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PR24 Draft Determination: UUW Representation

Area of representation: Cost and PCDs - Phosphorus removal

August 2024

This document outlines UUW response to the DD for the phosphorus removal enhancement case

Reference to draft determination documents: PR24-DD-Phosphorus-removal-cost-adjustment, PR24-draft-determinations-Expenditure-allowances-Enhancement-cost-modelling-appendix p32

United Utilities

Water for the North West

1. Key points

- **Ofwat's approach appears to systematically underfund phosphorus removal:** We consider that there is considerable scope to better align cost assessment to the pressures and challenges that companies are attempting to navigate in AMP8.
- **AMP8 cost pressures are not appropriately reflected in AMP7-based cost forecasts:** More weight should be placed upon forward-looking AMP8 costs within cost assessment, as AMP7 costs are not a valid basis on which to predict the cost of meeting AMP8 requirements. In addition to working at smaller sites, the industry is targeting much more stringent permit limits in AMP8 than it did in AMP7, towards the technical achievable level of 0.25mg/l .
- **Ofwat should reflect the higher construction costs of biological solutions in its cost benchmark:** biological phosphorus removal is the best value and more sustainable option for large sites that have both low phosphorus and tight sanitary drivers providing a better investment for customers in the long-term. Ofwat should reflect this within the regulatory framework.
- **Ofwat should update the Price Control Deliverable to reflect the WINEP profile:** The PCD set out in DD limits opportunity and penalises delivery in line with the WINEP regulatory dates. This should be updated to align with funded investment and therefore not penalise for on time delivery.
- **We have challenged ourselves on cost:** We have driven down the totex for phosphorus removal schemes in AMP8 by reviewing the scope of individual schemes. This has allowed a £56 m reduction in costs from that submitted in our business plan across five projects.

2. UUW's PR24 proposal

In our business plan, costs for phosphorus removal projects were included within the chemical and biological phosphorus removal and within the wastewater nutrient balancing cost drivers. Detail for our approach to phosphorus removal was included within the UUW63 Final Effluent document. Catchment nutrient balancing was included in the plan for nine sites which are also included within the phosphorus plan but with a less stringent P limit than the WINEP due to the catchment offsetting opportunity. At submission UUW did not recommend a price control deliverable for phosphorus as delivery was included within the ODI mechanism for the river water quality performance commitment. However, an option for a phosphorus removal PCD was included within UUW63.

3. Draft determination position

Ofwat has developed four econometric models to assess phosphorus removal costs. Two of these models are backwards-looking, using data on the AMP7 phosphorus removal programme, while two are forward-looking, using data on companies' proposed phosphorus expenditure within AMP8. These models perform well in terms of statistical significance, though there is a noticeable deterioration in the model fit of the backward-looking AMP7 models. PR24 is the first time Ofwat has used a scheme-level econometric approach.

Ofwat assesses outliers separately. It identifies outliers using the Cooks Distance statistic. Outliers are subject to a deep dive assessment. 'Efficient' outliers receive the business plan value rather than the (higher) modelled value. 'Inefficient' outliers receive the modelled value if insufficient evidence has been provided to support higher cost forecasts.

Ofwat does not distinguish between chemical and biological solutions, because it considers that biological solutions will only be adopted at a small number of sites in AMP8.

Ofwat includes two of UUW's largest sites within its contingent funding framework. There is a substantial cost challenge across the remainder of UUW's phosphorus programme.

Ofwat applied a high-level 'shallow-dive' efficiency assumption to UUW's catchment nutrient balancing programme.

4. Issues and implications

There are various issues which are further detailed below, as to why Ofwat should revisit its approach to cost assessment for UUW's P removal projects.

4.1 Ofwat's approach appears to systematically underfund phosphorus removal

In its DD, Ofwat notes that its approach:

> *"…Leads to a strong efficiency challenge to business plans of 19% at the sector level."*[1]

We are clear that this represents an unrealistic challenge and this representation sets out the reasons for this. However, we consider that the sector-level efficiency challenge quoted by Ofwat masks some company-level issues. In particular, we consider that one low-cost company appears to be masking the level of efficiency that Ofwat is requiring across all other companies in the delivery of a statutory obligation.

There is a risk that Ofwat is understating the true efficiency challenge at an industry level

Table 1 sets out the gap between Ofwat's models and company business plan requests (excluding those schemes that are assessed as outliers). It reveals that most companies are subject to a substantial cost challenge across their phosphorus removal programmes. However, it also reveals that Anglian is targeting costs that are substantially below the industry benchmark. This effectively masks the true efficiency challenge that Ofwat is imposing upon the industry.

