Southern Water CMA base cost modelling working paper response

12th January 2026

1. Executive Summary

1. This document is Southern Water's response to the CMA's base cost modelling working paper (**Working Paper**) dated 18 December 2025.
2. We recognise the significant effort made by the CMA to address concerns raised by us, and the other main parties, in response to the base cost modelling proposals in the PD. However, we remain concerned that the CMA is placing too much reliance on unstable new modelling, which purports to justify a significant cut in base allowances.
3. This further reduction in our allowances will jeopardise both our financeability and investment plans, which would lead to worse outcomes for consumers and the environment. Our business plan submission was already highly ambitious, with a significant efficiency challenge already included, and the CMA's proposals would reduce our allowances without any scrutiny of the bottom-up evidence or an assessment that the implied efficiency challenge is achievable.
4. We are pleased that the CMA has indicated that it is considering the merits of assessing our coastal CAC within its modelling framework. This is an issue that uniquely and materially affects Southern Water and is not accounted for within the industry-wide modelling. There is also broad consensus regarding the engineering rationale for these increased costs. We support the CMA's proposed approach to assessing this.
5. We are concerned the CMA panel has reached the wrong conclusion insofar as the Working Paper attributes AMP7 overspend largely to the energy price shock. In fact, AMP7 overspend (by almost every company in the sector) was due to, in hindsight, underfunding in the PR19 determination. For Southern Water in particular this overspend was used to important effect to improve outcomes for our customers and the environment. We requested additional base allowances as part of our Statement of Case as we are firmly of the view that we are not getting the allowances required to run the company within our operating environment. We are already overspending the AMP8 Ofwat FD allowances. Repeating this mistake, by curtailing appropriate allowances for AMP8, is not in the interests of our customers or the environment.
6. We have significant concerns that the CMA's new modelling techniques are resulting in an unrealistic catch-up efficiency challenge – a level of challenge which is more significant than in other price controls. There are factors other than the inclusion of energy prices within base models that are driving this challenge. The catch-up challenge is in fact dependent on a small number of companies that have unexpected outcomes related to some of the modelling changes made by the CMA.
7. The CMA has made a significant number of modelling changes in a short space of time. These have not been subject to the level of regulatory scrutiny typically associated with the adoption of such models and there is limited cross-checking of these results with other relevant data points. As such, the CMA's judgements are based solely on the technical modelling, notwithstanding the concerns identified by

the Cunliffe Review as well as our response to the PD with respect to such an approach. This gives less confidence in the overall results.

8. Given this lack of confidence, it would be wrong to ground the catch-up challenge as proposed by the CMA. Instead, we believe it would be more appropriate to base the catch-up challenge on the median company. This would align with the approach adopted by the CMA in relation to its PR14 redetermination for Bristol Water when there were similar concerns. Alternatively, there are other ways to moderate the catch-up challenge supported by regulatory (Ofwat) precedent.

9. In conclusion, we ask the CMA:
    - To apply the Coastal CAC asymmetrically; and
    - To moderate the catch-up challenge.

10. In addition, we have a number of specific concerns with the CMA's models and provide our response to other issues raised in the Working Paper. These points are set out in the appendices to this response.

2. We welcome the CMA revisiting our Coastal Population Cost Adjustment Claim

11. We are pleased that the CMA has proposed to assess our consistent claim for serving a coastal population within the cost adjustment claim framework. It is right that the CMA is proposing to use this process to account for the unique and material cost pressures faced by Southern Water which were not accounted for in Ofwat's FD models.

There is consensus regarding the engineering rationale for higher costs for coastal wastewater sites

12. Southern Water has the largest coastal population of all WaSCs. Coastal environments exert unique cost pressures on wastewater treatment. In our Statement of Case, we summarised the various engineering factors that collectively lead to specific cost pressures for wastewater treatment. These include:
    - space constraints and planning restrictions;
    - stricter Ultraviolet (UV) and Total Nitrogen consents;
    - enhanced corrosion due to salinity;
    - maintenance of sea outfall infrastructure;
    - high load variability due to summer tourism; and
    - stricter spill frequency constraints on coastal discharges[1].
13. Given the aggregate cost pressure of these factors is material, it would be wrong to deem that each individual factor is not sufficiently material. At FD, Ofwat concluded that given these factors *"from an engineering perspective, that there may be reasons why operating in coastal areas drive higher company costs.[2]"*
14. As we noted in our PD response, the CMA investigated these engineering factors during the company specific hearings, where each of the disputing companies identified similar engineering factors:
    - Anglian Water said explicitly that it "support the engineering rationale"[3] and "there is engineering rationale for higher costs"[4] while describing similar engineering factors it had with issues like UV consents and saline corrosion as per our engineering rationale;
    - Northumbrian Water explained that saline treatments and the coastal catchment areas led to coastal sites being more expensive[5]; and
    - Wessex Water noted that UV treatments and space constraints at its coastal sites (e.g. those at Weymouth and Swanage) lead to higher costs[6].

[1] Full details of these engineering factors can be found in Southern Water, August 2024, SRB-DDR-015: Coastal Population Cost Adjustment Claim, page 6-14, SOC-2-0030.
[2] Ofwat, December 2024, SRN CAC Feeder Model Code: PR24CA19, SOC-2-0020, Sheet SRN_CAC6. Cell D23
[3] Anglian Water PR24 Hearing Transcript, July 2025, page 41, line 22.
[4] Anglian Water PR24 Hearing Transcript, July 2025, page 42, line 26.
[5] Northumbrian Water PR24 Hearing Transcript, July 2025, page 17, lines 7-11.
[6] Wessex Water PR24 Hearing Transcript, July 2025, lines 11-18.

15. We support the approach now proposed by the CMA to now assess our Coastal Population CAC in its LASSO modelling framework.

The coastal population variable is the most suitable way to capture coastal impacts in the Sewage Treatment model

16. The CMA noted that, to assess our coastal population CAC through its LASSO modelling, it intends to add the coastal population variable to the list of candidate variables for the Sewage Treatment model. We support this approach and this is in line with our CAC and our Statement of Case.

17. There may be potential benefit in investigating other coastal-related variables, as seen in our response to RFI09, where we produced a series of scatterplots comparing different measures of coastal shares against the efficiency scores from Ofwat's FD Sewage Treatment model which all showed a significant correlation. However, to include a variable in the econometric model, it is important that there is robust data available for all companies throughout the modelling period.

18. We explained in our PD response that *"our Coastal population variable is most suited to the econometric modelling given there is data available over the entire period. This variable has been reviewed during the PR24 process[7]".* Other coastal load or coastal site variables are less suited to econometric testing as developing these requires significant assumptions given the lack of APR data regarding large wastewater treatment works prior to 2016.

19. In our PD response, we also explained that our CAC needed to be assessed in the bottom-up Sewage Treatment model rather than at the top-down Wastewater Network Plus aggregation level. The lack of sufficient allowances arising from coastal pressures only affects wastewater treatment and not wastewater collection, which means that the relationship is understated in the top-down model that includes wastewater collection costs.

20. The CMA has sought views on whether this variable should only be used for assessing this CAC or should be included in the standard set of candidate variables[8]. Given the CMA's modelling framework, it is only possible to use these variables to assess the CAC, as the bottom-up models are not included in a triangulated approach as previously applied by Ofwat.

21. We have added the coastal population variable to the list of candidate variables for the Sewage Treatment model[9]. The variable is selected by LASSO and achieves statistical significance at the 1% level. The RMSE is lower than in the equivalent version of the bottom-up models without the coastal variable included in the candidate pool (34.8 versus 39.3). Table 1 below sets out how the CAC-specific

[7] Southern Water, Response to the CMA's PR24 Provisional Determination, para 3.110.
[8] CMA, Base Costs Modelling – Working Paper, para 5.13(c)
[9] See SRN11 - Southern Water Base Cost Response Supporting Evidence, tab "Coastal SWT model" for modelling results.

model and the CMA standard model perform in the additional CMA's robustness and sensitivity checks[10].

Table 1 – Replication of CMA's statistical robustness testing for Sewage Treatment model including and excluding coastal population

CAC specific Sewage Treatment model (including coastal population variable)		
Statistical test	P-value	Interpretation
RESET	0.18	Pass - no evidence of misspecification
Max VIF	8.86	No severe multicollinearity (VIF < 10)
Shapiro-Wilks	0.15	Pass - Accept the hypothesis that residuals are normally distributed
Breusch-Pagan	0.03	Heteroskedasticity present
R-Squared	0.93	Model explains ~93% of variance
Adjusted R-Squared	0.93	Confirms strong explanatory power
CMA Sewage Treatment model (excl. coastal population variable)		
RESET	0.03	Fail - evidence of misspecification
Max VIF	5.01	No severe multicollinearity (VIF < 10)
Shapiro-Wilks	0.002	Fail - Reject the hypothesis that residuals are normally distributed
Breusch-Pagan	0.18	No strong evidence of heteroskedasticity present
R-Squared	0.91	Model explains ~91% of variance
Adjusted R-Squared	0.91	Confirms strong explanatory power

22. The Sewage Treatment model including the coastal population variable passes the tests for functional form and for the normal distribution of residuals whereas the Sewage Treatment model without the coastal variable fails these tests. Whilst the Breusch-Pagan test indicates that heteroskedasticity is present, we do not consider this issue sufficient to invalidate the Sewage Treatment model including coastal population given the overall superior performance of the model for the same reasons that the CMA provided when this issue was identified in its models[11],

[10] This table replicates the tests include in the CMA's working paper for its chosen models see CMA, Base Costs Modelling – Working Paper, table 3.5 and Table 4.5.
[11] CMA, Base Costs Modelling – Working Paper, para 3.31, page 24

23. These robustness test results for including the variable in the CMA Sewage Treatment model are in line with the equally strong outcomes we presented in our Statement of Case. Our results showed that the Ofwat FD models with coastal population as a driver meet all Ofwat's desirable statistical properties as defined by its model robustness tests, with the R-squared improving with the introduction of the coastal variable.[12]

An asymmetric adjustment is appropriate

24. The CMA has sought views on whether a change should be applied symmetrically or not[13]. In our original cost adjustment claim, we explicitly requested an asymmetrical adjustment, with no adjustment applied to other companies[14]. This is due to Southern Water being uniquely impacted by these cost pressures. We continue to believe this is appropriate.

