-29.67	6.2	-35.8	-48.6
SWB	5.87	-1.6	7.5	-5.3
TMS	-127.95	-12.7	-115.3	-128.1
WSH	46.19	30.1	16.1	3.4
WSX	-58.49	0.6	-59.1	-71.9
YKY	145.78	13.0	132.8	120.0
Total	**202.86**	**75.19**	**127.67**	**0.00**

4.4.11 The adjustment to UUW's claim as a result of these calculations is illustrated in Figure 20.

Figure 20 - Adjustment to UUW allowances



4.4.12 An adjustment to the model suite will not be sufficient for UUW to achieve Ofwat's upper quartile target.

4.4.13 As we stated in section 2.1.7., we do not consider that this amount is sufficient to hit Ofwat's upper quartile target for internal sewer flooding. The cost models allocate historical expenditure. However, no company with UUW's characteristics (high levels of urban rainfall, high prevalence of combined sewers) has achieved performance consistent with Ofwat's upper quartile target. This means that the costs of hitting the upper quartile target are not present within the historical dataset and therefore cannot be allocated by the cost models even if a factor reflecting urban run-off and combined sewer is adopted. This is why we consider the most appropriate outcome is for an environmentally adjusted PCL for internal sewer flooding.

4.4.14 Furthermore, this proposed cost adjustment is wholly independent of the enhancement investment proposed through the WINEP to reduce overflow spill frequency from our current level (which reflects compliance with existing permits). It also does not support Ofwat's proposed 2025 target of an average of 20 spills an overflow. A 2022 update of the EDM return data set out in our Future Ideas Lab paper 'Storm Overflow Incentives for PR24'[22], shows that only 21% of spills from overflows identified as spilling over the Storm Overflow Assessment Framework (SOAF) thresholds of >60x annually are due to operational and maintenance issues (Table 5), with the remainder being due to hydraulic capacity. Meeting such a target is therefore entirely unachievable from base expenditure and will require large-scale investment in storage and rainwater management solutions through successive WINEP programmes.

[22] UUW (2022) *Storm overflow incentives for PR24.* Available here

Table 5: 2022 Overflow performance by company. UUW has the joint highest percentage of spills (79%) that are due to hydraulic capacity. Addressing such spills will require large-scale enhancement investment in storage and rainwater management solutions. Note: Percentages do not always add up to 100 as the table does not show instances where the root cause is listed as N/A. Source: EA EDM Annual Returns. Available here.

Source		WSX	ANH	TMS	SRN	NES	WSH	SVT	SWB	UUW	YKY	Total /average
Table 1	Total no. storm overflows listed in the annual return 2022	1300	1552	777	978	1564	126	2466	1342	2254	2221	14580
Table 1	Average no. spills per storm overflow with spill data in 2022	18.5	15.3	17	17.8	20.3	23.3	18.4	28.5	35.1	25.6	21.98
Table 2	Total duration (hrs) of monitored spill events in 2022	129957	89514	74693	146819	107536	9470	249116	290271	425491	232054	1754921
Table 5	Of those that spilt over SOAF thresholds of >60x in one year, what % is due to operational?	44%	48%	39%	0%	9%	0%	1%	11%	21%	26%	20%
Table 5	Of those that spilt over SOAF thresholds of >60x in one year, what % is due to hydraulic capacity?	13%	17%	58%	0%	79%	0%	38%	55%	79%	69%	41%

5. Cost efficiency

5.1.1 Our claim valuation includes both a catch-up and frontier shift efficiency challenge

5.1.2 As set out in section 4.4, our claim value is derived using a modelled approach. This approach draws upon the framework implemented by Ofwat during PR19 to derive efficient cost allowances, namely generate allowances from econometric models based upon companies' data and then apply a catch-up and frontier-shift efficiency challenge. This process is set out in Table 6. This table also reproduces the adjustments set out in Table 4 in Section 4.4 to demonstrate how the gross claim value is adjusted to account for the implicit allowance and to force the symmetrical adjustment to zero to arrive at the net claim value of £152.6 million.

Table 6 - The effect of the catch-up and frontier-shift efficiency challenges

	Triangulated wholesale allowance, pre-efficiency	Upper quartile catch-up challenge	Frontier shift challenge	Efficient allowance
Ofwat's base comparator model suite (excluding SWC4-6 and WWNP5-8)	2,244	-38	-36	2,170
Introduce interaction term between urban rainfall and combined sewers	2,442	-19	-40	2,383
Gross claim value	198	19	-4	213
Implicit allowance				48
Gross claim value minus implicit allowance				165
Force symmetrical adjustment to zero				13
Net claim value				**152**

5.1.3 This demonstrates that the gross adjustment is post-efficiency challenges so is efficient, as per Ofwat's PR19 cost assessment framework. We have supplied the supporting documentation and files that generate the claim value alongside this document.

5.1.4 Table 4 in Section 4.4 demonstrates how the gross claim value is adjusted to account for the implicit allowance and to force the symmetrical adjustment to zero to arrive at the net claim value of £152.6 million.

5.1.5 We have used the following assumptions for the catch-up and frontier-shift efficiency challenges:

- **Catch-up efficiency challenge.** We have implemented an upper quartile catch-up challenge. The catch-up challenge relies upon a spread of residuals around the line of best fit estimated by the model. This means that when the catch-up challenged is strengthened, it becomes increasingly influenced by a smaller number of outlier observations. This increases the risk that the catch-up challenge is subject to statistical noise or bias i.e. the benchmark company may be one that is subject to particularly benign regional operating circumstances. As such, we consider the upper quartile is the maximum catch-up challenge that should be considered in cost assessment. The CMA concurred with this view in its redetermination: *"We decide that the upper quartile is the appropriate level of the efficiency benchmark. This balances our objective of setting a challenging benchmark while acknowledging the limitations of the econometric modelling (and the consequent risk that the company will have insufficient allowed revenue)."*[23]
- **Frontier-shift efficiency challenge.** We implement a slightly stronger challenge than the mid-point of the range Economic Insight identified in a study[24] it carried out on behalf of a consortium of

[23] CMA (2021) *Final Report*. Available here.

[24] Economic Insight (2023) *Productivity and frontier shift at PR24. Available here.*

companies. The range identified by Economic Insight was 0.3% to 0.7%, meaning the mid-point is 0.5% per year. We consider that the mid-point is justified because the frontier shift estimate produced by EU-KLEMS data is potentially subject to both upwards and downwards bias. There is a risk of downwards bias (i.e. the estimate being too low) due to question marks over the extent to which embodied technical change is reflected in the estimate. There is a risk of upwards bias (i.e. the estimate being too high) due to the presence of catch-up efficiencies within the EU-KLEMS data, the presence of which would produce a double count in the catch-up efficiency challenge. However, there is no robust way to quantify these opposing factors. Therefore, we consider the mid-point to be an appropriate and pragmatic estimate for frontier shift. We do not net off any Real Price Effects (RPEs) against the frontier shift challenge. We added an additional stretch to the mid-point to reflect the uncertainty inherent in estimation of the frontier shift, resulting in an overall frontier shift challenge of 0.55% per year.

5.1.6 In addition to these explicit efficiency challenges, we are also subject to a number of implicit efficiency challenges. Section 4.1 of this claim sets out the regional factors that impact on the costs and performance. However, this claim only relates to the impact of urban rainfall and combined sewers. Therefore, the effect of the other regional factors act as a source of implicit efficiency challenge.

5.1.7 Third party assurance of our claim value

5.1.8 We have sought external assurance from PwC for the methodology and information used to derive our claim value. An extract from PwC's report is provided below.

"As a result of the work performed, we can conclude that management has developed a detailed and logical methodology for producing each cost build and the approach followed to develop the cost estimates appears robust. We have undertaken detailed walkthroughs to understand the source of the cost data and rationale for assumptions and estimates made. We have not identified any priority actions which require attention in advance of the submission."

6. Need for investment

6.1.1 As we are requesting an adjustment to our cost baselines and not proposing discrete investment/interventions, we do not consider this section applicable. Indeed, in their Final Methodology Ofwat state *"But need for investment… may only be required for specific cost adjustment claims (e.g. a large, atypical investment which may not be included in our cost baselines)".* We do not consider this claim to be an atypical investment. Ofwat also deemed the equivalent section to be N/A during its PR19 Final Determinations for this reason:

Assessment gates

Need for investment	N/A	Adjustment to cost baselines.

7. Best option for customers

Note: We do not expect all of Ofwat's questions for this assessment gate to be directly relevant to the case, as this claim pertains to an adjustment to cost baselines to reflect ongoing operation and maintenance costs rather than discrete interventions. Indeed, Ofwat also determined this assessment gate to be 'N/A' during the PR19 Final Determinations for this reason. However, we choose to use this section to reflect our preferred hierarchy of options for reflecting exogenous factors, as well as provide justification for why a one-off claim for system reconfiguration was discounted.

7.1.1 Customer research demonstrates that sewer flooding performance is a key priority for our customers. We are therefore committed to stretching ourselves to the limits of what is achievable within the constraints imposed by our unique operating circumstances. In the first instance, we therefore consider that PCLs adjusted for a region's operating circumstances are the most appropriate way to achieve this while limiting impact on customers' bills (this is set out in Appendix A). If, however, Ofwat rejects our proposal for an environmentally adjusted PCL, then this cost adjustment claim will ensure UUW's cost allowances better reflect the challenging operating environment we face for managing drainage services.

7.1.2 UUW recognises that internal sewer flooding is one of the worst service failures that customers can experience. Indeed, qualitative joint research conducted by CCW and Ofwat shows that any type of sewer flooding has a significant negative impact on customers irrespective of severity, with feelings of stress, anxiety, hopelessness and disempowerment reported by customers[25]. UUW's own customer research into sewer flooding experiences further confirms the scale of the long-term psychosocial impact of flooding[26].

7.1.3 We are therefore committed to stretching ourselves to the limits of what is achievable within the constraints imposed by our unique operating circumstances. It is for this reason that we propose that the PCL for internal sewer flooding is set at the maximum level of performance modelled to be achievable within the constraints imposed by our unique operating circumstances (i.e. at the frontier level of performance predicted by our sewer flooding PCL model). While this represents an extremely stretching position, we believe that it is possible to achieve this level of performance economically without the need for a further uplift to the modelled **botex** allowance. In this way, we can limit the impact to our customer's bills.

7.1.4 Furthermore, we consider that PCLs adjusted for a region's operating circumstances present the best outcome for customers of all WaSCs. Ofwat's existing approach of setting common PCLs for sewer flooding distorts incentives between companies, leading to suboptimal outcomes for customers. In our PR24 business plan submission, we will therefore recommend an environmentally adjusted PCL for internal flooding for all WaSCs. In this way, all companies receive a challenge that is as equally stretching, meaning that customers across the country are paying for an equivalently efficient and stretching level of service. UUW therefore considers that environmentally adjusted PCLs are the best option for customers nationally. Appendix A sets out more detail regarding how UUW considers the regulatory framework should be adjusted to adequately reflect the influence of exogenous factors and thereby provide the best outcome for customers of all WaSCs.