25. We also note that whilst Ofwat did seek the option to make symmetrical adjustments for CACs at PR24, it did not do so in any instance. It would therefore be inappropriate to do so during these redeterminations, where it is not possible to apply any change to the sector as a whole.

Proposed solution

26. The CMA should re-run a CAC-specific version of the bottom-up wastewater models with coastal population variable included in the list of candidate variables for the Sewage Treatment model. The difference in modelled allowance for Southern Water compared the standard version of the bottom-up wastewater models represents the value of asymmetric adjustment for Southern Water.

27. The modelled allowance for Southern Water from the CMA's bottom-up wastewater models increases from £1,798m to £1,900m. This indicates that the value of the CAC should be £102m[15].

[12] Southern Water Statement of Case, Table 18, page 169
[13] CMA, Base Costs Modelling – Working Paper, para 5.13(b)
[14] Southern Water, August 2024, SRB-DDR-015: Coastal Population Cost Adjustment Claim, page 5 and page 22, SOC-2-0030.
[15] See SRN11 - Southern Water Base Cost Response Supporting Evidence, tab "CAC value" for modelling results.

3. The catch-up challenge from the CMA's new models is excessive and unjustified

28. As part of these redeterminations, the CMA has made significant changes to the well-established Ofwat approach to setting base cost allowances. The CMA now proposes to set these allowances based on one econometric formula for each of the water and wastewater price controls, with no triangulation or cross-checks used to act as a sense check to the outcomes.

29. The models presented in this working paper represent a change since those presented at PD. Whilst these technical refinements may address specific concerns with those models, these changes introduce further concerns at a late stage in the redetermination; we have outlined some of these in Appendix 1. However, there has been limited opportunity for industry-wide consultation and scrutiny of these models which have been developed within a short timeframe.

30. The limited scrutiny and lack of triangulation adopted means that there is less confidence in the results from the CMA's modelling process than is typically the case from a longer price review process.

31. The CMA's new LASSO modelling approach results in a much more stretching catch-up challenge than applied by Ofwat at FD. The catch-up efficiency challenge has increased six-fold from 1.3% to 7.3% in wholesale water and ten-fold from 0.6% to 5.9% in wastewater network plus[16].

32. At PD, the CMA included Table 4.3,[17] to compare its catch-up challenge with previous Ofwat price reviews but has chosen to not include a similar comparison now. We note the catch-up challenge is even more stringent in the updated CMA models. We note that whilst the CMA does refer in the body of text to the comparison with previous catch-up challenges in water[18] it neglects to do so in wastewater, where the proposed catch-up challenge has increased from 2% at PR19 to over 6% in the latest CMA's proposals.

33. The CMA themselves note the increasing challenge but explain this is largely due to a flawed model used by Ofwat at FD, that did not capture the recent energy price shock. The CMA state "*The failure of Ofwat's econometric model to account for this [energy cost shock] led to firms appearing more inefficient and as such resulted in a reduced UQ challenge. As in our PR24 PD, we consider that this was flawed and largely explains the difference in post-UQ efficiency allowances between our updated models and Ofwat's.*"[19] However, the scale of the change in the catch-up efficiency challenge since Ofwat's FD is much more significant than the increase in model precision, as measured from the R-squared from the models which increased from 0.96 – 0.97[20] at

[16] CMA, Base Costs Modelling – Working Paper, paras 3.25 and 4.21.
[17] CMA, Provisional Determination, Volume 1, table 4.3, page 56
[18] CMA, Base Costs Modelling – Working Paper, para 3.24
[19] CMA, Base Costs Modelling – Working Paper, para 2.12
[20] Ofwat FD top-down wholesale water models only included to enable comparison with CMA's selected top-down water model

FD to 0.97 in wholesale water and from 0.94 – 0.95[21] at FD to 0.95 in wastewater network plus[22].

34. What is clear is that the challenge resulting from the new CMA models is much more stringent. We believe it is incumbent on the CMA to consider if this is appropriate or not, especially given the lesser confidence in the modelling results. There is clear precedent from the CMA's own redetermination for Bristol Water at PR14 for a reduced efficiency challenge in such circumstances:

> *"a less demanding benchmark than the upper quartile may be appropriate in cases where there was less confidence in the modelling results. The effect of modelling error and limitations will tend to mean that an upper quartile benchmark will require levels of efficiency that are, in practice, greater than the upper quartile."* [23]

Inclusion of energy prices does not explain the difference in post-UQ efficiency allowances

35. The CMA is right that the inclusion of energy input prices in the model does have an impact on how efficient companies appear historically compared to the modelled outcome. However, it is wrong to imply that the inclusion of this variable largely explains the difference in post-UQ efficiency allowances. This can be empirically verified through re-running the CMA's models without the energy price variable included as shown in Table 2 below.[24].

Table 2 - Catch-up challenge comparison

Price control	Ofwat FD	CMA	CMA (excl. energy)
Wholesale water	0.987	0.927	0.943
Wastewater	0.994	0.941	0.959

36. In this version of the model, the catch-up efficiency challenge would still be 5.7% in wholesale water and 4.1% in wastewater network plus; still significantly higher than Ofwat's FD. In fact, 70-80% of the increase in catch-up efficiency challenge is caused by factors in the modelling other than the inclusion of energy input prices.

37. The CMA's explanation that the Ofwat PR24 models are flawed and led to a less stringent efficiency challenge than should have been applied is not concordant with the way in which the PR24 CMA models lead to a much more stringent challenge

[21] Ofwat FD top-down wastewater models only included to enable comparison with CMA's selected top-down wastewater model
[22] Ofwat, December 2024, PR24 Final determinations expenditure allowances base cost modelling decision appendix A2
[23] CMA, October 2015, Bristol Water PLC a reference under section 12(3)(a) of the Water Industry Act 1991, para 4.222
[24] See SRN11 - Southern Water Base Cost Response Supporting Evidence, tab "Table 2 – Efficiency scores" for the results from this modelling.

than adopted by the Ofwat models at PR19 (when energy prices were stable). The PR19 models were also approved by the CMA, prior to the energy price shock.

In reality, overspend in AMP7 was real and not solely caused by the energy prices

38. The CMA states that its model is superior to Ofwat's as it includes energy input prices as a cost driver (from now on referred to as the 'DESNZ index'). It considers that the model accounts for the sustained energy price shock that contributed to water companies overspending their PR19 allowances. However, whilst rising energy costs were one aspect of this overspend in AMP7, other cost items had a much larger impact.

39. Our analysis of our AMP7 expenditure data shows that only 10% of overspend in base costs is attributable to power costs (see Table 3 and Table 4 below). In both water and wastewater, the majority of overspend, approximately 60%, was driven by base capex, which includes maintenance and asset health-related activities. Therefore, the CMA's conclusion that AMP7 overspend was primarily driven by rising energy costs does not align with the underlying data.

Table 3 3 - Water base cost overspend in AMP7 by category

Expenditure category	Implicit Allowance (£m)	Expenditure (£m)	Difference (£m)	% of total overspend	% of category overspend
Wholesale water	**890**	**1,367**	**476**	**53%**	
Power	70	107	37	8%	53%
Capex	523	803	280	59%	54%
Other opex exc. renewals	287	441	154	32%	54%
Other	9	14	5	1%	55%
Growth	1	2	1	0%	100%

Note: Figures are in 2022/23 price base
Source: Southern Water analysis, derived from Ofwat base costs dataset.

Table 4 4 - Wastewater base cost overspend in AMP7 by category, £m

Expenditure category	Implicit Allowance (£m)	Expenditure (£m)	Difference (£m)	% of total overspend	% of category overspend
Wastewater	**1,697**	**2,258**	**561**	**33%**	
Power	182	243	60	11%	33%
Capex	1,062	1,413	351	63%	33%
Other opex exc. renewals	514	683	170	30%	33%
Other	-104	-139	- 34	-6%	33%
Growth	43	57	14	3%	33%

Note: Figures are in 2022/23 price base
Source: Southern Water analysis, derived from Ofwat base costs dataset.

The 'Other' category is negative due to two expenditure items, atypical expenditure, and the backcast[25]. Ofwat estimates the latter. Both are net negative across the industry from 2011-12 to 2024-25.

40. The two tables above show that the majority of overspend in AMP7 was due to capex, whereas power only accounted for 8-11% of overspend. In AMP7, we began some major programmes of work that were unforeseen and beyond our PR19 business plan but have nonetheless led to significant improvements in performance as measured by the ODIs we face.

41. The most material example on the water side is where we developed new spending which was not included in our PR19 business plan. Due to unforeseen circumstances, we began a major programme of works to rebuild five treatment sites, [redacted] and Weirwood. The work is driven by enforcement orders from the DWI. We have spent around £200m[26] so far and the programme is continuing into AMP8. As a result, the reliability of these five sites has increased noticeably, and we have seen a huge improvement in the unplanned outage ODI of 65% in AMP7.

42. On the waste side, we have spent approximately £670m[27] to improve asset health, nearly three times the funding in our PR19 FD. We faced adverse weather conditions in the AMP, particularly very high levels of ground water, and incurred high tankering costs as a result. Specifically, we invested over £100m in digitisation of our network, AI enhancements to our control room, and improved maintenance logistics, all of which have led to quicker responses to issues in the network. In AMP7, following this additional investment, we saw a 33% reduction in pollution incidents, 30% reduction in internal sewer flooding, and a rise in treatment compliance to 98.23% (1.17 percentage points).

43. Economic Insight reached the same conclusion for the sector when analysing the drivers of overspend in AMP7. They found that only 14% to 29% of the industry AMP7 base cost overspend was attributable to rising power costs[28]. This is consistent with the Southern Water specific analysis presented above[29].