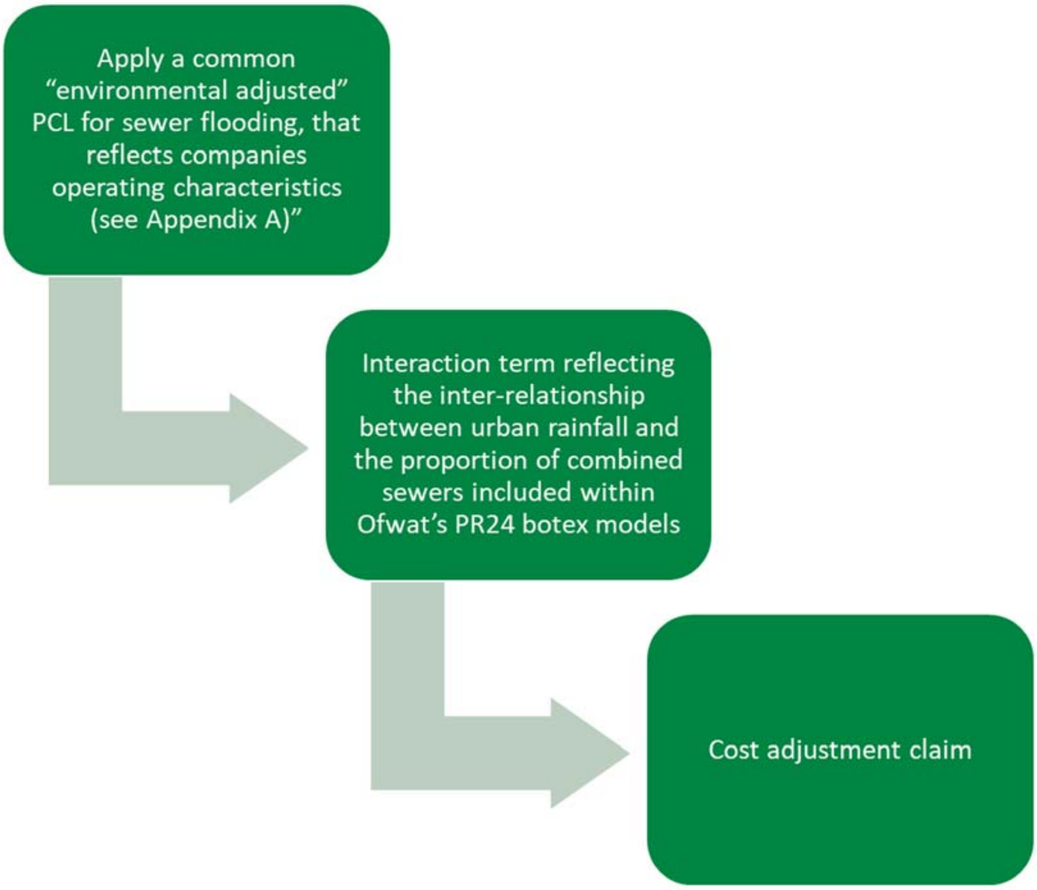
7.1.5 If, however, our PCLs are not adjusted for our unique operating circumstances (Figure 21), we have presented compelling evidence to demonstrate that UUW will incur higher costs that reflect the challenging environment in which we are managing drainage services. We consider the next most appropriate outcome for customers would therefore be for an interaction term reflecting urban rainfall and combined sewers to be included within all sewage collection and wastewater network plus models. We have made representations to this effect in our response to the PR24 Econometric Base Cost Models

[25] Ofwat (2022) *Customer experiences of sewer flooding: A joint report by CCW and Ofwat.* Available here.

[26] UUW (2021) *Sewer Flooding Experience.* Available here

Consultation. If this does not occur, we consider this cost adjustment claim to be the next best option for customers.

Figure 21 - In developing the best option for customers, we considered a range of options for how the exogenous circumstances at play within companies' operating regions could be accounted for.



7.1.6 In the short to medium-term, if our proposal for an environmentally adjusted PCL for internal sewer flooding is not accepted, we consider this claim to be the most appropriate option for customers, whilst our longer-term vision to reduce rainwater entering combined systems is enacted. In this way, bill impacts can be kept to a minimum.

8. Customer protection

8.1.1 This claim is proposing a more appropriate allocation of botex costs that better reflects the operating circumstances facing companies in delivering drainage services. As such this better protects customer in more favourable regions from overpaying for services, and protects customers in adverse regions from the risks associated with companies being underfunded for operating and maintenance activities.

8.1.2 Customers are also protected from partial or non-delivery of this investment through the many drainage related PCLs that will apply to companies during AMP8, including internal sewer flooding, external sewer flooding, storm overflows, total and serious pollution and sewer collapses.

8.1.3 Table 7 outlines how each of these performance commitments would be affected by failure to deliver the investment outlined in this claim.

Table 7: An outline of the performance commitments that provide protection if the investment is cancelled, delayed or reduced in scope

Performance Commitment	How Does this Protect Customers?
Internal Sewer Flooding External Sewer Flooding	The claim value includes both operation and maintenance costs allocated to 'sewage collection' activities, as well as an allowance for 'reducing flood risk for properties'. If UUW fails to deliver the expenditure set out within this claim, we can therefore expect to observe both FoC (flooding other causes) and hydraulic flooding incidents in areas where we would have otherwise avoided them. For example, additional properties that could have benefitted from flood mitigation measures may flood without this investment. This will be reflected in underperformance payments for those incidents.
Storm Overflows	While the majority of spills are caused by hydraulic inadequacy and can only be addressed by enhancement investment in storage solutions/hybrid interventions outside of the scope of this botex claim, this claim will support the ongoing maintenance and management of our existing storage availability. Underinvestment in this area will put at risk our ability to achieve the spill reduction performance that is expected to be delivered from our enhancement programme. If key storage assets cannot perform as designed, spill performance will deteriorate and will be reflected in underperformance payments for the 'storm overflows' performance commitment.
Pollution Sewer Collapses	While not direct drivers for this claim, these measures reflect the underlying performance of our asset base. If the additional botex is not spent on the operation and maintenance activities outlined in this claim, including sewer cleaning and structural assessments (serviceability), the benefits for these measures will not be realised and underperformance payments may be incurred.

Appendix A Challenges in wastewater service provision vary regionally

A.1 Two distinct services are provided within wastewater

First of all, as we stated, in our Future Ideas Lab paper[27], it is important for the cost assessment and performance framework to recognise the different services that companies provide, and to recognise the different factors that drive cost in providing those services. The wastewater value chain provides two distinct services:

- Foul sewage collection and treatment; and
- Surface water and highways drainage collection and treatment.

Each of these services is associated with different cost drivers and performance challenges. Importantly, the extent to which these pressures vary between company regions is also different – i.e. by reflecting the drivers of one of these services (e.g. within cost assessment) that does not automatically also reflect the regional differences impacting on the other service.

Characteristics of the foul sewerage service

Providing a foul sewage service requires the following elements:

- Companies must transport foul sewage through their network to a wastewater treatment works;
- Companies are expected to meet discharge permits at their wastewater treatment works; and
- Companies are required to treat and appropriately dispose of sewage sludge received from the wastewater treatment process, as part of their Bioresources activities.

Historically, cost assessment models have reflected the associated pressures within cost assessment e.g. through the use of a treatment complexity cost driver. PR19 models used a treatment complexity driver relating to ammonia and the same approach is proposed for PR24. Ofwat has also suggested it is considering how best to recognise the efficient higher ongoing costs associated with phosphorous removal, implemented as part of the AMP7 WINEP[28]. All these factors focus on cost differentiation within the wastewater treatment process alone – i.e. there is no differentiation in cost or performance assumed within the wastewater network.

Additionally, foul sewage is associated with relatively steady and predictable volumes, so it may be reasonable to assume that this service does not (in of itself) result in any differentiated impact within the wastewater network.

Characteristics of the surface water and highways drainage sewerage service

Providing a surface water collection and treatment service is fundamentally different to providing a foul sewerage service:

- Companies need to provide and manage network system capacity to deal with periods of high rainfall;
- Customer flooding in the upstream network can only be mitigated through appropriate operation and maintenance within the network assets. Where further operational interventions aren't possible/economic, companies are required to implement capital interventions such as cellar disconnections and schemes to increase capacity in targeted areas; and
- Companies are legally required to ensure storm overflows operate in compliance with permits.

Factors that impact on surface water costs and performance include rainfall that enters the sewer network (which varies between regions, both the volume of rainfall, and the scale of urban areas that are connected to the sewer

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

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

networks), and the proportion of combined sewers (which also varies significantly between companies) which are associated with a greater risk to service performance (e.g. sewer flooding)

Historically, cost assessment has not reflected the pressures associated with dealing with surface water. At PR19, we proposed that an "urban rainfall" driver be included within botex plus model suite but this was not adopted. Additionally, UUW's drainage-related cost adjustment claim was rejected.

At PR24, Ofwat is proposing to apply common performance targets for wastewater network performance measures. The next section demonstrates that regional pressures impact upon the ability of companies to provide a common service level.

A.2 There are significant regional differences between wastewater companies

The wastewater system is susceptible to environmental impacts. However, these environmental impacts affect the foul and surface water services in different ways.

The WINEP enables companies to achieve comparable performance for the foul sewerage service

Foul sewage is associated with regularly constant flows and these can be reasonably expected to be comparable on a per customer basis across the industry.

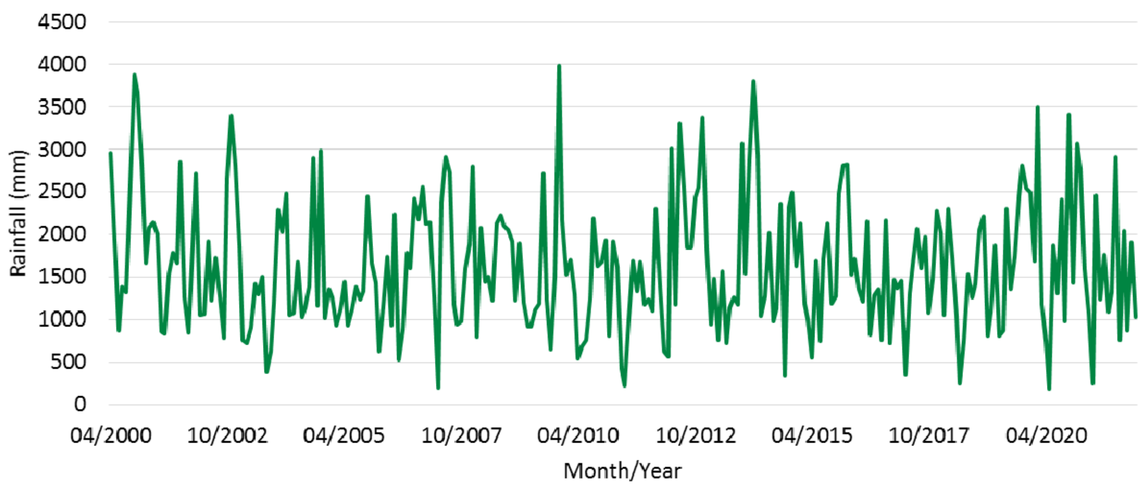
Additionally, improvements in the quality of foul sewerage provision are managed through the WINEP process. The WINEP places a statutory obligation on companies to meet better quality environmental standards and the regulatory framework ensures companies have sufficient enhancement allowances to move towards these better standards.

Once companies have invested sufficiently to meet these new standards, it is reasonable to have a common target for treatment works compliance. This is because the WINEP has enabled companies to make the company specific levels of investment required to meet compliance and hence to move towards and operate on a level playing field. As a result it is entirely appropriate to test and incentivise compliance in accordance with this level playing field i.e. through a common target.

There is no surface water equivalent of the WINEP to allow companies to invest sufficient to achieve equal levels of sewer flooding incidents

However, unlike foul sewage, the surface water service is associated with extremely variable volumes. This can clearly be seen in ***Figure 22***, which illustrates total rainfall across all areas of England and Wales since 2000.