44. Notably, Economic Insight also identified a weak negative relationship between AMP7 modelled base cost overspend and the extent of energy price increases experienced by companies.[30] Companies facing larger energy price rises tended, on average, to show slightly lower modelled base cost overspend in AMP7. This

[25] The backcast is a reallocation of costs between bioresources and sewage treatment. See Ofwat, Econometric base cost models for PR24, April 2023, page 70.
[26] Source: Internal Southern Water analysis, which is converted into 2022/23 prices.
[27] Source: Internal Southern Water analysis, which is converted into 2022/23 prices.
[28] Economic Insight (2026), The Treatment of Energy Input Price Inflation in Base Cost Econometric Models, pg. 2
[29] Given the fact that our company was unusually well-hedged when the energy crisis began, accordingly, we would expect the sector's power-related overspend to be slightly higher than ours, while power costs overall represent only a small share of total overspend.
[30] Economic Insight (2026), The Treatment of Energy Input Price Inflation in Base Cost Econometric Models, pg. 6

correlation does not imply causation, nevertheless, it does provide further evidence to substantiate that AMP7 overspend was not driven by energy input price inflation.

45. Including the DESNZ index as a cost driver does improve the explanatory power of the CMA's base cost models, as indicated by metrics such as RMSE. However, it appears to create unintended interactions with other real price effects beyond energy input costs, which may artificially inflate model performance. Two straightforward tests provide empirical evidence of these unintended interactions when the DESNZ index is incorporated into base cost models:

    (1) Firstly, even when power costs are excluded from base costs, the LASSO framework still selects the DESNZ index. This indicates that the index is likely highly correlated with other base cost components experiencing cost pressures. Because LASSO operates without traditional economic or engineering constraints, it can capture spurious or indirect relationships, leading to the DESNZ index being chosen despite its lack of direct relevance or logic.

    (2) Secondly, when the DESNZ index is excluded from the candidate LASSO variables in wastewater network plus, the construction wage driver is selected. This driver is statistically significant at the 5% level, with a positive coefficient of approximately 0.4, broadly consistent with labour cost shares reported in wastewater operations[31]. This evidence suggests that the DESNZ index interacts unintentionally with other real price effects, such as regional wage inflation given its inclusion leads to the omission of the wage variable despite a high degree of economic and engineering logic supporting its inclusion

46. The CMA's statements in this regard contrast the findings of the independent Cunliffe Review, which suggests the backward-looking nature of Ofwat's approach to setting allowances for asset health related activities may have resulted in material underfunding, "*When the Scottish regulator switched from using backward-looking indicators, similar to those Ofwat have used, to a forward-looking in-depth assessment, the conclusion was that there had been material underfunding of capital maintenance.*"[32]

Rather than being largely driven by energy index, the catch-up challenge is mechanically driven by a small number of companies which are not appropriate benchmarks

47. The specific catch-up challenge applied to the sector by the CMA is not dependent on the efficiency of the industry but rather the efficiency of the specific company that ranks as the 5th most efficient water company and the specific companies that rank as the 3rd and 4th most efficient wastewater companies. Therefore, it is instead completely dependent on the modelling outcome for the following small set of companies:

[31] See SRN11 - Southern Water Base Cost Response Supporting Evidence, tab "Exclude DESNZ index WWNP model" for the results from this modelling
[32] Sir Jon Cunliffe: Speech on the Independent Water Commission final report, July 2025

Wholesale Water

- South Staffs Water
- Portsmouth Water
- Hafren Dyfrdwy (HDD)
- Affinity Water
- Anglian Water

Wastewater Network Plus

- Welsh Water
- Wessex Water
- Yorkshire Water (YKY)
- Anglian Water

48. In our response to PD, we set out that the CMA had not applied Ofwat's required checks to assess whether the UQ companies were in a capital maintenance trough or a period of poor performance. We performed these necessary checks having reviewed the latest APR data and identified that many of the companies included in the UQ benchmark set should indeed be excluded on these grounds. We stand by this analysis and look forward to the CMA assessing it robustly in advance of its FD.[33]

49. Given that this level of industry challenge is dependent on a small number of potentially unrepresentative companies, the CMA needs to be confident that the numerous modelling changes it has implemented are not impacting these companies in an unexpected or disproportionate way. Given that these modelling changes have been made over a much shorter timeframe than a standard price review, and most of the UQ companies are not a main party to the redetermination process, there is a risk that these company-specific concerns may not be identified.

The CMA's increased challenge in Wholesale water is driven by HDD's significant increase in efficiency vs Ofwat's models

50. HDD was formed in 2018 from the combination of Severn Trent's Welsh Service area in Powys and Dee Valley's Wrexham (DVW) service area. Dee Valley originally had 128k water customers (total connected properties) in 2018. It transferred most customers to HDD, which was 105k in 2019, and the rest went to Severn Trent[34,35]. There are significant reasons why HDD is atypical and inappropriate to form the basis for the industry efficiency benchmark:

    - Despite being a separate company, HDD is not included in the wastewater models but is instead merged with Severn Trent to form an SVH data point in

[33] Southern Water, Response to the CMA's PR24 Provisional Determination, para 3.39-3.40 and supporting documentation appendix PDR-3-002.
[34] Severn Trent News Releases, May 2018.
[35] Source: Ofwat base costs dataset for water, and find the total connected properties, household and non-households.

Ofwat's dataset. HDD therefore could not be used as an UQ company in wastewater[36].

- Data for HDD only existed from 2018 after the company was formed. This means much of the total dataset calibration is unaffected by HDD's performance. There are also unusual data discrepancies in some explanatory variables from 2017-18 to 2018-19 which cast doubt on the stability of the factors influencing the modelling[37]. Given the critical importance in how explanatory variables are used to explain more efficiency, these changes are particularly problematic.
- HDD has a highly outsourced cost base to Severn Trent and in 2023-24, 26% of its water costs were allocated in under a transfer pricing arrangement[38]. This means that small changes in cost allocations could materially impact the stated cost base of HDD.
- HDD is also an extreme outlier on both scale and density, two important drivers of cost. HDD is the smallest company with three times fewer customers than the next biggest and is eleven times smaller than the industry median. HDD is also the least dense water company, with a population density of only 12% the industry median according to the "Weighted Average Density – from LAD" driver

51. One significant and unexpected change between Ofwat's FD model and the CMA's model is in the make-up of the UQ companies for wholesale water. At FD, Thames Water is the fifth most efficient company with an efficiency score of 0.99. In the CMA's model, Thames falls to the thirteenth most efficient company with an efficiency score of 1.07. Conversely HDD is now the third most efficient company with its efficiency score increasing from 1.03 to 0.84[39]. HDD's increased efficiency is now directly driving the higher industry catch-up efficiency challenge in water. The unexpected change in efficiency for these two companies is seen in Table 5 below.

Table 5 - Movements in wholesale water efficiency scores

Company code	Ofwat PR24 FD		CMA		CMA (excl. DESNZ index)		Change between PR24 FD and CMA working paper
	Efficiency	Rank	Efficiency	Rank	Efficiency	Rank	
SSC	0.76	1	0.74	1	0.77	1	0.01
PRT	0.81	2	0.84	2	0.86	3	-0.03
ANH	0.97	3	0.93	5	0.94	5	0.04
AFW	0.97	4	0.90	4	0.91	4	0.07

[36] If we develop an equivalent SVH datapoint in water, this combined company has an efficiency score of 1.01 and the industry catch-up challenge is reduced accordingly. See SRN11 - Southern Water Base Cost Response Supporting Evidence, tab "SVH – Modelling outcomes" for the results from this modelling.
[37] See Appendix 3 for details of some data discrepancies identified with HDD
[38] Hafren Dyfrdwy Cyfyngedig (2023/24) Annual Performance Report, pages 85-90
[39] See SRN11 - Southern Water Base Cost Response Supporting Evidence, tab "Table 5 – TMS & HDD efficiency" for the efficiency scores for each company at Ofwat FD and from the CMA Working Paper

Company code	Ofwat PR24 FD		CMA		CMA (excl. DESNZ index)		Change between PR24 FD and CMA working paper
	Efficiency	Rank	Efficiency	Rank	Efficiency	Rank	
TMS	0.99	5	1.07	13	1.09	13	-0.08
NWT	1.01	6	1.01	9	1.04	11	0.00
HDD	1.03	7	0.84	3	0.85	2	0.19
SEW	1.04	8	0.96	6	0.96	6	0.08
SVE	1.04	9	1.01	11	1.04	9	0.03
SWB	1.09	10	1.01	10	1.04	10	0.07
WSH	1.10	11	0.99	8	1.01	7	0.11
BRL	1.10	12	0.98	7	1.01	8	0.12
NES	1.11	13	1.10	14	1.13	14	0.01
YKY	1.12	14	1.06	12	1.09	12	0.05
WSX	1.30	15	1.20	15	1.23	15	0.10
SES	1.33	16	1.32	16	1.34	16	0.01
SRN	1.56	17	1.38	17	1.39	17	0.18

52. As shown by Table 5 above, the substantial changes seen in Thames and HDD's efficiency scores between Ofwat's FD and the CMA's new model is not explained by the inclusion of energy input prices in the model as presumed by the CMA. In the version of CMA's water model without energy prices included, similar efficiency scores are achieved for both companies[40]. These significant changes to HDD and Thames' efficiencies are instead resulting from other novel aspects of the CMA's models.

53. A clear connection between Thames and HDD is related to scale and population density, with both being significant outliers (at other extremes) compared to the rest of the industry. The CMA has chosen to make significant changes related to these variables.

- **Scale:** Ofwat only included the connected properties driver in the top-down model, whereas the CMA has developed a PCA to also incorporate length of mains;
- **Density:** Ofwat triangulated between separate models with three different measures of density, whereas the CMA has now developed a PCA to in-effect incorporate all three measures together.

54. It is in fact this new treatment of density that is driving the unexpectedly large increase in HDD's efficiency score, and the direct knock-on effect to the catch-up efficiency challenge. As explained in Appendix 1, the sign of the coefficient for the linear density PCA, and the underlying coefficients is positive. This is unexpected and differs from the negative sign in Ofwat's models. The CMA has not explained the basis for this new relationship. However, what is clear is that this significantly impacts

[40] In a version of Wholesale water top-down model excluding energy input prices, HDD achieves an efficiency score of 0.854 and Thames Water achieves an efficiency score of 1.089.

on the 'U'-shaped relationship between density and costs at lower population density – whereby HDD is an extreme outlier as the least dense company.

55. Table 6 shows that whilst HDD is an outlier across all three measures of density, it is less of an extreme outlier in the properties per length of mains driver, where its density is approximately 50% of the median compared to 33% and 13% for the other density measures[41].