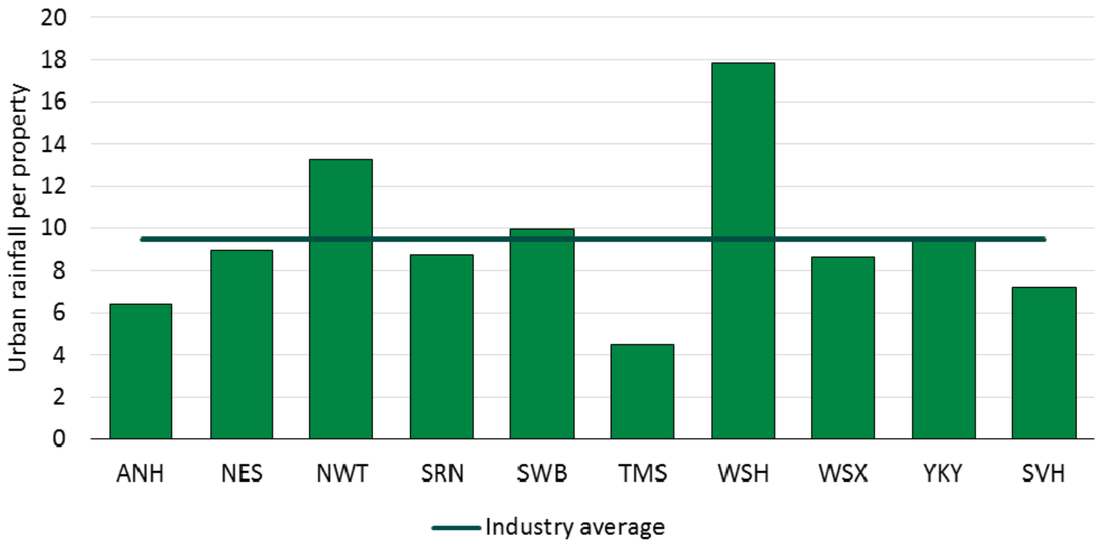
Figure 22 - Total monthly rainfall across England and Wales



Whereas foul sewerage is defined by consistent and predictable demand, a wide range of environmental factors impact upon companies' ability to deliver equal performance for the surface water service:

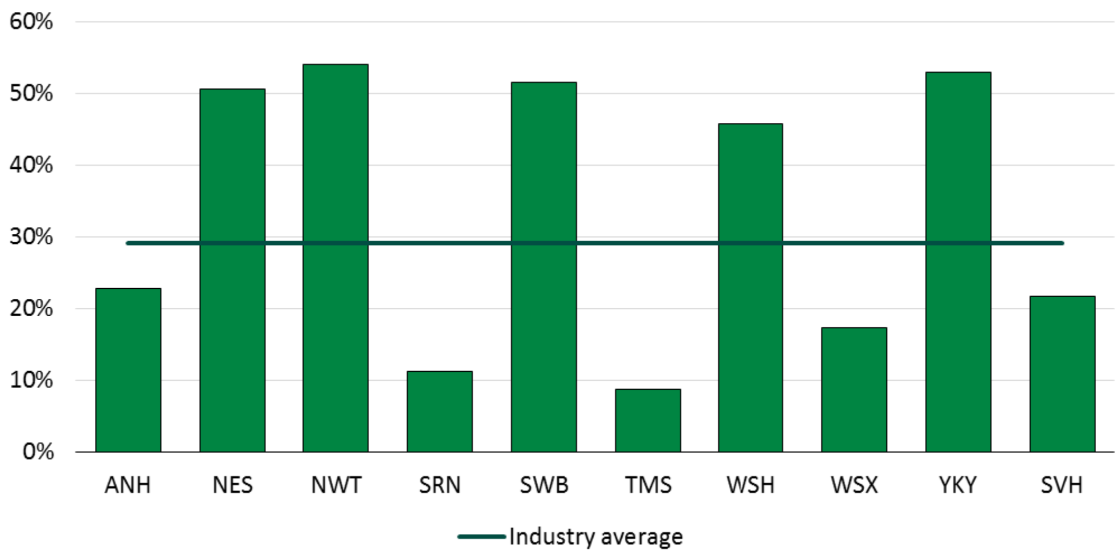
- Rainfall, but particularly urban rainfall because rainfall onto urban areas tends to be directed into the sewer system. ***Figure 23*** illustrates average urban rainfall per property over the period 2011-12 to 2021-22.
- The North West is clearly significantly above average. We also note that the value for Wales may be overstated due to the apparent difference in classifying the "urban areas" between England and Wales (see appendix B)

Figure 23 - Average urban rainfall per property (2011-12 to 2021-22)



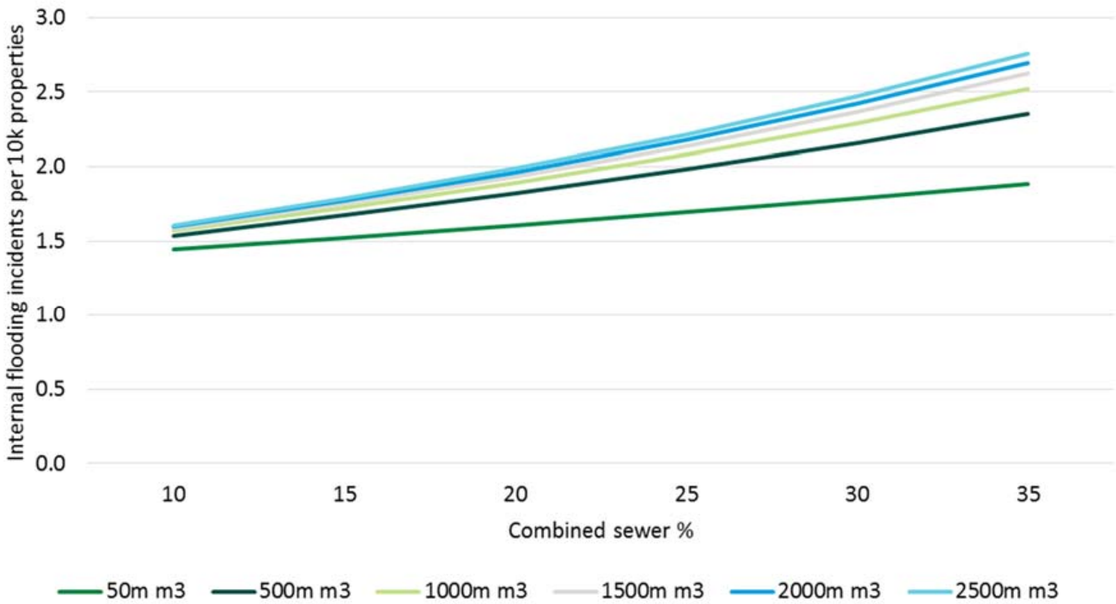
Combined sewers convey both foul sewage and surface water sewage. This means that the hydraulic capacity within combined sewers is very sensitive to periods of rainfall. Indeed, in our experience, the key challenge in operating and maintaining combined sewers is the large, and often rapid, change in flow. Managing large variations of inflow into drainage and sewerage networks leads to a need for significantly larger network and storage assets, if they are to support the same level of sewer flooding incidents as separated sewer systems. Combined sewers tend to be legacy assets, inherited at privatisation. Whereas surface water only sewers are able to convey urban run-off to a nearby watercourse, combined sewers must transport sewage to a treatment works. ***Figure 24*** shows the average prevalence of combined sewers as a percentage of the 'legacy' network.

Figure 24 - Combined sewers as % of legacy sewers (2011-12 to 2021-22)



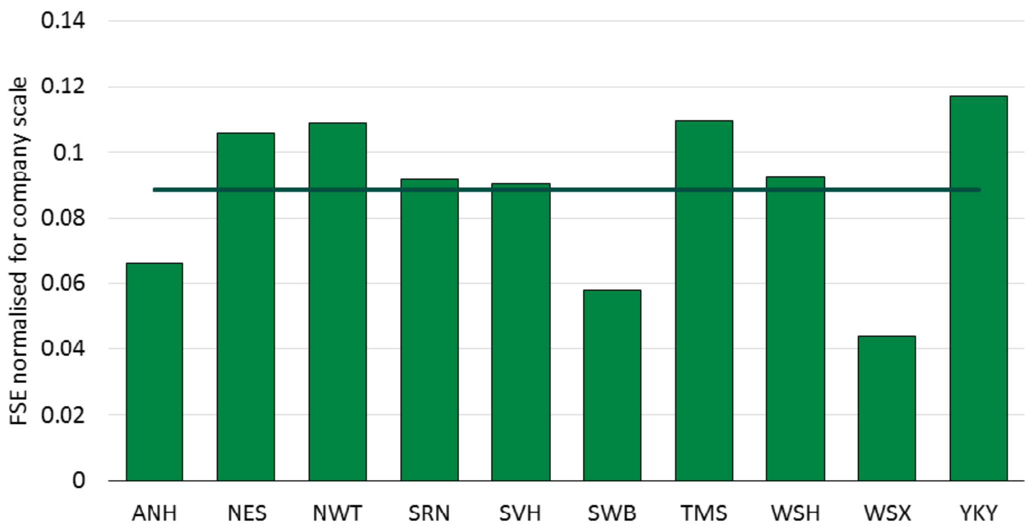
As stated above, urban rainfall can lead to rapid, material swings in the hydraulic capacity of combined sewers. Urban rainfall effectively reduces the capacity of combined sewers relative to an equivalent separated system that carries foul and surface water in separate pipes. In dry weather, this is 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. This engineering prior is borne out by industry level data. ***Figure 25*** illustrates the relationship between combined sewer prevalence and internal flooding incidents, conditioned on urban rainfall. It's clear that the negative impact of combined sewers on internal flooding incidents increases as the volume of urban rainfall in a region increases.

Figure 25 - A high prevalence of combined sewers makes the impact of urban rainfall worse



A number of other factors can also act to increase the risk of blockages. For example, a high Food Service Establishment (FSE)[29] density is associated with a higher incidence of fats, oils and greases being introduced into the sewer network and leading to blockages and other operational issues, which further impacts on sewer flooding performance. Similar issues can be caused by a high property density, as a higher density of people increases the risk that unsuitable items are introduced into the network. ***Figure 26*** uses data published by Public Health England to demonstrate the relative density of FSEs across the industry.

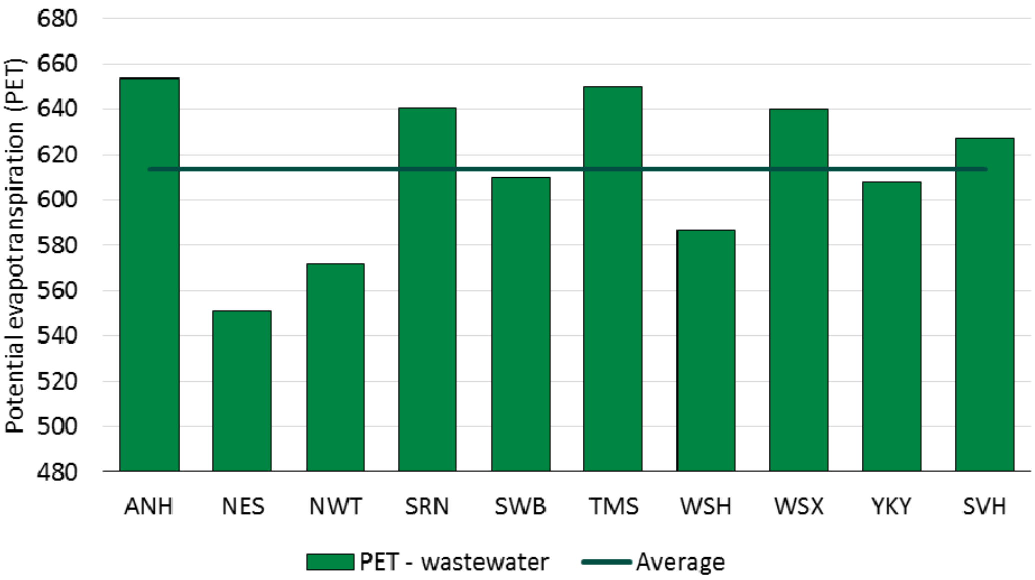
Figure 26 - Food Service Establishment density across the industry



[29] Loosely defined as takeaways.

Potential evapotranspiration (PET). PET is a measure of the rate of the maximum potential loss of water via evaporation from the land surface and transpiration by plants. A low PET means that less water is being lost from the system via these routes and therefore a greater proportion of surface runs overland into the sewer network (and UUW has a particularly low PET score). Relative PET across the industry is illustrated in ***Figure 27***.

Figure 27 - Potential evapotranspiration across the industry



As the preceding analysis shows, these environmental factors vary significantly across the industry, which will impact upon companies' ability to deliver equal levels of performance – in particular, it is clear that UUW operates in an area of high urban run-off, high proportion of combined sewers, high levels of food service establishments, and a low PET score – all of these factors combine to make it impossible for UUW to achieve an equivalent level of sewer flooding incidents as companies that operate in areas that are more favourable for surface water drainage. The only way this would be possible would be to invest billions of pounds in surface water disconnection – we believe this would be inefficient, a view supported in the Government's Strategic Policy Statement, which did not consider complete separation of surface water to be a viable economic option[30] .

Historically, the regulatory framework has allowed expenditure to improve the surface water service in two way

- Moving UIDs back into compliance with existing permits (i.e. without any specified maximum spill frequency) – however, this investment has been downstream, and does not provide any reduction in sewer flooding risk; and
- Some marginal improvements to sewer flooding, but this has not been sufficient to move companies to equivalent levels of service. As we discuss later, for UUW to achieve a simple upper quartile level of sewer flooding incidents would require very significant levels of investment.

This demonstrates that there is no WINEP equivalent for the surface water drainage service that would allow companies to i) move towards; ii) operate on; and iii) be measured against a level playing field for sewer flooding incidents.

Furthermore, we do not agree that setting company targets based on a simple upper quartile of flooding incidents between companies is targeting an equivalent level of performance. It is, in fact, setting an unachievable level of performance for some companies, whilst setting a relatively easy target for others.

[30] UK Government (2022) *Storm overflows discharge reduction plan.* Available here.

It's clear that performance/compliance is facilitated and measured differently across foul and surface water services.

For the foul service, company specific investment requirements to achieve service quality are facilitated and funded via the WINEP process and botex is then assumed to be sufficient to maintain performance in line with existing service quality at each company. A cost driver is typically included to account for differences in treatment complexity.

Performance and compliance is then measured by reference to the permit level i.e. companies are penalised if they are not compliant with the performance level facilitated by the WINEP. Additionally, the average performance level against which companies are measured will vary, depending upon the requirements set out in that companies' WINEP.

In contrast, in the surface water service, while (historically) the WINEP process has enabled companies to address unsatisfactory overflows, the intention of this has not been for it to enable companies to achieve comparable service levels – neither flooding incidents, nor overflow spill frequency. In effect, the current framework is asking companies to go further, and achieve a common industry target for performance both downstream (overflows) and upstream (sewer flooding) without any recognition of the investment that would have been required to achieve that equivalent service level. There has been no surface water WINEP driver to identify and recognise the investment required to achieve an equal level of customer flooding incidents, or (historically) to achieve an equal level of spills from overflows.

A.3 The implication of a common target on sewer flooding and overflows

The factors set out above will require that 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.

These are clearly significant infrastructure requirements, which would cost a substantial amount to deliver and would, by nature, be extremely disruptive to local residents. Conversely, 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.

For overflows, the AMP8 (and beyond) WINEP programmes will be aimed at identifying the company specific investment requirements to achieve the long term common spill frequency targets. However, each company will have its own company specific trajectory of spill frequency reduction, from the modelled level of expected spills achievable by their existing assets.

Also, given the Government's Strategic Policy Statement did not consider complete separation of surface water to be a viable economic option[31], spill frequency reductions will mostly be achieved via increases in downstream storage. Whilst this will reduce overflow spill frequency, it will not support any improvement in sewer flooding risk in the upstream network. Therefore the different challenges faced by companies in achieving a common level of sewer flooding incidents will remain.

This difference in the relative challenges faced by companies in achieving a common level of sewer flooding incidents was generalised and set out in more detail in our FIL paper[32]. We established that the investment required to achieve a common level of flooding incidents (adjusted for scale) would be excessive, and therefore the most efficient way to manage the impact of companies facing different environmental challenges would be to set sewer flooding targets in a way that also normalised for the impact of some of those environmental factors

[31] UK Government (2022) *Storm overflows discharge reduction plan.* Available here.

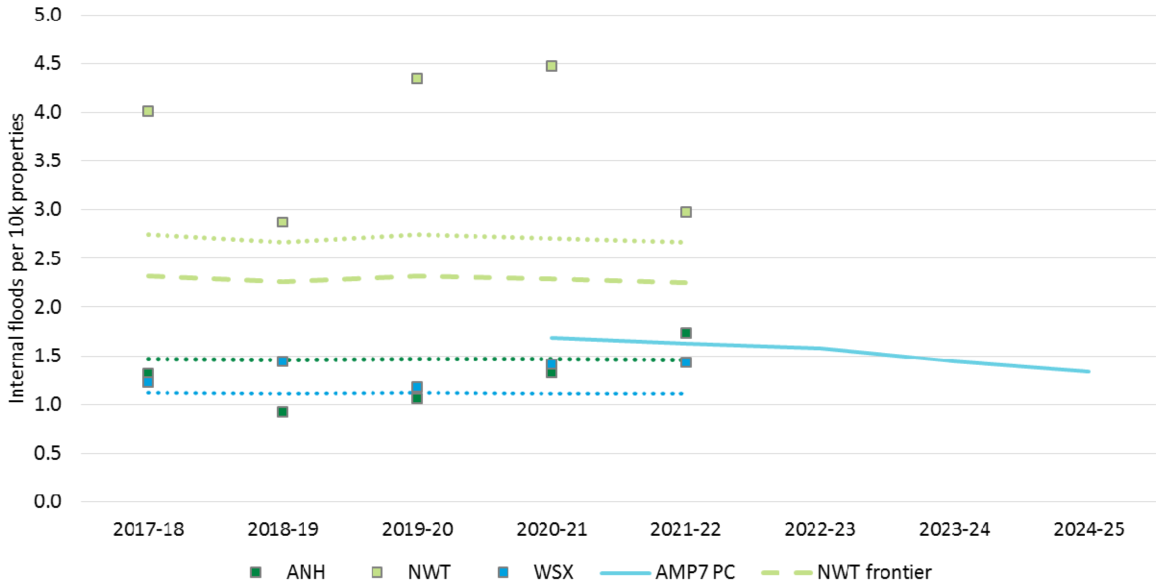
[32] UUW (2022) *What lessons can we learn from cost assessment at PR19?* Available here.

(notably urban run-off, combined sewers and food service establishments). In our view, such a normalisation is warranted because (a) there has been no prior mechanism (e.g. WINEP) to support companies to invest in sewer network assets in a way that enables common flooding incidents to be achieved, and (b) the cost of doing so would be excessively prohibitive (as recognised in the Government's Strategic Policy Statement, which did not consider complete separation of surface water to be a viable economic option[33]).

Using normalisations in setting performance targets is already applied extensively, in normalising for company scale. It is therefore justifiable for other normalisations to be used, to ensure that service performance targets are set on a common basis for all companies, in a way that ensures that targets are equally stretching for all companies operating in different regions and facing different challenges in achieving those performance levels.

This impact of this is illustrated in ***Figure 28***. The dotted lines indicate the performance predicted by our internal sewer flooding performance model[34] for each company, overlaid with the PR19 upper quartile target for internal sewer flooding. Actual performance is denoted using the square dots. It's clear that Wessex and Anglian are predicted to achieve a lower level of incidents than the PR19 upper quartile, and they do in fact outperform this target in most years. In contrast, UUW does not hit the common target in any year. Furthermore, the frontier level of performance for UUW is above the common target. This suggests that UUW's regional characteristics make it impossible for UUW to achieve the level of performance required by the PR19 common target.

Figure 28 – The PR19 upper quartile target for internal sewer flooding is beyond the modelled frontier for a company with UUW's regional characteristics



A.4 Equivalent performance is not possible for companies in different regions

The PR19 approach of setting a common target for wastewater network performance measures suggests that equivalent numbers of flooding incidents equates to companies having equivalent performance, regardless of companies operating in areas with very different regional characteristics. However, in reality, achieving a level playing field will require substantial infrastructure investment. It cannot be achieved through simple changes to operating models.

On overflows, due to the factors listed above, UUW will need to invest billions of pounds to achieve performance levels on overflows currently being achieved by some companies that are operating in more benign

[33] UK Government (2022) *Storm overflows discharge reduction plan.* Available here.

[34] This model was first developed within our FIL paper referenced above. We will submit an updated version as part of our business plan submission.

environments. Because of this, we consider that Ofwat should recognise that it is appropriate for UUW to have a company-specific trajectory to the long-term spills target of 10, with other companies in more beneficial circumstances having their own trajectory.

On sewer flooding, further billions of pounds of investment would be required in order to achieve an equivalent level of sewer flooding incidents to companies in more benign regions. We consider that the lack of a legal requirement for sewer flooding means that this level of expenditure and the associated disruption would be uneconomic and not in the best interests of customers. For this reason it would be more appropriate to modify the way that common performance levels are set for sewer flooding, to normalise for the key factors that impact on the level of flooding incidents.

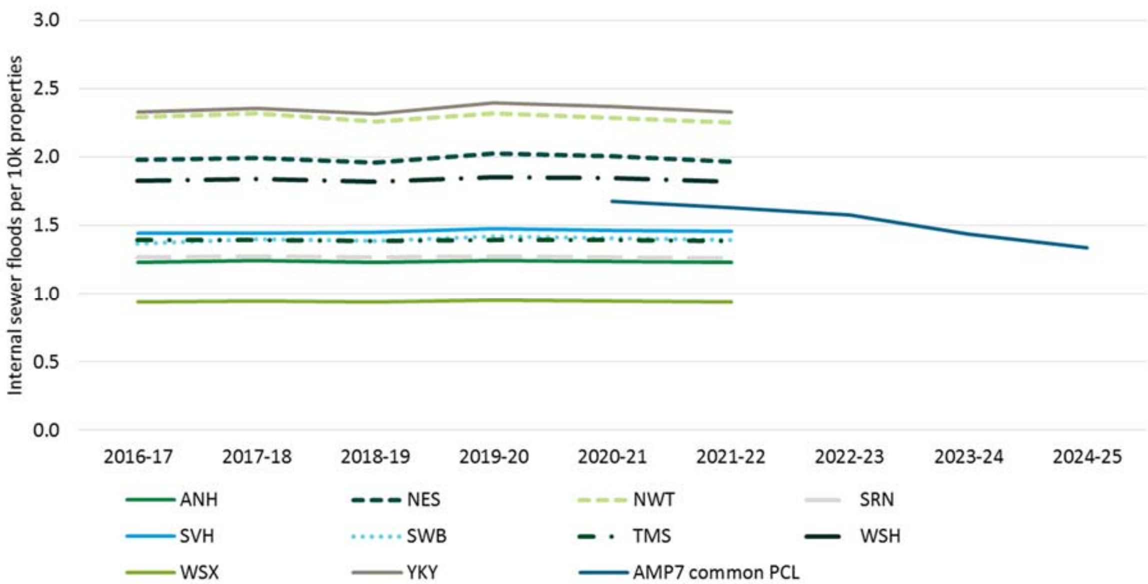
A.5 A company-specific target is the most appropriate solution

Given the preceding discussion, we consider that the most appropriate solution is to set sewer flooding targets in a way that normalises for certain environmental factors, as well as normalising for scale. We are not seeking a company specific "easier target", but we are seeking for Ofwat to apply "environmentally normalised" (i.e. not just normalising for scale) sewer flooding targets to better reflect the different environments in which companies operate, so that they better reflect what is equally achievable and equally stretching for each company. We summarise our proposals below, but we will explain the proposed adjustments in more detail in our business plan submission.

An environmentally normalised target will prevent companies in less challenging areas benefitting from relatively achievable targets, and enable companies operating in more challenging environments to compete on a level playing field of performance.

We propose that sewer flooding targets are established using an econometric model that reflects scale, urban run-off, combined sewer and food service establishments (as set out in our FIL paper[35]). Figure 29 illustrates predicted frontier performance for each company relative to the PR19 AMP7 internal sewer flooding target. It's clear that some companies will find the PR19 common target comparatively easy to achieve, while for others this level of performance is impossible. This disparity in performance stretch is due to the environmental factors set out in section A.2.

Figure 29 – The PR19 common AMP7 PCL is relatively easy to hit for some companies while for others, the common target is not achievable



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

It is important to make clear that an environmentally normalised target is not letting companies off the hook for bad performance because performance must be considered relative to the operating area. Ofwat already implicitly recognises this because it normalises the target for company scale. Indeed, as ***Figure 29*** demonstrates, a common target is also letting companies in benign regions off the hook with a relatively easy to achieve target.