Table 6 6 - Ranking of alternative density metrics in the wholesale water sector by company[42]

	Properties per length		WAD – from LAD		WAD - MSOA	
Rank	Company	AMP8	Company	AMP8	Company	AMP8
1	HDD	40.9	HDD	236.7	HDD	1,017.1
2	WSX	53.2	WSX	363.4	WSH	1,673.0
3	WSH	53.6	ANH	569.8	WSX	1,761.2
4	ANH	59.5	SEW	654.2	ANH	1,803.0
5	SWB	60.8	WSH	652.6	SEW	2,109.2
6	SEW	72.2	SWB	1,123.8	SWB	2,165.9
7	YKY	74.4	YKY	1,102.3	SSC	2,781.8
8	SVE	78.9	NES	1,749.6	YKY	2,818.5
9	NES	78.4	NWT	1,905.5	SVE	3,088.4
10	BRL	80.7	SRN	1,916.6	NES	3,120.1
11	NWT	81.9	BRL	1,927.3	NWT	3,306.0
12	SRN	84.2	SVE	2,000.8	SES	3,337.7
13	SES	87.6	SSC	2,196.1	BRL	3,601.9
14	SSC	88.0	AFW	2,505.7	SRN	3,796.1
15	AFW	94.0	SES	2,468.8	AFW	3,803.4
16	PRT	97.5	PRT	2,877.3	PRT	4,342.4
17	TMS	130.4	TMS	7,131.4	TMS	8,892.8
	Median	78.9	Median	1,905.5	Median	3,088.4
	Company metric as percentage of median					
	HDD	52%	HDD	12%	HDD	33%
	TMS	165%	TMS	374%	TMS	288%

Note: Properties per length: the total number of connected properties (business and residential) in thousands divided by the total length of potable mains in km.

WAD – from LAD: Weighted Average Density calculated by attributing population density data from the ONS to companies based on area served at the Local Authority District geography.

WAD – MSOA: Weighted Average Density calculated by attributing population density data from the ONS to companies based on area served, from the more granular Middle Super Output Area geography.

56. In Ofwat's FD models, HDD's efficiency scores are highly unstable and differed significantly based on which density measure was used, as demonstrated in Table 7 below. Whilst it was an UQ company in models which included the properties per length density variable (where HDD was much less of an outlier), HDD ended up being one of the least efficient companies in other Ofwat models.

[41] The opposite effect can be observed for Thames which is an outlier as the densest company.
[42] See SRN11 - Southern Water Base Cost Response Supporting Evidence, tab "Table 6 – Density measures" for the calculations for this based in the Ofwat dataset.

Table 7 7 - Efficiency scores across Ofwat's twelve Wholesale water models

	WW1	WW2	WW3	WW4	WW5	WW6	WW7	WW8	WW9	WW10	WW11	WW12
	MSOA to LAD density		MSOA density		Property per length density		MSOA to LAD density		MSOA density		Property per length density	
	Water treated bands 3-6	WAC	Water treated bands 3-6	WAC	Water treated bands 3-6	WAC	Booster per length	APH	Booster per length	APH	Booster per length	APH
HDD	1.08	1.07	1.06	1.05	0.94	0.93	1.17	1.17	1.19	1.18	0.97	0.96
TMS	1.07	1.08	1.00	1.03	1.07	1.09	0.97	0.98	0.87	0.88	1.01	1.02
UQ	**1.00**	**1.00**	**1.02**	**1.02**	**1.02**	**0.99**	**0.97**	**0.98**	**0.97**	**0.96**	**0.97**	**0.96**

Source: Ofwat PR24-FD-CA05-Base-costs-water-model-3, sheet: Efficiency.

57. As shown in Appendix 1, the change in the sign of the linear density term in the PCA variable reduces the prominence of the U-shaped curve, particularly at extremely low densities. This modelling change drives the unexpected improvement in HDD's efficiency score.

58. The evidence above indicates that the PCA for density, introduced to address high multicollinearity, has resulted in an altering of the traditional U-shaped relationship historically accepted by regulators. Unless the CMA can clearly justify why this change in the cost relationship and associated atypical improvement in HDD's efficiency score is now appropriate, it would be wrong to rely on HDD to set the water catch-up challenge.

The CMA's increased challenge in wastewater network plus is driven by Yorkshire and Anglian's hedging strategies

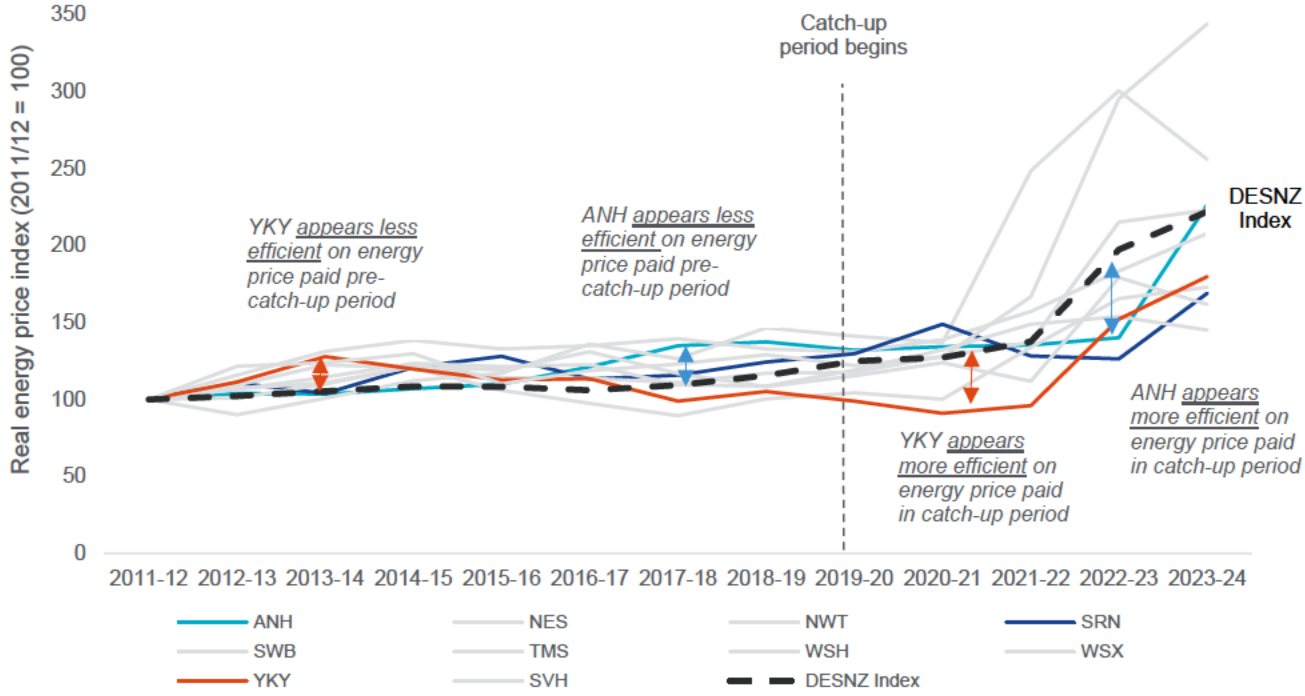
59. For reasons set out in Economic Insight's report[43], atypical energy price hedging strategies should not affect assessments of base cost efficiency or the degree of catch-up challenge. Outcomes from atypical strategies largely reflects uncertain market movements as opposed to managerial efficiency in procuring energy.

60. Base cost models using the DESNZ index as a cost driver are affected by the impact of hedging given this index captures the average hedging position of the non-domestic industrial users from which it is based, and not company-specific hedging strategies. This means the modelled efficiency of a company at a point in time is affected by its hedge coverage relative to the DESNZ index, especially during volatile markets.

61. As an alternative to the DESNZ index, implicit energy price indices for each company within the base cost dataset can be estimated by dividing reported power costs by energy consumption (e.g., p/kWh).[44] Figure 1 plots each company's implicit index against the DESNZ index below.

[43] Economic Insight (2026), The Treatment of Energy Input Price Inflation In Base Cost Econometric Models, pg. 8
[44] See SRN11 - Southern Water Base Cost Response Supporting Evidence, tab "Figure 1 – energy indices". The company's implicit and DESNZ indexes are sourced from the CMA's provided dataset through its "1A. Import data" R code.

Figure 1 - Impact of DESNZ energy index on modelled efficiency of UQ companies in wastewater



Source: Southern water analysis from CMA dataset

62. Figure 1 illustrates that company indices broadly tracked the DESNZ index prior to 2021. Notably, UK energy prices began rising even before the energy crisis was triggered by conflict in Europe in 2022, driven by a sharp increase in energy demand following the relaxation of Covid-19 social distancing measures. During the energy crisis, the degree of exposure to elevated prices varied across companies. This divergence reflects differences in hedge coverage between companies when the energy price shock occurred. It therefore captures the extent to which companies were insulated from the prolonged energy price shock due to the hedged position it held at that point in time.

63. This is relevant when setting AMP8 base allowances as the catch-up period used to assess UQ efficiency spans an extraordinary episode of energy price increases driven by Covid-19 recovery and geopolitical instability. For example, YKY is an UQ company and influences the degree of catch-up challenge. Figure 1 indicates that YKY was more insulated from energy price shocks during the whole of AMP7. A similar effect can be seen for ANH since 2022, which also influences the UQ. As noted in Economic Insight's report, ANH is a material outlier in their analysis of increases in energy import prices in 2022/23, due to its hedging position at that time.[45]

64. Including the DESNZ index as an explanatory variable in the base cost model, as opposed to the implicit company index, will result in both companies being assessed as more efficient relative to its peers during the catch-up period, all else held equal.

[45] Economic Insight (2026), The Treatment of Energy Input Price Inflation in Base Cost Econometric Models, p.10

Given their UQ position, this increases the industry catch-up challenge despite this outcome arising solely from hedging outcomes and market volatility.

65. Table 8 below contains the efficiency scores, and UQ challenge yielded from both the CMA working paper top-down wastewater model and instead the equivalent specification using the implicit company-specific indices as the energy cost driver to control for differences in hedging when assessing the degree of catch-up challenge.

Table 8 8 - Top-down Wastewater efficiency scores when including the DESNZ Index versus company-specific indices

	DESNZ Index		Company Indices	
Company code	Efficiency score	Rank	Efficiency Score	Rank
WSH	0.905	1	0.923	1
WSX	0.913	2	0.948	3
YKY	0.932	3	0.973	5
ANH	0.967	4	0.988	6
NWT	0.969	5	0.970	4
SVH	0.970	6	0.943	2
TMS	1.001	7	1.018	8
NES	1.023	8	0.994	7
SRN	1.135	9	1.149	10
SWB	1.145	10	1.143	9
UQ	0.941		0.953	

Source: Southern water analysis[46]

66. When removing the impact of hedging from the wastewater base model, the assessed efficiency of YKY and ANH falls[47]. YKY and ANH see a c.4% and 2% fall in modelled efficiency respectively during the catch-up period. Both companies lose two places in the efficiency ranking. The resulting industry catch-up challenge is 1.2% less stringent for the sector.

67. This evidence indicates that the CMA's choice of using the DESNZ index rather than company specific power costs is leading to an increased -catch-up challenge as some firms are appearing more efficient purely due to the fortunate timing of their hedging decisions; this is not management efficiency. The CMA should not be relying on these artificial efficiency scores for YKY and ANH to set the wastewater catch-up challenge.

[46] See SRN11 - Southern Water Base Cost Response Supporting Evidence, tab "Table 8 – efficiency scores" for the results of this modelling
[47] Whilst other companies (e.g. Welsh Water) also experienced a fall in efficiency score, we have focused on YKY and ANH, as the change in score directly impacts the CMA's proposed UQ catch-up efficiency challenge.

Proposed solution to the unduly stringent catch-up challenge

68. The CMA's proposed catch-up challenge relies heavily on a small subset of companies and how they are affected by the CMA's recent previously untested modelling changes. Our analysis indicates that some of these companies may be achieving artificially high efficiency scores due to unintended consequences of these changes and the unexpected cost pressures in the last 5 years. These inflated scores do not accurately reflect true performance and would create a distorted benchmark for the industry.

69. Setting the industry catch-up challenge based on these anomalies would be wrong. It is essential that any efficiency targets are grounded in robust, representative data rather than being driven by modelling artefacts.

70. This change to the catch-up challenge can be done through either:

    (1) manually removing or correcting companies that appear to have an unexpected increase in efficiency;

    (2) calculating the catch-up efficiency challenge over the full historical sample to alleviate these artificial efficiencies arising from hedging; or

    (3) moving to a sector median catch-up challenge to alleviate enduring uncertainty concerning new and untested models and techniques.

71. Option (1) aligns with Ofwat's approach to manually check if companies setting the UQ efficiency challenge were in a capital maintenance trough or were poor performers[48]. The issue with implementing option (1) is that it is unclear whether other companies may have similar issues that have not been identified in this short consultation window. The CMA would need to investigate if there are other companies for which there are unexpected counter-intuitive outcomes due to the modelling choices made by the CMA. Option (2) aligns with Ofwat's approach to determining the catch-up efficiency challenge for Bioresources at the PR24 Final Determination. By drawing on a broader dataset rather than relying solely on the most recent five years, it reduces the influence of cost shocks experienced by companies during the most recent period. Option (3) proposes a move to a sector median catch up challenge to reflect the lower confidence with the new CMA models which have not been scrutinised in the same way as standard Ofwat models. This approach would be consistent with the CMA's specific method for a reduced efficiency challenge to address similar modelling concerns for Bristol Water at the PR14 redetermination.

72. Table 9 sets out the catch-up efficiency challenge yielded from the three options, and Table 10 sets out the resulting allowances under the CMA's base cost modelling framework.

[48] See Southern Water, Response to the CMA's PR24 Provisional Determination, para 3.39-3.40 and supporting documentation appendix PDR-3-002 for full details of these Ofwat checks.

Table 99 - Comparison of catch-up challenge options

	Ofwat FD UQ challenge	CMA PD UQ challenge	CMA Updated UQ challenge	**Option 1) excluding companies from UQ[49]**	**Option 2) full historical sample UQ challenge**	**Option 3) sector median challenge**
Wholesale water	0.99	0.94	0.93	**0.95**	**0.95**	**1.01**
Wastewater	0.99	0.96	0.94	**0.96**	**0.97**	**0.97**

Source: Southern water analysis[50]

Table 10 10 - Impact on modelled allowances of moving to sector median catch-up efficiency challenge

	Ofwat PR24 FD - including RPEs (£m)	CMA PR24 PD (£m)	CMA Updated – UQ (£m)	**Option 1) excluding companies from UQ[51]**	**Option 2) full historical sample UQ challenge**	**Option 3) sector median challenge**
Wholesale Water						
Anglian	1,837	1,722	1,734	1,775	1,775	1,892
Northumbrian	1,484	1,403	1,366	1,398	1,399	1,490
South East	840	867	825	844	844	900
Southern	858	888	876	897	897	956
Wessex	530	634	529	542	542	577
Wholesale Wastewater						
Anglian	1,970	1,933	1,870	1,899	1,933	1,927
Northumbrian	867	828	790	802	817	814
Southern[52]	1,921	1,926	1,849	1,878	1,911	1,906
Wessex	973	886	898	912	929	926

Source: Southern water analysis[53]

49 Excluding HDD from wholesale water, and YKY and ANH from wholesale wastewater UQ companies.
50 See SRN11 - Southern Water Base Cost Response Supporting Evidence, tab "Table 9 – Alternative catch-up" for the results of this modelling
51 Excluding HDD from wholesale water, and YKY and ANH from wholesale wastewater UQ companies.
52 Southern's wastewater allowance does not include the coastal CAC value of £102m.
53 See SRN11 - Southern Water Base Cost Response Supporting Evidence, tab "Table 10" for the results of this modelling

73. These approaches are aligned with company plans, which are underpinned by bottom-up engineering reviews and with careful consideration of region-specific features which econometric base cost models cannot capture. These approaches are also aligned with the recommendations of the Cunliffe Review to move away from an overreliance on econometric models when setting appropriate base cost allowances.

Appendix 1: The CMA's LASSO models still contain several significant flaws

74. Following the response to its PD base cost models, the CMA has made several updates to its LASSO modelling framework. Whilst these partially address the most material concerns raised at PD, several issues persist. Moreover, the introduction of novel techniques introduces further complexity and issues which disputing companies have not had adequate time to interrogate.

If Principal Component Analysis (PCA) is adopted – it needs to be applied consistently, and its limitations need to be accounted for

75. To address the concerns raised with multicollinearity and multiple similar drivers within its PD models, the CMA has now chosen to introduce another novel modelling approach. Rather than including multiple scale and density drivers within one model, the CMA has utilised Principal Component Analysis (PCA) to develop single composite scale and density variables[54]. It appears that the CMA has chosen to apply PCA to improve statistical robustness and because the LASSO framework fails to discriminate between similar variables.

76. Adopting PCA has led to modelling outputs that are more complex to interpret. For example, the CMA's combined scale variable has a negative coefficient, which, if read at face value, suggests that efficient costs decline as scale increases. In practice, the implicit coefficients of the individual scale drivers underlying this combined variable are positive, but additional analysis is required to unpack the PCA to discern this. The CMA indicates that this outcome reflects the weighting applied by PCA to the coefficients; nevertheless, the resulting interpretation is not straightforward. The CMA itself states '*Unfortunately, however, the coefficient has no direct interpretation*[55]*'*.

77. The CMA has explained in its model commentary that *"The results show that for this model coefficients are either of intuitively expected signs or as (in the case of scale) are of the expected sign when the PCA weighting is taken into account.*[56]*"* Whilst the CMA's conclusion is correct in relation to the scale PCA, this is not the case for the density PCA, which when unpacked indicates that the model coefficients for the three underlying density drivers are also positive, and therefore at odds with the traditional U-shaped relationship in PR24 and acknowledged by regulators to date.

78. PCA yields multiple components, each summarising a distinct observed pattern across the original measures. In its base cost models, the CMA has chosen to include only the first principal component (PC1) for density and scale. The CMA state "*a subset of the principal components can be included in a model in place of the original variables. For example, if the original variables are highly correlated, the first principal component may adequately capture the variation in the underlying data*[57]". In selecting only PC1 for both

[54] The CMA specifically selected only the first principal component to include within base models
[55] CMA, Base Costs Modelling – Working Paper, page 46
[56] CMA, Base Cost Modelling – Working Paper, para. 3.17, page 19
[57] CMA, Base Costs Modelling – Working Paper, para. A.13, page 45

scale and density, it is unclear which features of the underlying cost drivers in the other principal components may have been omitted - and how much associated explanatory detail may have been lost. This is particularly pertinent given that the rationale for using alternative density drivers was to capture features that some density measures represent better than others, thereby improving confidence in the results.

79. Regardless of the changes made through PCA, there are enduring issues with strong correlations between the cost drivers selected by LASSO which drive multicollinearity, as indicated by the models failing standard variance inflation factor (VIF) tests. We also observe extreme modelled efficiency effects for HDD and Thames, who sit at the extreme ends of the sector's observed density distributions for all three measures of density used by the CMA. This indicates that the new density driver diverges from the traditionally observed relationship between base cost and density.

80. Furthermore, it is concerning that the CMA have adopted PCAs inconsistently. Whilst it has adopted this for the scale and density drivers, it continues to either include multiple correlating drivers for economies of scale at sewage treatment plants or actively choose only one water treatment complexity variable.

81. The CMA states that both water treatment complexity measures are derived from the same underlying data, whereby one variable uses a discrete percentage banding measure and the other uses a weighted average measure, and therefore differ only in weighting, so a PCA would not add any further insight beyond the calculation differences.[58] This argument is particularly weak as the exact same reasoning could be applied to the density drivers which are also drawn from different cuts of the same underlying data. For consistency, the CMA should include a PCA in all instances of highly correlated drivers.

The PCA included for the density driver in the water model does not have an intuitively expected sign

The traditional 'U'-shaped relationship between base costs and density measures

82. Ofwat explained that population density can have two opposing effects on wholesale water base costs. CEPA, Ofwat's advisor, explain *clearly "At lower levels of density, scale economies are strong and therefore increasing density reduces costs. However, the positive effect of the quadratic term suggests that as density rises its negative impact on costs decreases, ultimately becoming positive at high values of density."* [59] This relationship is therefore often referred to as holding a 'U'-shape.