Additionally, as the EA makes clear, weather has a noticeable impact upon surface water drainage related performance: *"The 2022 EDM data shows a decrease in spills, which reflects last year's drier than average weather"*[36].

As set out, regional characteristics make it impossible to achieve the equivalent incidents target without substantial infrastructure investment. An environmentally normalised PCL ensures that incentives to outperform are equal across all companies. It will reflect a reallocation of effort such that the overall target is equally stretching for all companies.

Our preference is for environmentally normalised performance targets which reflect differences in regional operating circumstances between companies

While the preceding discussion is based upon objective facts, we recognise that Ofwat may be minded to reject an environmentally normalised PCL. If this this case, then it is important that there is a suitable adjustment to our costs. However, it is important to recognise that this adjustment would still be insufficient to hit a simple UQ common target. This is because a cost allowance based upon backwards-looking information wouldn't reflect the extent of intervention of investment that would be needed in adverse operating regions.

For example, surface water separation would require the extensive replacement of the combined sewer network. However, as ***Figure 30*** shows, no company has carried out a sustained and significant programme of reducing the prevalence of combined sewers. The data suggests that the length of combined sewers is actually slightly increasing over time.

Figure 30 - Industry average rate of change in combined sewers in historical dataset

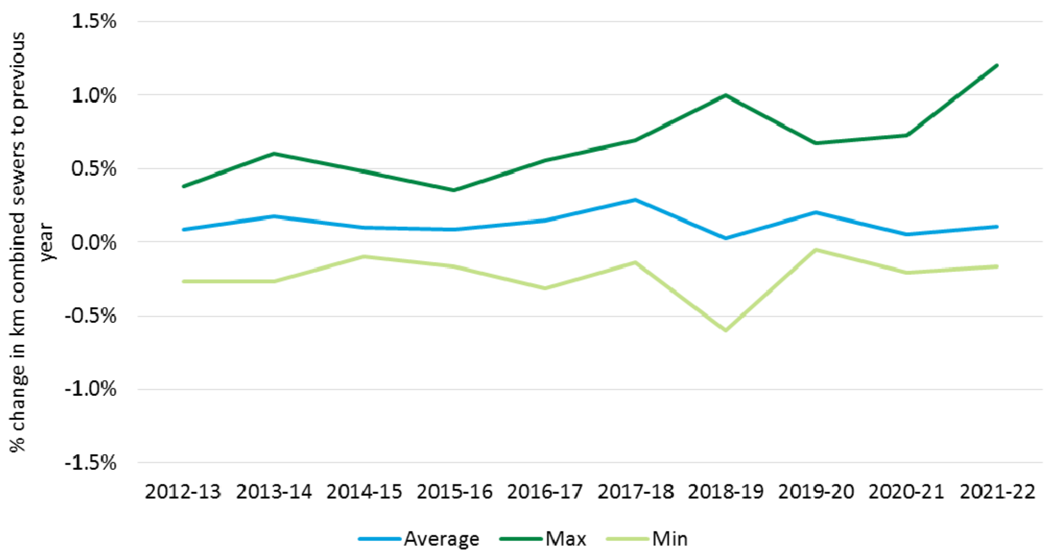


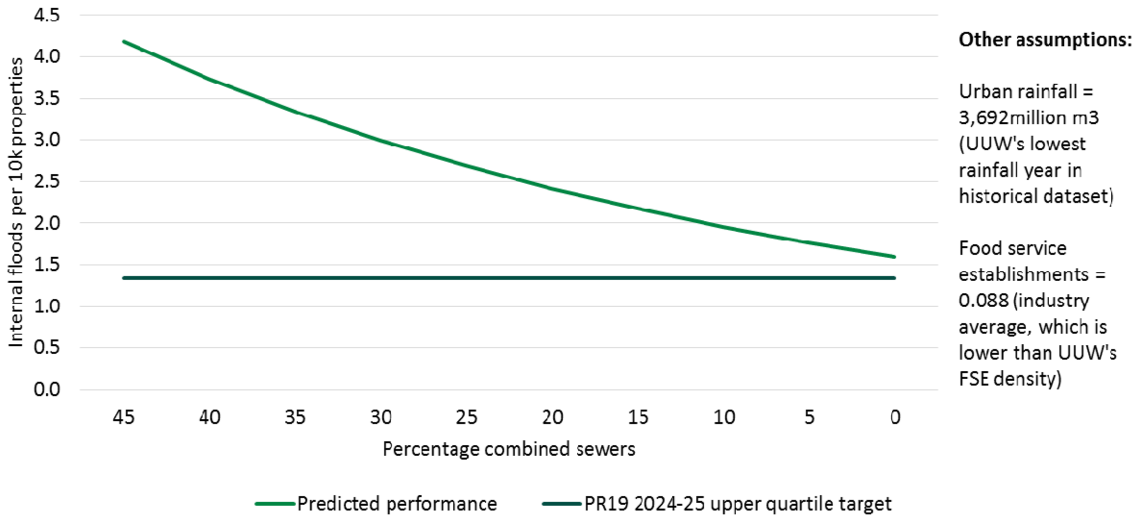
Figure 31 uses the relationship predicted by our internal sewer flooding performance model to analyse what happens to performance when the prevalence of combined sewers is reduced. It's clear that removing combined sewers is expected to have a positive impact upon performance. However, as ***Figure 30*** demonstrates, there is no evidence in the historical record of this scale of combined sewer removal.

This means that while a cost uplift would provide some support in managing the higher cost of operating in a more adverse environment, it still cannot be expected to enable companies to achieve a simple UQ common

[36] EA blog. Available here.

level of performance, because it would constitute a relocation of historical costs. As ***Figure 30*** demonstrates, the lack of relevant activity means that these costs will not be reflected in the historical cost record.

Figure 31 - How reducing the prevalence of combined sewers moves UUW towards the common target



This means that facilitating a move towards equal flowing incidents will require a substantial uplift to the backwards-looking benchmark. Additionally, such a move will involve activity that would be extremely disruptive to our customers and the local economy. This was recognised in the Government's Strategic Policy Statement, which did not consider complete separation of surface water to be a viable economic option[37].

A.6 Conclusion and recommendations

It is clear that a number of exogenous regional factors drive relative wastewater network performance across the industry. The influence of these factors means that it would not be economic to reflect these factors by making adjustments to cost allowances in PR24, unless there is a clear legal driver.

Our Future Ideas Lab paper[38] provides a clear framework by which Ofwat can set an environmentally normalised performance target for sewer flooding. These environmentally normalised targets will ensure that all companies operate on a level playing field and customers do not pay for the uneconomic levels of investment required to achieve equal performance on non-statutory measures.

However, if this option is not adopted, then UUW considers the interaction term, representing the combined impact of urban rainfall and combined sewers, should be added to all relevant econometric models. We do note that the lack of sustained and substantial flood mitigation activity within the historical cost record will mean that any reallocation of historical cost will always underestimate the efficient costs a company with UUW's characteristics would incur in achieving a common performance measure as stretching as that included within the PR19 FD.

If the performance targets are not appropriately adjusted (as we propose), then UUW will seek a cost adjustment to recover efficient additional costs. The cost adjustment claim set out within the main part of this document represents this option.

[37] UK Government (2022) *Storm overflows discharge reduction plan.* Available here.

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

Appendix B How urban areas are reflected within urban rainfall

B.1 Background

Urban rainfall results in run-off into the wastewater network, which increases the costs of operating and maintaining wastewater assets and has a detrimental impact upon aspects of performance. As a result, United Utilities strongly supports the use of an urban rainfall variable within cost assessment. We were greatly encouraged to see that Ofwat has developed an urban rainfall variable, building upon Arup and Vivid Economics' work during PR19[39]. We strongly support this positive development, which will result in a more robust cost assessment.

The urban rainfall variable has two key inputs, which are combined in the following way:

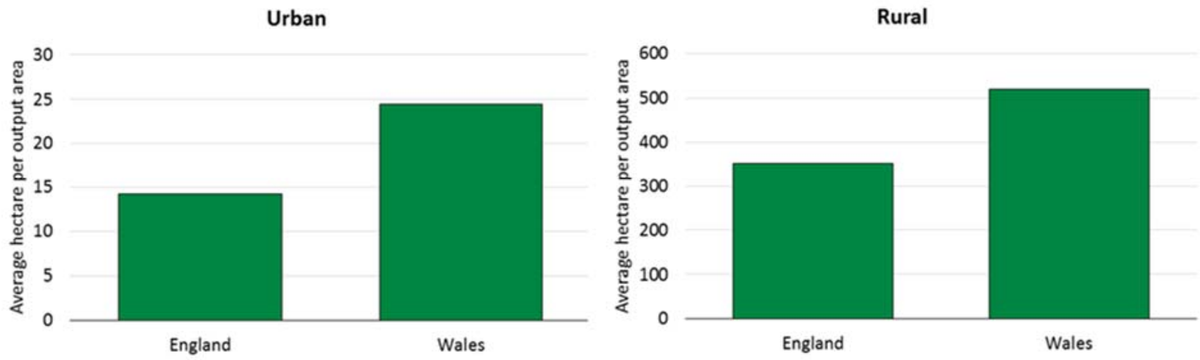
$$urban\ rainfall = rainfall\ \times urban\ area$$

We have closely examined Ofwat's methodology for calculating urban rainfall and consider that it is generally appropriate. We have, however, identified one particular aspect where we consider a slight bias is introduced into the calculation – in particular, how urban areas are reflected within the urban rainfall variable and possible methodological differences in how these are captured across England and Wales. In identifying this issue and possible ways to address it, we have drawn upon our previous work in this area, in particular Arup and Vivid Economics' work commissioned by UUW at PR19, our sewer flooding 'hackathon'[40] and submissions to Ofwat's Future Ideas Lab[41].

The systematic difference in the size of geographical areas can be seen from the average size of an output area in England and Wales, illustrated in Figure 32.

It's clear from this that the average urban area in Wales is larger. Given the calculation of urban rainfall scales with urban area, this shows that urban rainfall within Wales is likely overestimated to a degree, relative to urban rainfall in England.

Figure 32 Output areas are systematically bigger in Wales relative to England



To be clear, we are not seeking to discredit either the RUC or Ofwat's urban rainfall variable; the RUC provides a well-understood and well-established methodology that allows a wide variety of users to consistently compare population characteristics across different areas of England and Wales while the urban rainfall variable represents a pragmatic way to capture variances in urban run-off across the industry. Our overriding ambition for this appendix is not to criticise Ofwat's pragmatic approach to calculating urban rainfall but to note some possible

[39] Arup and Vivid Economics (2017) *Understanding the exogenous drivers of cost in England and Wales.* Available here.

[40] The 'hackathon' brought together a range of business experts, analysts and data scientists to explore the drivers of internal sewer flooding performance, using a wide range of internal and external datasets. We have previously presented the outcome of this work to Ofwat.

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

reasons as to why Welsh Water appears to have substantially larger volumes of urban rainfall relative to other companies and ask that any resulting comparative analysis be viewed in this context.

This appendix exclusively focuses on the 'urban area' element of this equation:

- **Section B.2 discusses the Rural Urban Classification (RUC)**, which is used by Ofwat to define the "urban area" element of the equation about. The ONS uses RUC to categorise geographic areas using physical settlement characteristics and we have examined the ONS's approach. This section highlights some methodological features of the RUC that mean it might not accurately reflect areas that drain to a wastewater company's assets.
- **Section B.3 presents some real-life examples of areas classed as "urban" by the RUC, but which comprise mostly undeveloped rural land.** We provide both quantitative and visual GIS analysis. This provides evidence that the methodological issues highlighted in Section B.2 are impacting upon the definition of urban conferred by the RUC.
- **Section B.4 demonstrates that while urban areas may be overstated as a whole across England and Wales, Welsh geographical areas appear to be systematically larger than English areas.** This would tend to overstate the level of urban areas in Wales relative to England. In turn, this would tend to overstate the level of urban rainfall in Wales relative to England.