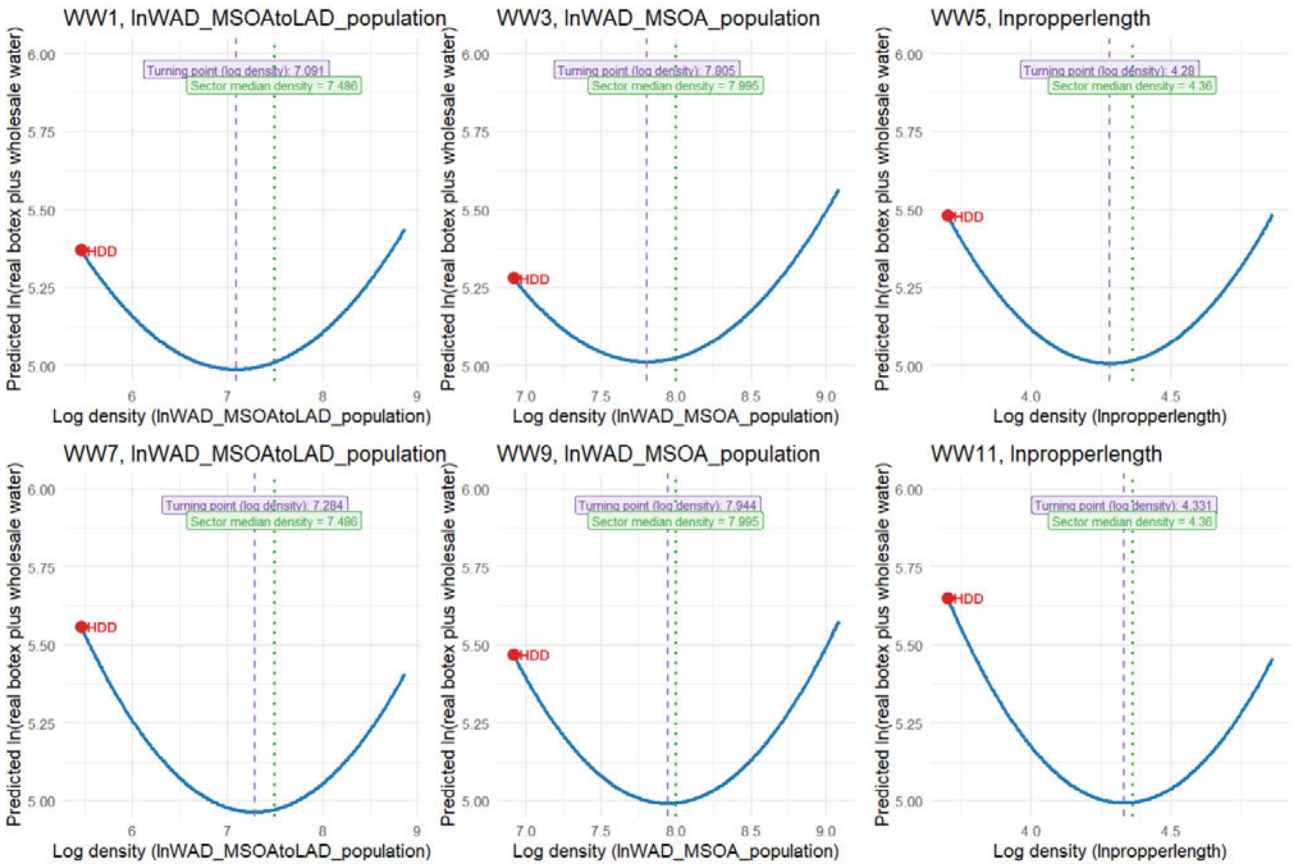
83. In Ofwat's PR24 wholesale water base cost models, density was specified in a quadratic (squared) form to capture this U-shaped relationship. Across all twelve models (using three measures of density), the linear density term had a negative coefficient, and the squared term had a positive coefficient. This empirical pattern is consistent with the economic and engineering logic set out by CEPA.

[58] CMA, Base Costs Modelling – Working Paper, para 3.9
[59] CEPA, PR24 Wholesale Base Cost Modelling, April 2023, Footnote 18,

84. In other words, the observed U-shaped relationship reflects two opposing effects - economies of scale at low density which reduce base costs, while congestion and operational complexity at high density increase them. As density rises, costs fall to a minimum and then rise beyond that point. See Figure 2 below which show this cost relationship in Ofwat's wholesale water cost models.

85. For all three density measures, the estimated turning point at which costs begin to increase occurs at density levels broadly in line with the sector median, subject to the specific model specification. This implies that many companies operate close to the cost-minimising range of density, so further increases in density may provide limited additional cost savings, while both lower- and higher-density conditions are associated with higher costs. This establishes a reference point for assessing whether the cost–density relationship implied by the CMA's new combined density driver aligns with established economic logic and the available empirical evidence.

Figure 2: Estimated relationship between density and costs in Ofwat's wholesale water cost models



Notes: The curves are based on margins from Ofwat's WW1, WW3, WW5, WW7, WW9 and WW11 base cost models. Models 1,3 & 5 include booster pumping stations. Models 7, 9 & 11 include average pumping head.[60]

[60] For completeness, see SRN11 - Southern Water Base Cost Response Supporting Evidence, tab "PR24 FD density Curves" for the similar relationship from the six other Ofwat Wholesale Water cost models. To replicate these relationships, see R script file "SRN7 - density analysis - 2A. Water - Regression Baseline.R".

The relationship between base cost and density implied by the CMA's approach

86. PCA takes several related measures and turns them into a set of summary variables called principal components (PC). Each PC captures a distinct pattern in the data. This can be beneficial because principal components can combine overlapping information into a subset of non-overlapping summaries. This can tackle multicollinearity, a key concern raised with the PD models, given the PCs are constructed to be uncorrelated with one another.
87. The PCA of the density variables undertaken by the CMA produces three principal components (PC). Each PC captures a different aspect of the observed density measures. In simple terms, each density PC captures a different, relevant pattern in the selected density measures whereby each density PC is also uncorrelated with one another.
88. The CMA has chosen to include only PC1 in the base cost models. PC1 captures the largest share of variation in cost across the three density measures, but not all of it; the remaining variation sits in PC2 and PC3. The other two components (PC2 and PC3) represent distinct, observable features of density that are not fully reflected in PC1. Based on the reported loading patterns[61], PC1 places the greatest structural weight on the two MSOA-level density measures, whereas PC2 loads most strongly on variation within the properties per length measure.
89. In the model selected by LASSO, both the linear and squared density PC1 coefficients are positive. A positive sign on the linear density variable coefficient is counter-intuitive at face value and departs from Ofwat's models; it implies that costs rise as density increases across the observed range, with the rate of increase accelerating at higher density, rather than exhibiting the traditional U-shape (with an initial cost-reducing effect at lower density). However, we note the CMA's statement that the coefficient of the PCA has no direct interpretation without recovering the true coefficients of the original density variables underpinning it.
90. The CMA has explained in its model commentary that *"The results show that for this model coefficients are either of intuitively expected signs or as (in the case of scale) are of the expected sign when the PCA weighting is taken into account.[62]"* Whilst the CMA's conclusion is correct in relation to the scale PCA, this is not the case for the density PCA, which when unpacked indicates that the model coefficients for the three underlying density drivers are also positive, and therefore at odds with the traditional U-shaped relationship acknowledged by regulators to date (see Table 11 below).

[61] In principal component analysis, the loading of variable X_j on component PC_k is the coefficient (weight) in the linear combination that defines PC_k. It quantifies the strength and direction of the association between X_j and PC_k

[62] CMA, Base Costs Modelling – Working Paper, para. 3.17, page 19

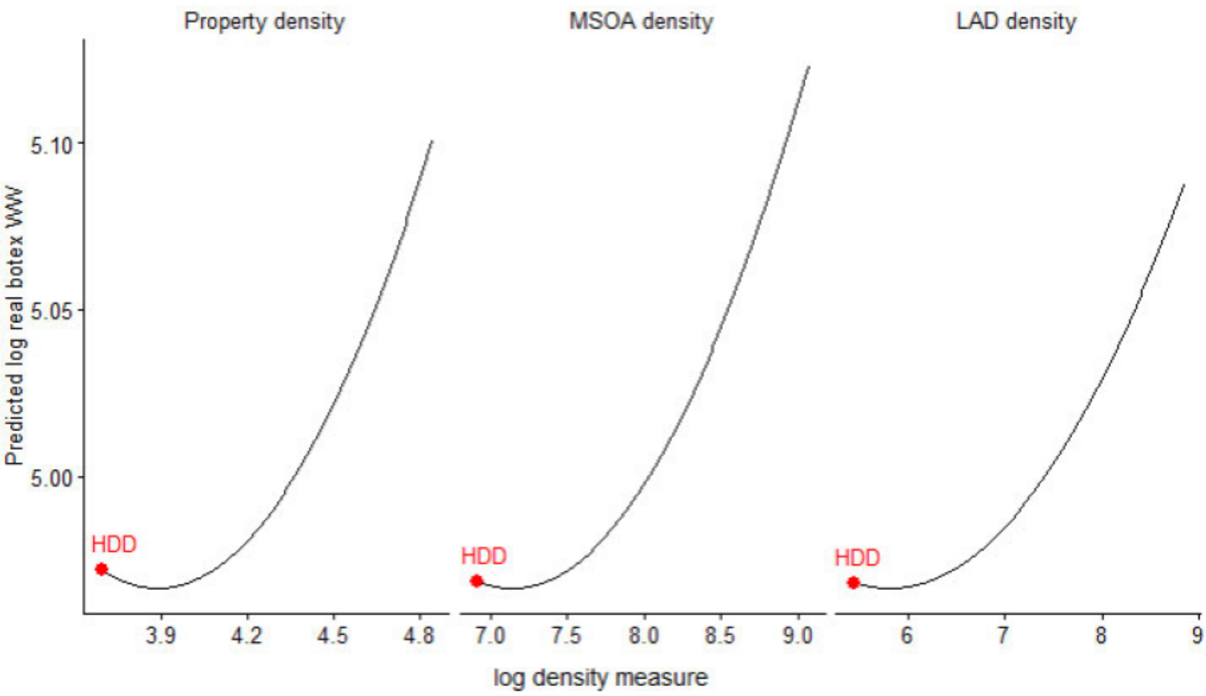
Table 11 11 - Coefficients of the density drivers in density PC1 variable

Driver	Coefficient
LAD from MSOA - weighted average density (log)	0.036
MSOA - weighted average density (log)	0.064
Properties per length - density (log)	0.120
Density combined PCA (log)	**0.05**

Source: Southern water analysis[63]

91. These coefficients result in the skewed U-shape described above, with an earlier turning point and a steep upwards arm (see Figure 3 below) when combined with the positive quadratic density term.

Figure 3 - Underlying density variable cost curves within combined density PC1



Source: Southern Water analysis[64]
Note: Each curve shows the predicted log cost as a quadratic function of a single log-density driver, obtained by mapping that driver through the ***linear PCA (PC1)*** *and evaluating the model* $\beta_1 \cdot PC1 + \beta_2 \cdot PC1^2$ *with all other variables held at their means*

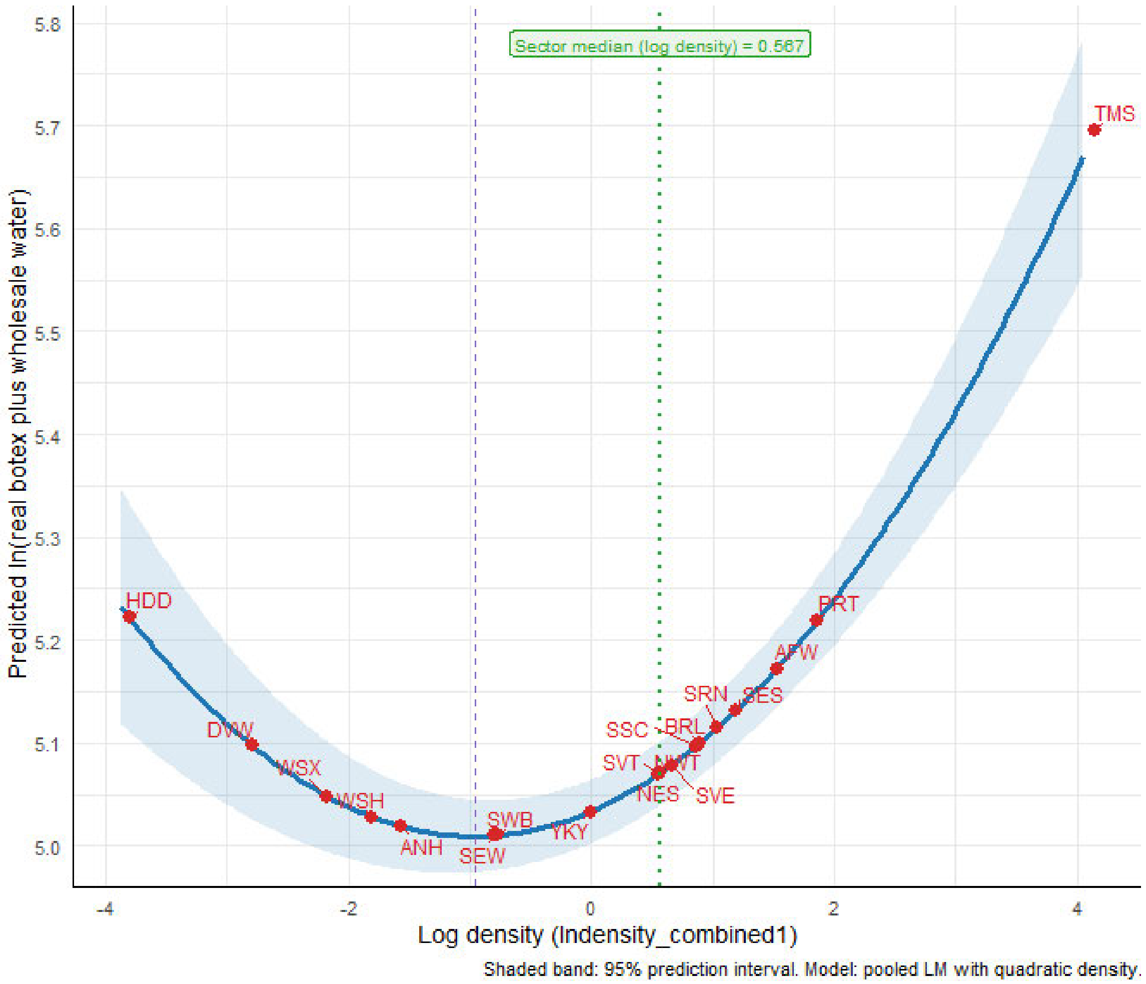
92. The U-shaped relationship estimated using PC1 differs materially from Ofwat's models. First, the turning point occurs at a density level below the sector average, indicating that any economies of scale are limited and are rapidly offset by

[63] See SRN7 - density analysis - 2A. Water - Regression Baseline.R for the R script
[64] See SRN7 - density analysis - 2A. Water - Regression Baseline.R for the R script

congestion effects. Second, the upward-sloping segment is longer and steeper, implying that congestion-related cost increases affect a larger share of companies, rather than predominantly the most densely served firms. This pattern is a consequence of the choice to include only PC1 - capturing a single density pattern with greater weight on the MSOA-based measures, without incorporating the complementary density features captured by PC2 and PC3.

93. To make the implications transparent, we have plotted the quadratic relationship implied by the CMA's wholesale water model (see Figure 4 below).

Figure 24 - CMA wholesale water combined density driver relationship



Source: Southern Water analysis[65]

94. The turning point occurs well below the sector-median density, and by a far wider margin than in any one of Ofwat's Final Determination models. This is counterintuitive given that the combined driver is based on the same underlying density measures that Ofwat used. A plausible explanation is the reliance on a single principal component (PC1), which places greater weight on particular density measures and underlying patterns and may therefore omit relevant variation captured by the other components.

[65] See SRN7 - density analysis - 2A. Water - Regression Baseline.R for underlying R-script

95. When PC2 and PC3 are used within the LASSO framework, they lead to different variable selections, coefficient estimates, and therefore different allowances. Consequently, by selecting only PC1, especially one that places more weight on specific density measures, it is unclear which important density features are being attenuated or lost. In this respect, it appears CMA may have inadvertently selected one of several distinct patterns within the density measures and anchored the density relationship on that single pattern. Accordingly, the revised cost–density relationship departs from the traditional U-shape and has contributed to pronounced, undue movements in efficiency estimates for TMS and HDD.

96. We acknowledge the CMA's efforts to improve model performance, however it is not clear that the CMA has considered these issues. Based on the above we draw the following conclusions:

   (1) features of the combined density analysis, particularly the reliance on a single principal component (PC1) and the resulting coefficient signs, conflict with established economic and engineering logic on the relationship between cost and density in base costs (typically U-shaped);

   (2) this has resulted in material swings in estimated efficiency at the extremes, (HDD and TMS) and thereby distorted the mechanically calibrated catch-up challenge;

   (3) the complexity of the PCA approach and its limited interpretability under the current time constraints mean that neither the CMA nor disputing companies have had adequate opportunity to interrogate and test the new modelling artefacts introduced by this specification; and

   (4) as a result, confidence in the model and the efficiency scores it yields is constrained.

Not including the new density PCA driver in its top-down wastewater model

97. At PD, the CMA chose to include all three density drivers as part of the set of candidate variables for top-down and bottom-up wastewater models. The density drivers were all chosen by LASSO as part of the wastewater network plus top-down model. Now, the CMA has chosen to not include the density driver within the candidate set of variables for the top-down model. This is the only cost-driver that was picked at PD but is now excluded entirely from the set of candidate variables for that same model.

98. The CMA's specific reasoning provided for not including the density driver is because Ofwat only included density in its SWC model.[66] However this reasoning is not consistent with the revised base cost modelling approach set out in Section 2, whereby the CMA explain only that it is *"ensuring that the cost drivers it uses have an economic and engineering rationale"*[67] and does not explain that it would only include drivers which were selected in the equivalent level of aggregation by Ofwat.

[66] CMA, Base Costs Modelling – Working Paper, Footnote 36, page 27
[67] CMA, Base Costs Modelling – Working Paper, para 2.15

99. CEPA, Ofwat's advisors, did initially investigate including a density driver in the wastewater network plus model and found the properties per sewer length driver had both engineering and economic rationale for potentially including. However, CEPA ultimately was concerned that *"the R-squared value of all three models is slightly lower than the univariate regression model with just load.[68]"* This statistical concern is not a relevant consideration under the CMA's LASSO modelling framework, as LASSO will pick the variable if it improves the RMSE of the model. When the density PCA is included in the set of candidate variables, it is picked and the model has a lower RMSE than when it is excluded (34.9 versus 35.7). Table 12 below sets out the full comparison of the CMA's statistical robustness testing with and without this driver included.

Table 12 – Replication of CMA's statistical robustness testing for Wastewater Network Plus model including and excluding Density PCA

CAC Wastewater Network plus model (including density PCA variable)		
Statistical test	P-value	Interpretation
RESET	0.21	No evidence of model misspecification
Max VIF	13.88	High multicollinearity (VIF >10)
Shapiro-Wilks	0.10	We cannot reject the hypothesis that residuals are normally distributed
Breusch-Pagan	0.02	Heteroskedasticity present
R-Squared	0.95	Model explains ~95% of variance
Adjusted R-Squared	0.95	Confirms strong explanatory power
CMA Wastewater Network plus model (excluding density PCA variable)		
RESET	0.11	No evidence of model misspecification
Max VIF	5.07	No serious multicollinearity (VIF < 10)
Shapiro-Wilks	0.05	We cannot reject the hypothesis that residuals are normally distributed
Breusch-Pagan	0.01	Heteroskedasticity present
R-Squared	0.95	Model explains ~95% of variance
Adjusted R-Squared	0.95	Confirms strong explanatory power

[68] CEPA, PR24 Wholesale Base Cost Modelling, April 2023, p41

100. The Wastewater Network Plus model including the density PCA driver has very similar modelling performance to the original CMA wastewater network plus model. The only statistical robustness test that differs materially in outcome is related to multicollinearity, which was always present but there is evidence of higher levels in that model specification. In line with the CMA's treatment of this statistical test[69], and Ofwat's original guidance at FD[70], we do not view this as invalidating predictions of the model for benchmarking, but we consider that more caution may be required when interpreting specific model coefficients.