B.2 The Rural Urban Classification

The Rural Urban Classification (RUC) categorises a range of statistical and administrative geographic areas on the basis of physical settlement characteristics. The statistical and administrative units range in size from the smallest (Output Area) to larger areas (like Local Authority Districts or Electoral Wards). The RUC was created by the Department of Town and Regional Planning at the University of Sheffield on behalf of a government working group and was designed to allow social and economic analysis to account for rural and urban areas in a consistent manner.

B.2.1 How the ONS classifies geography

In order to understand how the RUC works, we first need to understand how the ONS classifies and aggregates geographic areas within England and Wales.

The ONS has divided all of England and Wales into around 180,000 small geographic parcels known as Output Areas (OA)[42]. Output areas were introduced for the 2001 Census and are used to measure and compare population characteristics for different geographic areas. They were designed to have roughly similar population sizes (roughly 125 households), which means that less populated Output Areas may contain large areas of undeveloped land and/or be bigger geographically than others.

Figure 33 shows an example of Output Area boundaries. It's clear that there is substantial variation in the geographical size. The smaller Output Areas cover the northern edge of Bolton (a densely populated area), while the larger Output Areas cover the beginning of the West Pennine Moors (a sparsely populated area).

[42] ONS (online) *Introduction to Output Areas – the building blocks of geography.* Available here.

Figure 33 - Example of differences in the size of Output Areas

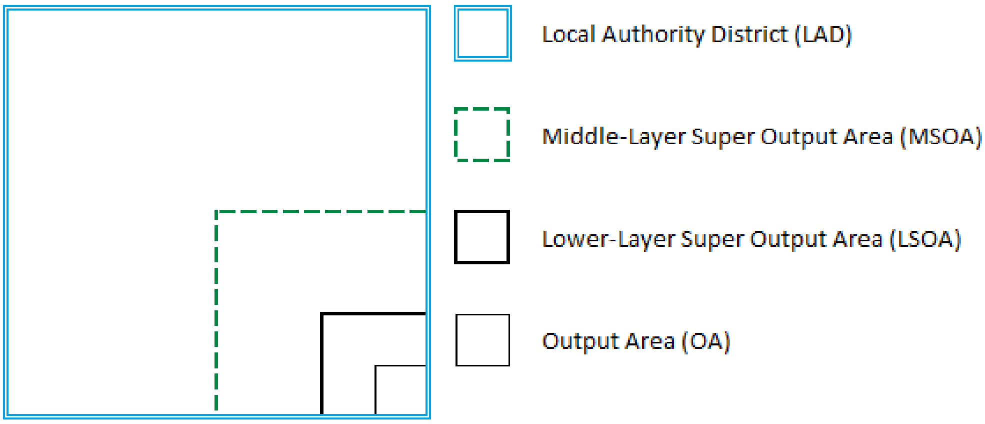
Output Areas are aggregated into larger geographic parcels:

- Several Output Areas can be aggregated into a Lower-layer Super Output Area (LSOA). These have roughly 650 households in them.
- The next largest parcel is known as a Middle-layer Super Output Area (MSOA). These have roughly 4,000 households in them.
- The next largest parcel is a Local Authority District (LAD), which can vary substantially in size.

The aggregation of an Output Area to larger geographic parcels (LSOA and MSOA) is determined algorithmically by the ONS.

Figure 34 is a stylised example of how these geographical parcels relate to each other. It's clear that an Output Area can be considered a building block of all other geographical parcels. Note that this example is illustrative only and not to scale.

Figure 34 - Stylised example of the geographical hierarchies used by the ONS (not to scale)



B.2.2 How the RUC classifies Output Areas as urban or rural

The RUC defines an Output Area as either urban or rural depending upon whether its population-weighted centre point sits within a built-up area where over 10,000 people live[43], where 'built-up area' is determined by the Ordnance Survey[44].

[43] ONS (2015) *The 2011 rural-urban classification for output areas in England.* Available here.

[44] ONS (2015) *2011 Built up areas – methodology and guidance*. Available here.

Note that the use of a population-weighted centre point means that Output Areas can cover a section of countryside but still be considered urban if the majority of the population lives in a built-up area. In this way, the RUC prioritises settlement type, rather than other elements of land cover[45]. This slight weakness is recognised by the RUC's creators: *"More critically in practice, RUC takes no explicit account of any aspect of the land cover typical of a statistical unit other than settlement"*[46].

B.2.3 Aggregating the RUC from an Output Area to larger geographical units

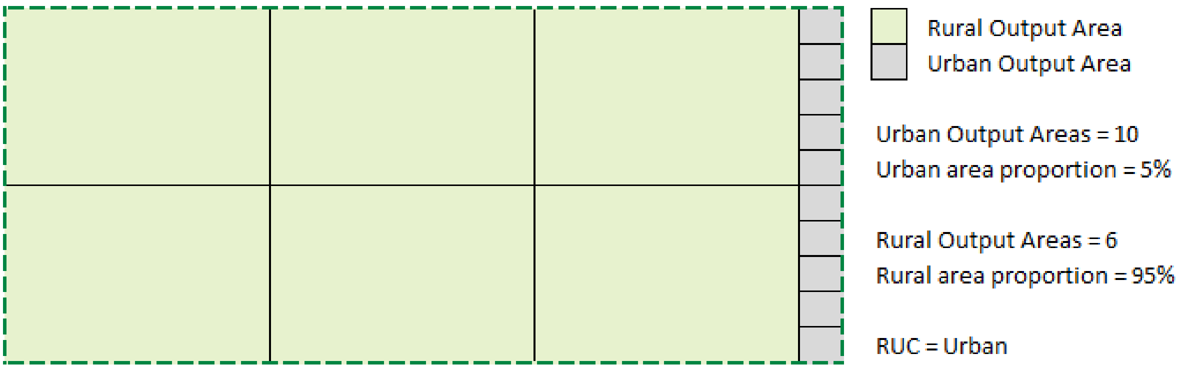
As set out in section B.2.1, a number of Output Areas can be aggregated to form an MSOA. Under the RUC, **whether this MSOA is classed as rural or urban depends upon whether a majority of its constituent Output Areas are rural or urban.**

At this point, it's important to note that as Output Areas are aggregated to higher geographic parcels, there is a corresponding loss in granular detail. We will return to the implications of this loss of granularity later.

We now present a stylised example of how this aggregation occurs in practice. We then hypothesise that this could lead to possible perverse results. Section B.3 will then present evidence that this has occurred in practice.

Figure 35 shows an example MSOA with 16 constituent Output Areas, six of which are considered by the RUC to be rural and ten of which are considered urban. The six rural Output Areas are larger because they are sparsely populated (as discussed in section B.2.1). Clearly, the majority of the MSOA's land coverage is rural. However, because there are ten Output Areas classed as urban and only six classed as rural, the entire MSOA is classed as urban.

Figure 35 - An MSOA classed as 'urban' despite most of its land coverage being 'rural'



This might be considered to be an extreme case. However, it is relatively easy to find real world examples of this happening and analysis of all MSOAs suggests that a significant proportion of their land cover is made up of rural Output Areas (we discuss this further in section B.3).

This means that using the RUC at an MSOA level for the purposes of deriving a measure of urban rainfall could overestimate the amount of urban rainfall in each region by overestimating the amount of urban area in each region. This is because applying RUC at the MSOA causes a loss in granularity. For example, under Ofwat's current approach of applying RUC at the MSOA level, the entirety of the MSOA in ***Figure 35*** would be reflected in the measure of urban rainfall. Clearly, this would probably include a large amount of undeveloped land which inputs minimal flow into the local sewer network.

Importantly, this effect should not be expected to cancel out between companies due to the significant differences in population density and conurbation types across the industry. Section 4 presents evidence that supports this expectation.

We should acknowledge that this issue also exists at an Output Area level, due to the use of a population-weighted centre when applying the RUC to Output Areas. As discussed previously, it's possible for an Output Area

[45] Bibby and Brindley (2013) *Urban and rural area definitions for policy purposes in England and Wales: methodology*. Available here.

[46] ONS (2013) *RUC user guide.* Available here.

to consist of areas of undeveloped land and still be considered urban. However, the much greater granularity conferred by the use of Output Areas significantly reduces the degree to which this systematic bias influences the result at a company level.

The next section presents real world examples of the use of MSOAs overstating urban areas. Section B.4 then demonstrates that this also occurs generally across England and Wales but that areas in Wales will be particularly affected by this overstatement.

B.3 Examples of urban MSOAs with large areas of rural land

This section presents some real life examples of largely rural MSOAs being classified as urban because a majority of their constituent Output Areas are classed as urban. Section B.4 then shows that Welsh areas are bigger in general.

Table 8 sets out each of the MSOAs considered in this section. We have identified these particular MSOAs through cursory analysis of each companies' area; there are many more examples that we could have picked. The table includes information on the number of output areas within each MSOA, split by those considered urban and rural by the RUC. We can see how RUC aggregation works; each MSOA has a majority of Output Areas classed as urban, which under the RUC methodology means the MSOA is classed as urban (the one exception is South Kesteven 007 which is evenly split between urban and rural MSOAs. Under the RUC's methodology, in these cases the MSOA is classed as urban). ***Table 8*** also sums up the geographic area of the MSOA's constituent Output Areas, again split by Output Areas classed as urban and those classed as rural. As discussed in section B.2, Output Area boundaries are drawn to contain roughly the same number of households/population. This means that rural Output Areas tend to be bigger geographically, which is clearly demonstrated in ***Table 8***.

Table 8 Analysis of the urban/rural make-up of MSOAs classed as urban (all these MSOAs are classed as urban by the RUC)

MSOA	Number of urban Output Areas within the MSOA	Number of rural Output Areas within the MSOA	Size of urban Output Areas within the MSOA (hectares)	Size of rural Output Areas within the MSOA (hectares)	Share of MSOA's area made up of urban Output Areas	Share of MSOA's area made up of rural Output Areas
South Kesteven 007	17	17	195	20,199	1%	99%
Monmouthshire 001	19	8	881	13,612	6%	94%
Northumberland 034	13	11	571	10,149	5%	95%
Shropshire 029	18	16	883	14,131	6%	94%
South Hams 001	11	8	261	8,390	3%	97%
Test Valley 001	15	8	313	6,678	4%	96%
South Oxfordshire 004	13	10	439	5,164	8%	92%
South Lakeland 005	19	8	387	19,018	2%	98%
Mendip 012	16	10	802	5,327	13%	87%
East Riding of Yorkshire 044	13	11	720	5,962	11%	89%

Overall, it's clear that these urban MSOAs are mostly comprised of land that is considered rural by the RUC and is very unlikely to drain to the company's sewer system. The following pages contain maps that illustrate the boundary of selected MSOA set out in ***Table 8***, along with clear markings surrounding built-up areas with a population of 10,000 or more (this information feeds into the RUC's urban classification). This confirms that the scale of rural areas within each MSOA suggested in ***Table 8*** is accurate.

The extent of the MSOA is illustrated in blue shading or a blue boundary, while the built up area with a population greater than 10,000 is set out in purple. All these MSOAs will be included within an urban rainfall variable that applies the RUC at an MSOA level.