101. Moreover, the CMA's specific reasoning for excluding the density driver does not appear consistent with it developing PCAs for different scale drivers for the top-down models. At FD, Ofwat only included Sewer Length in the SWC model and Length of Mains in the TWD models. Yet CMA persists in developing PCAs for the top-down models to incorporate these drivers which were originally not chosen by Ofwat in the equivalent FD model. This is inconsistent with the CMA's decision to exclude density based on what was included by Ofwat in the top-down models.

102. The CMA should include the density PCA driver in the candidate set of variables for the wastewater network plus model and see if it is chosen by LASSO.

Bootstrapping approach does not provide any further sensitivity to the CMA results

103. As part of its sensitivity analysis, the CMA performs a repeated sampling analysis using a bootstrapping approach to resample the data multiple times and observe the stability of the model predictions under different cuts of the data.

104. The CMA explain that this bootstrapping is more appropriate as a sensitivity than removing the most or least efficient company from the sample as some responses to the PR24 PD suggested. The CMA's reasoning for this is because an individual company data cannot be lost in the event of a merger. It is unclear what relevance this has to checking the sensitivity of a model to the removal of an outlier. The CMA does not mention that this test was one of Ofwat's chosen model robustness tests that was employed at PR24 with results provided at FD for each model[71]. Moreover, CEPA used this sensitivity as a basis for including and excluding drivers at the start of the PR24 process.

105. What is unclear about the bootstrapping approach taken by the CMA is how it then makes use of these results as a sensitivity. For example, in the wastewater bootstrap

[69] CMA, Base Costs Modelling – Working Paper, para 2.22 *"It is however important to recognise that, in the presence of potential multicollinearity between sets of variables, limited weight should be placed on the interpretation of individual model coefficients…For this reason,* ***our modelling approach places greater emphasis on the overall predictive performance and robustness of the model, rather than on the interpretation of specific parameter estimates."***

[70] Ofwat, December 2024, Expenditure allowances - Base cost modelling decision appendix, page 62 "*But while the high collinearity may impair our ability to accurately estimate the impact of the individual terms on the dependent variable,* ***it should not impair our ability to accurately estimate their collective impact.*** *Since these two terms always move together,* ***the collective impact is what is important****."*

[71] Ofwat, December 2024, Expenditure allowances - Base cost modelling decision appendix, page 63.

runs the CMA presents evidence to show that the construction wages driver is chosen in 59% of bootstrap runs, whilst the load treated in size bands 1 to 3 driver is chosen in only 57% of bootstrap runs[72]. The CMA then neglects to consider the implications of construction wages subsequently not being chosen in the final LASSO model whilst the bands 1-3 driver is chosen.

Proposed solution

106. In this appendix we have set out a number of modelling issues that remain within the CMA's LASSO models. There are some simple changes that can be made to address these (e.g. include the density PCA driver in the candidate set of variables for the wastewater network plus model). We are conscious that it may not be possible to address the other substantial issues may not be possible to address within the timeframe of this redetermination.

107. The issues identified cast significant doubt on the conclusions that can be reached from the modelling results and consequently the CMA should moderate its interpretation of these results and the resulting catch-up efficiency.

[72] CMA Base Costs Modelling – Working Paper, table 4.6, page 37.

Appendix 2: Further issues from the Working Paper

Our arguments around data quality for Average Pumping Head Variable have never been responded to

108. The CMA has now noted that *"Since our PR24 PD, we have not seen sufficient evidence to change our view on the data quality of the APH cost driver, so include this in our updated bottom-up TWD model and our top-down wholesale model[73]."* We were unaware that the CMA had come to a view on the data quality of the APH cost driver. In its PD, the CMA indicated explicitly that LASSO was the appropriate mechanism to determine whether APH should be included in the model[74]. The CMA noted it did not want to assess our APH-related submission in a "piecemeal way" and the logical conclusion was that the CMA had not made an assessment on the data quality of the APH cost driver at this point.

109. Our concerns regarding APH data quality have been set out in depth both in written submissions and at the base cost hearings. As we noted in our response to the PD, we are concerned that no assessment has been conducted by the CMA of the representations we have made.[75] If the CMA has indeed concluded that APH data quality is good, we ask to see the details of this assessment so we can respond prior to the CMA making its final determination.

South East's claim for Economies of Scale at WTW

110. The CMA has invited views on its proposed CAC-specific modelling approach for assessing South East's claim for economies of scale at WTW[76].

111. We welcome that the CMA has accepted the concerns we raised in our PD response related to the inclusion of the average size of WTW within the candidate set of variables for the LASSO modelling[77]. At PD, given it sought a within-model solution, the CMA chose to remove the CAC allowances provided by Ofwat to Southern and Wessex for this issue[78]. Now that the CMA is proposing a separate CAC specific model for South East, we consider that the rationale for the PD adjustment no longer applies. Accordingly, we believe the CMA should reinstate Southern's CAC allowances of £19m originally provided by Ofwat. If this is not the CMA's intended approach, then we reserve the right to come back on this issue prior to the CMA making its final determination.

112. In our response to base cost modelling issues, we noted that there may be benefits in including the WATS variable in the LASSO candidate set.[79] However, given the CMA's modelling framework, it is only possible to use this variable to assess the CAC

[73] CMA, Base Costs Modelling – Working Paper, para 3.7
[74] CMA, Provisional Determination, Volume 1, para 4.34 -4.36
[75] Southern Water, Response to the CMA's PR24 Provisional Determination, para 3.55
[76] CMA, Base Costs Modelling – Working Paper, para 5.9
[77] Southern Water, Response to the CMA's PR24 Provisional Determination, para 3.57-3.66
[78] CMA, Provisional Determination, Volume 1, para 4.499
[79] Southern Water, comments on main party submissions on base cost modelling, para 23

in a separate model, as the bottom-up WRP model is not included in a triangulated approach as previously applied by Ofwat.

113. We can see the merit to the CMA's approach of assessing South East's CAC by including both WATS and average size of WTW in its CAC-specific model to reflect the full range of evidence on economies of scale, and let LASSO decide if the variables should be selected.

Approach to true-ups

114. We are pleased the CMA has confirmed a true-up will be used for energy and wages and added detail to its proposed approach. In our response to PD, when it was unclear whether the CMA would adopt this, we set out that this was required[80].

115. These true-ups will certainly be necessary, particularly in energy. In our Statement of Case we had a specific claim related to Ofwat's overly optimistic forecast, which was not in line with the most recent forecasts we have seen[81]. This issue is still relevant now that this Ofwat forecast has been incorporated into the base model.

116. The CMA note that *"the resulting true-up would therefore be calculated as follows:* ***True-up = %contribution × modelled allowance × change in index"***[82]

117. It will be helpful for the CMA to provide more clarification of each aspect of this calculation so we can ensure that we have correctly interpreted the proposed true-up approach. We understand the CMA has meant the following for each term within the formula:

   (1) **% contribution:** should be the industry average of power costs as a share of base costs for wholesale water and wastewater network plus for the period from 2019/20 to 2023/24;

   (2) Modelled Allowance: The total modelled allowance for each company in AMP8 for wholesale water and wastewater network plus respectively; and

   (3) **Change in index:** the percentage change in the index of the outturn index (in outturn real terms) relative to the ex-ante index (based on ex-ante inflation assumptions) used in the CMA FD.

118. We also reiterate our request from our PD response that the CMA should apply a true-up on an annual basis during AMP8 (as opposed to an end-of-period true up proposed by Ofwat originally). This will provide more protection from the significant cashflow risk we anticipate given the more recent energy price forecasts we have seen.[83]

[80] Southern Water, Response to the CMA's PR24 Provisional Determination, para 3.116-3.121
[81] Southern Water, Statement of Case, pages 190-199
[82] CMA, Base Costs Modelling – Working Paper, para 5.4
[83] Southern Water, Response to the CMA's PR24 Provisional Determination, para 3.121

Appendix 3: Further details related to HDD being atypical and inappropriate to form the basis for the industry efficiency benchmark

Data discrepancies in HDD explanatory variables

119. There are material and unexplained changes in some key explanatory variables between 2017-18 and 2018-19 which cast doubt on the stability of the factors influencing the modelling.

120. One anomaly in the data is related to APH. Given the change involved in moving some assets and customers between licensees, weighted average APH across both companies would be expected to remain broadly equal within a regulatory year. Instead, we see large increases for both companies after HDD was formed:

    (1) DVW reported an APH of 57.5 in 2017-18, whereas HDD reported an APH of 120.7 in 2018-19, showing an increase of 110% year-on-year. Given that approximately 75% of HDD's customer base in 2018-19 originated from DVW whose APH was 57.5, the 39k new customers from Powys would need to have an APH of 228 to reach HDD's new combined APH of 120.7. This is roughly double the highest value reported by any other company[84].

    (2) SVT reported an APH of 93.8 in 2017-18, increasingly by 5% to 98.4 for SVE in 2018-19[85].

121. A similar anomaly arises in the reported figures for mains length. HDD shows an increase of 29% in mains length compared to DVW, while also reporting 18% fewer customers. This implies that the transferred Powys area customers would have had an average density of 25 properties per km of main, a value that is three times lower than the industry median.[86]

122. As these two variables are critical in assessing relative efficiency e.g. higher APH implies more efficiency and length of main drives connected property density values, the substantial unexplained increase observed for HDD is a challenge if they are to be relied upon for the efficiency benchmark.

[84] Sources: Ofwat base costs dataset for water. See the variables BN4870 for APH, BN1100 for mains length, and BN2221 + BN2161 for properties.
[85] Sources: Ofwat base costs dataset for water. See the variables BN4870 for APH, BN1100 for mains length, and BN2221 + BN2161 for properties.
[86] Sources: Ofwat base costs dataset for water. See the variables BN4870 for APH, BN1100 for mains length, and BN2221 + BN2161 for properties.