Figure 36 - South Kesteven 007

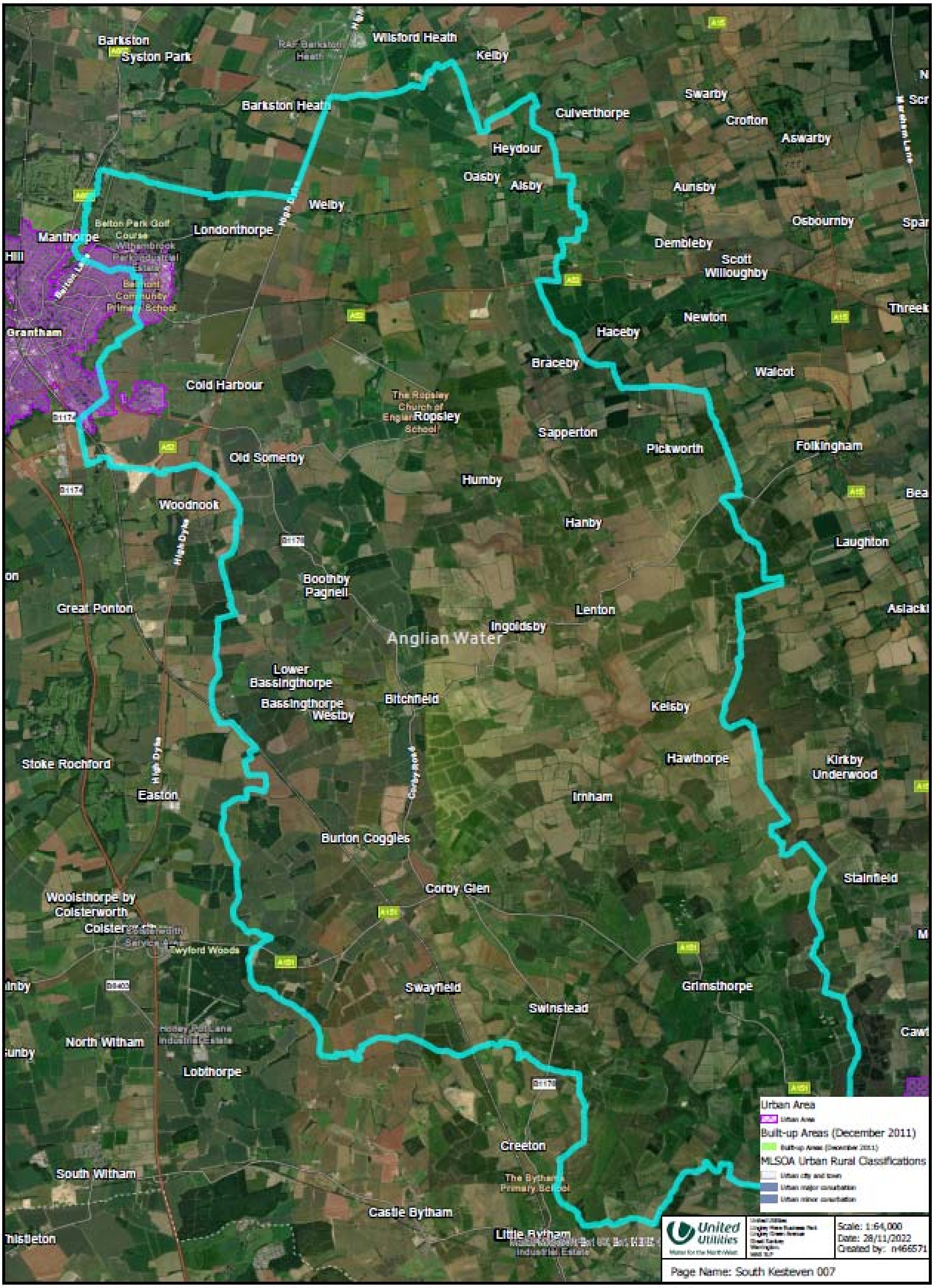


Figure 37 – Monmouthshire 001

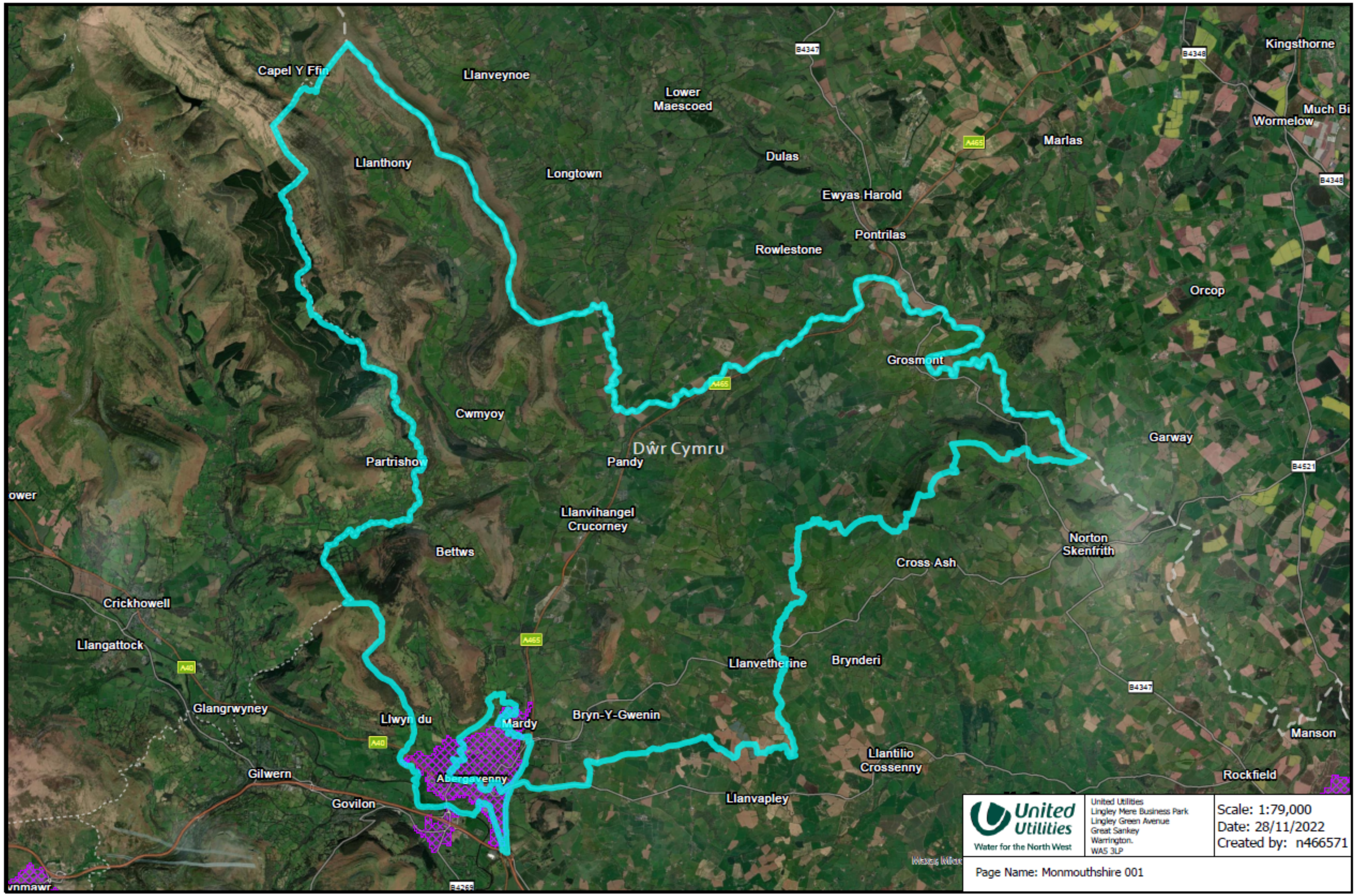


Figure 38 – Northumberland 034

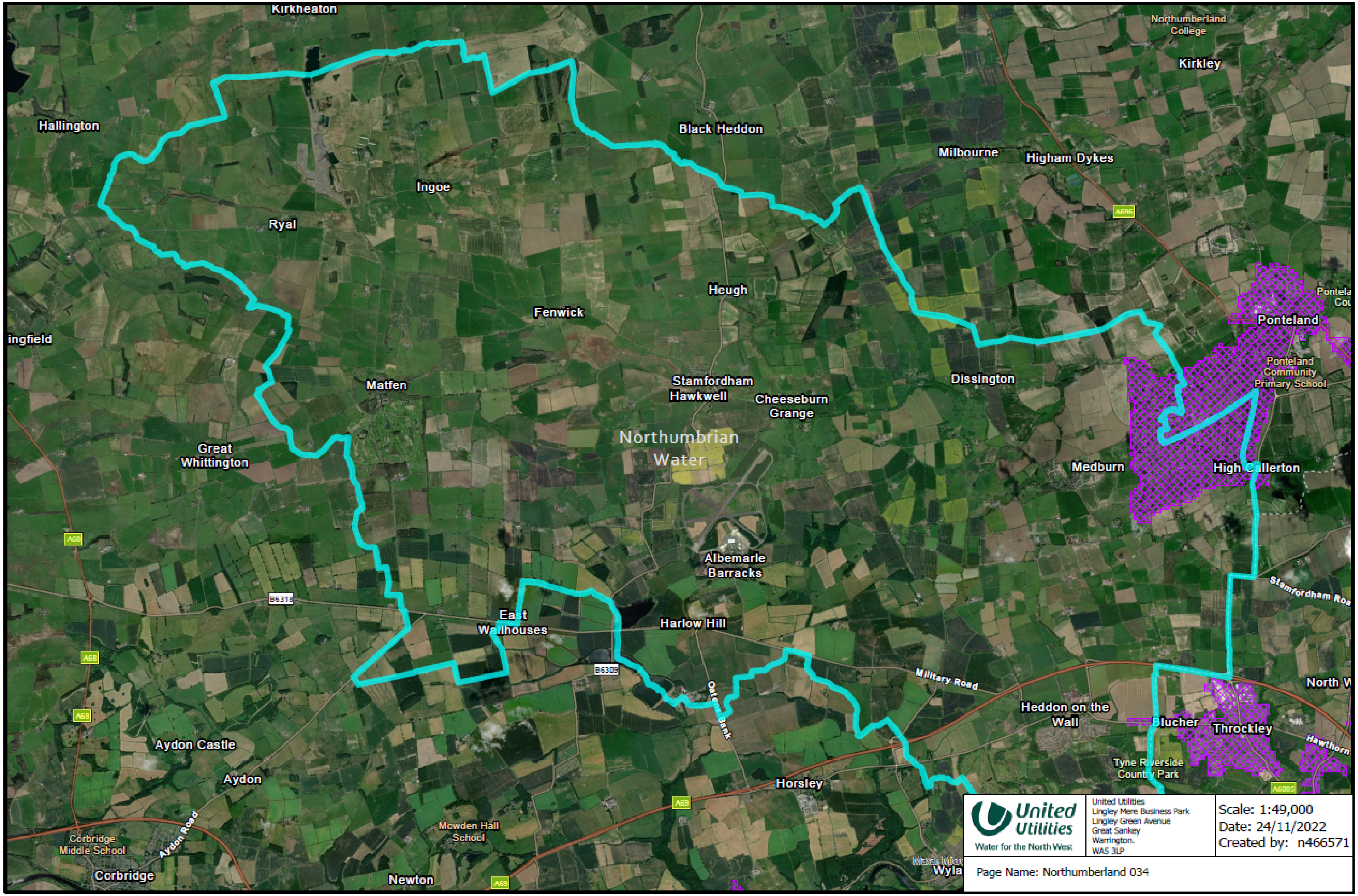


Figure 39 - South Hams 001

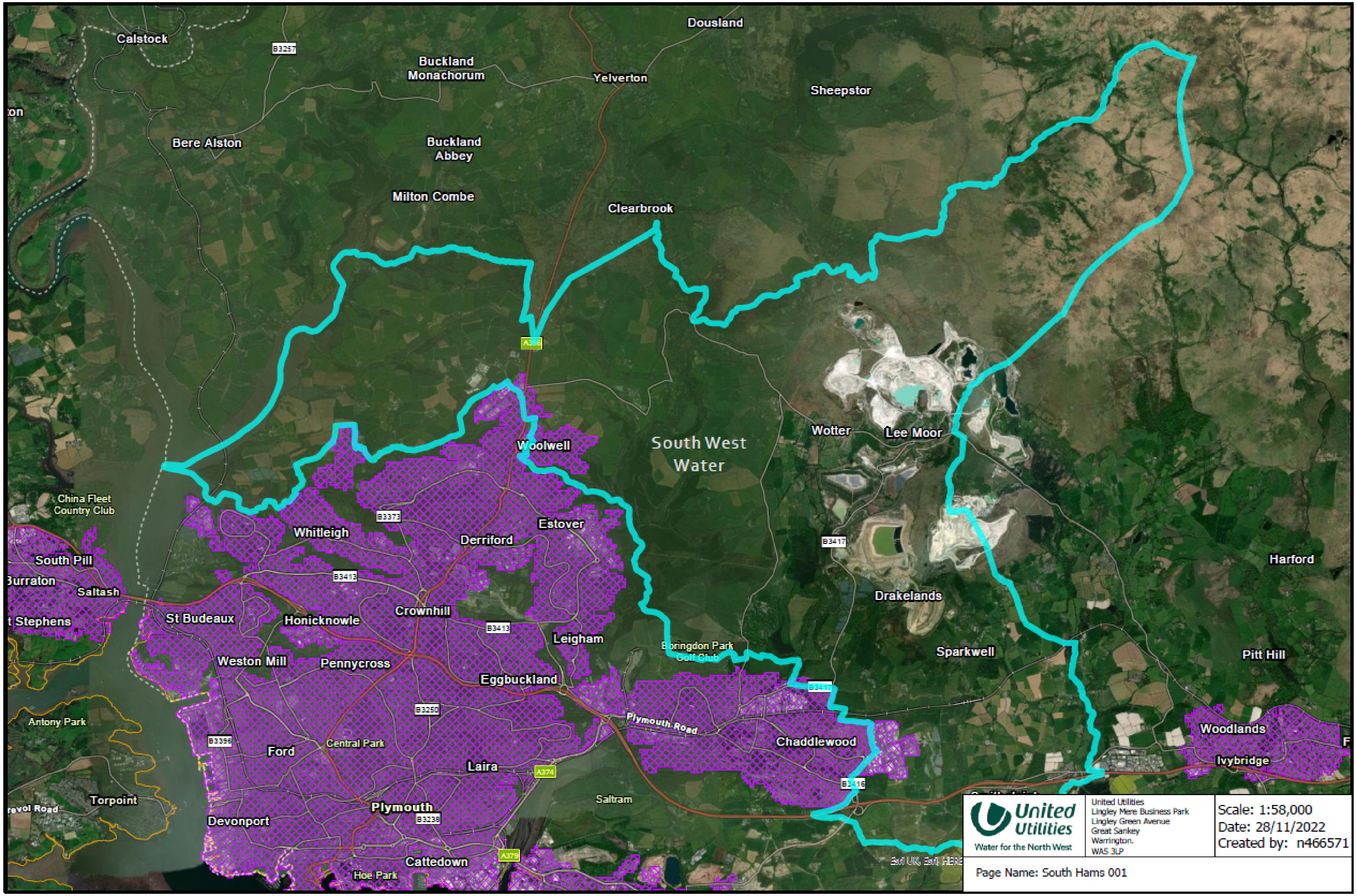
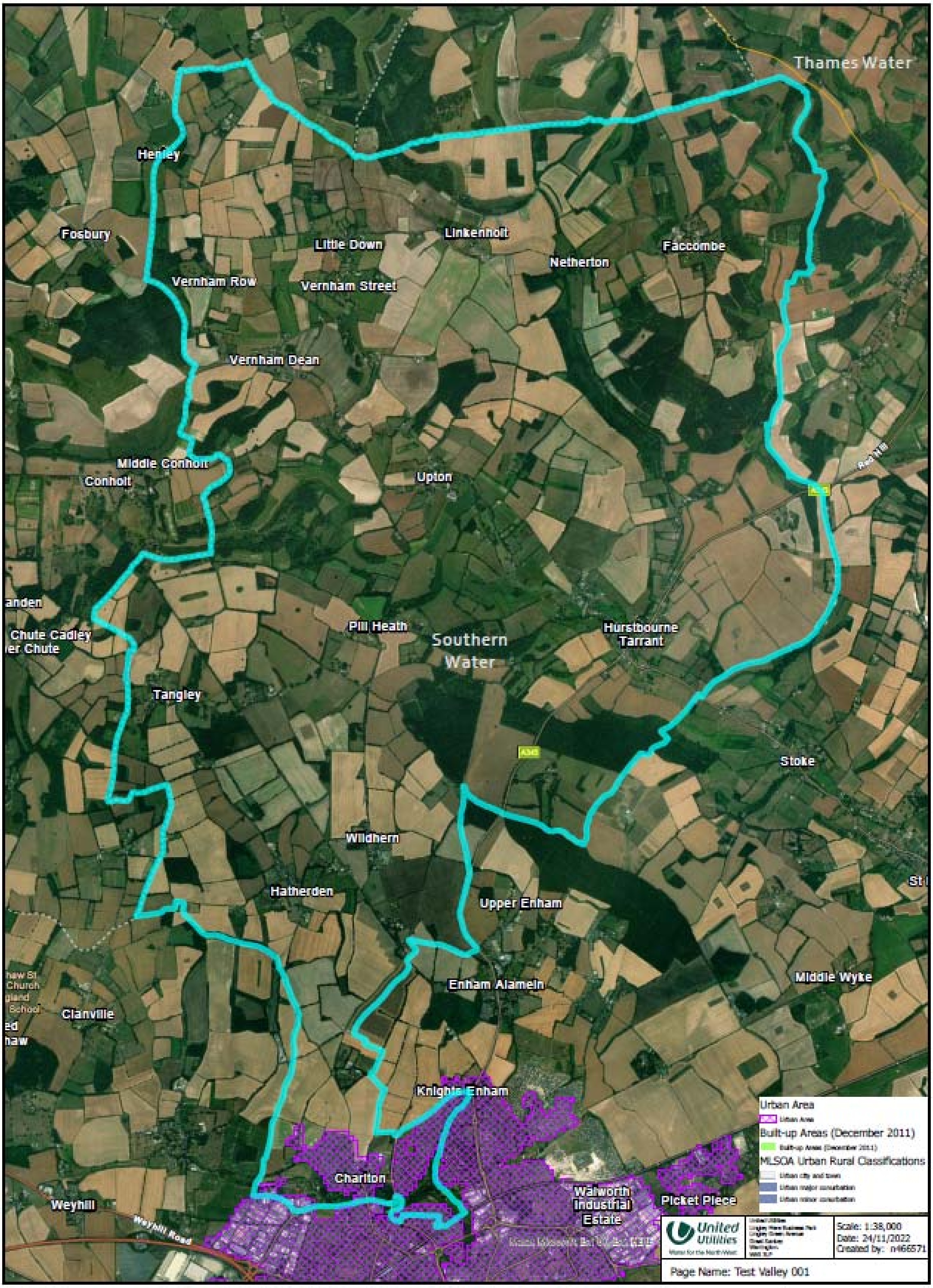


Figure 40 - Test Valley 001



B.4 Using the RUC to define urban rainfall will overstate urban rainfall in Welsh areas

Section 2 hypothesised that defining urban areas by applying the RUC to MSOAs could overstate urban areas. Section 3 presented some examples of this happening in practice in each company's area. This section presents evidence that this happens in a systematically different way between England and Wales.

We can carry out similar analysis to that set out in ***Table 8*** in the previous section for **all** MSOAs. ***Table 9*** looks at the make-up of all MSOAs in England and Wales by RUC classification. As section B.2 explained, the RUC for an MSOA depends upon the RUC of a majority of its constituent Output Areas. This means that an urban MSOA can include rural Output Areas (and vice versa). Crucially, because rural Output Areas tend to be bigger (due to being more sparsely populated), this means that a large proportion of the land coverage of MSOAs classed as urban by the RUC can be made up of rural areas.

As ***Table 9*** shows, despite there only being 3,507 Output Areas classed as rural contained within MSOAs with an overall urban RUC classification, those 3,507 Output Areas comprise 38% of the land coverage of MSOAs classed as urban, across all of England and Wales. This demonstrates that using the RUC at the MSOA level is overstating urban areas by around 38% across England and Wales. This is an issue for the purposes of defining urban rainfall because rural areas will tend not to drain to sewer networks, which means including such areas within the analysis will overstate the demand put onto a company's asset base.

Table 9 Analysis of the make-up of urban/rural MSOA in England and Wales

MSOA RUC classification	Number of urban Output Areas within MSOAs	Number of rural Output Areas within MSOAs	Size of urban Output Areas within MSOAs (hectares)	Size of rural Output Areas within MSOAs (hectares)	Share of MSOAs comprised of urban Output Areas	Share of MSOAs comprised of rural Output Areas
Urban	144,570	3,507	2,002,502	1,240,810	62%	38%
Rural	1,910	31,421	159,309	11,718,541	1%	99%

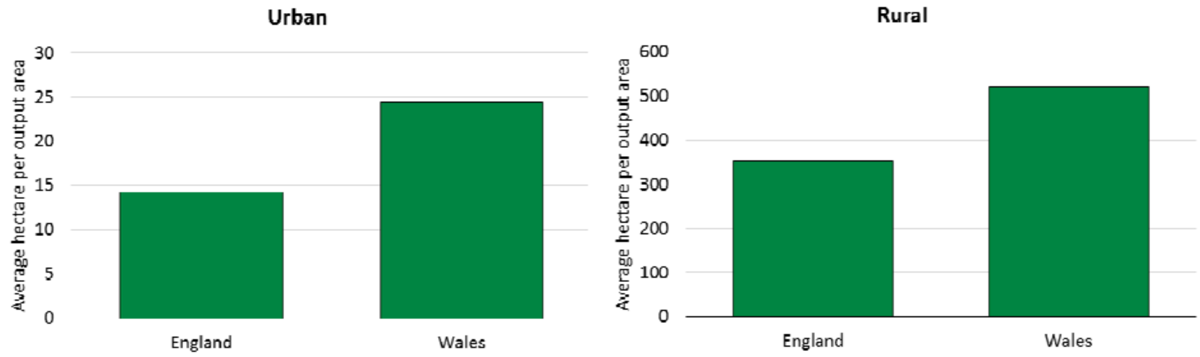
We also considered whether this happens at more granular definitions of urban. However, we have found that using the RUC at the next most granular (LSOA) level will still tend to overstate urban areas. ***Table 10*** carries out the same analysis as ***Table 9***, but at the LSOA level rather than the MSOA level. It's clear that the greater granularity of an LSOA has improved the definition of urban because the share of urban areas made up of rural Output Areas has decreased from 38% at the MSOA level to 23% at the LSOA level. However, this does still mean that defining urban areas at the LSOA level will overstate urban areas by around 23%.

Table 10 Analysis of the make-up of urban/rural LSOAs

LSOA RUC classification	Number of urban Output Areas within LSOAs	Number of rural Output Areas within LSOAs	Size of urban Output Areas within LSOAs (hectares)	Size of rural Output Areas within LSOAs (hectares)	Share of LSOAs comprised of urban Output Areas	Share of LSOAs comprised of rural Output Areas
Urban	145,922	1,477	2,078,741	604,336	77%	23%
Rural	558	33,451	83,069	12,355,015	1%	99%

To an extent, this may not affect industry comparisons, **assuming that urban areas are equally overstated across all areas of England and Wales**. However, on average, the size of geographic parcels between England and Wales appears to be systematically different – Welsh areas appear to be larger. This can be seen in ***Figure 41***.

Figure 41 - Both urban and rural areas in Wales tend to be larger



The fact that urban areas in Wales are substantially larger than those in England means that the inclusion of 'urban areas' within the equation set out in 51 will mean that when rainfall is multiplied by urban area to calculate urban rainfall, on average, urban rainfall in Wales is calculated as being larger than urban rainfall in England.

Therefore, we do not consider that industry comparison of urban rainfall set out in Figure 3 is entirely reflective of actual differences in urban run-off between companies in England and companies in Wales. Instead, we consider that the systematic differences between how geographical area are measured between the two countries (as set out in ***Figure 41***) is a major reason behind Welsh appearing to have the largest level of urban rainfall.

While we consider that the addition of an urban rainfall variable to the recommended model suite is a positive development and we consider the calculation to be pragmatic and generally appropriate, we do consider that any resulting comparative analysis should be viewed in context of the underlying systematic differences between England and Wales set out in this appendix, rather than being viewed as entirely reflective of differences in urban rainfall.

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