Table 1: Gap to Ofwat's models by company (outliers excluded)

Company	Cost challenge (£m), negative values indicate a gap to Ofwat's model	Percentage difference
ANH	413	85%
HDD	0	-1%
NES	9	43%
SRN	-71	-16%
SVE	-146	-24%
SWB	-10	-9%
TMS	-516	-41%
NWT	-208	-43%
WSH	32	21%
WSX	-422	-45%
YKY	-2	-1%
Total	-922	-19%
Total excluding ANH	**-1,335**	**-30%**

Source: UUW analysis

Given this, we consider that it is reasonable to ask whether this cost challenge is realistic. One company is a materially low-cost outlier, while most others face substantial cost challenges. Excluding Anglian, the total

[1] Ofwat (2024) *Draft Determinations: expenditure allowances.*

industry cost challenge is £1.3bn. We do not consider that this would appear reasonable to an outside observer, particularly when the programme in question is statutory. We consider that there is considerable scope to better align cost assessment to the pressures and challenges that companies are attempting to navigate in AMP8.

This representation sets out evidence to support our case that Ofwat's chosen set of models are less able to explain the costs the industry in general, and UUW in particular, can expect to efficiently incur in the delivery of their AMP8 WINEP.

4.2 Site-specific costing increases the accuracy of cost estimates

Ofwat has identified some of UUW's schemes as outliers, sitting either below or above Ofwat's view of efficient cost. Ofwat removes these schemes from its models and assesses them through a deep dive process. Efficient outliers receive the business plan value while efficient outliers receive the modelled allowance unless companies an provide compelling evidence of cost efficiency.

UUW implements an approach that develops scheme-level costing. This contrasts with the uniform approach other companies have taken. We consider that site-specific costing is an optimal approach. It identifies and mitigates site-specific risks, which enhances overall deliverability. It also identifies sites where costs are expected to be lower, the benefit of which can be passed back to customers.

This section contains two case studies of our AMP8 site costings:

- One is a particularly high-cost scheme; and
- One is a particularly low-cost scheme.

We provide detail on both to highlight the site-specific reasons why costs may vary at otherwise similar sites.

Case Study One – Low Marple (High Outlier)

Table 2: Low Marple WwTW example

UU Cost	Draft Det.	WINEP Drivers	Solution
12.15	3.86	EnvAct_IMP1 WFD_IMPg WFD_IMP_MOD (0.5mg/l P)	Tertiary solids removal & chemical dosing

Source: UUW63 Final Effluent enhancement case and July 2024 WINEP

Figure 1 shows the current location and layout of Low Marple WwTW. It is a small filter works with a current permit of 40mg/l BOD and 60mg/l suspended solids. The solution for Low Marple WwTW to achieve the new requirement of 0.5mg/l phosphorus includes a new inlet works, primary settlement tank (PST) distribution chamber, upgrade of the trickling filters, ferric and caustic dosing and tertiary solids removal (TSR). This treatment scope has been sized based on the headroom and performance of the existing assets which has identified assets which may not have been picked up in the econometric models such as the need for a new inlet works, distribution chamber and upgrade of the existing trickling filters.

The site has a relatively small and old inlet works. Even for tight phosphorus permits most of the crude phosphorus is removed in the PSTs through ferric assisted settlement. The current inlet will not provide sufficient preliminary removal to ensure that the PST can remove enough solids for the new P permit. Improving the inlet works performance also removes the risk of blockage to the downstream TSR process.

To guarantee the low phosphorus permit is achieved, PST performance will need to be improved. To do this the flow split to the PSTs needs to be balanced through a new distribution chamber. This is also necessary to manage an increase in maximum instantaneous flows due to the TSR backwash returns and eliminate potential flooding risk. To enable these works, temporary over pumping will be required.

The humus tanks are hydraulically undersized and it was determined that refurbishing the trickling filters to make them motor rather than hydraulically driven would reduce solids sloughing thereby taking sufficient pressure off the humus tanks and avoiding overloading the TSR with solids. This is a significant saving compared to installing new humus tanks as can be seen in Table 3.

Table 3: Low Marple WwTW scope to improve solids

Scope	Cost (£k)
Change filters to motor driven	139
New humus tank	1,674
Total cost saving	**1,535**

TSR is required to achieve low phosphorus of 0.5mg/l. The TSR will ensure effective capture and management of solids which is essential for these tight P permits.

Due to the topography of the site, influent to the TSR will need to be pumped, as will the dirty backwash returns. As this is a first-time chemical dosing site all ancillary equipment is also needed, including tanker unloading points, blind tanks, MCC kiosks and instrumentation. The access road to site is shown in the image below (Figure 1) and is not suitable for construction traffic. It goes down a steep slope between residential properties and through the centre of a working farm. To enable a capital project to take place, a significant upgrade of the existing access road is therefore required.

Figure 1: Low Marple WwTW

Turning areas for chemical deliveries will need to be established on site and demolition of old sludge drying beds, which will contain hazardous material will be required at additional cost. There are 11KV overhead cables crossing the access track and the southern element of the works. This has restricted the positioning of new assets. The site is also within a flood zone 3 with a main river on its western and southern boundaries, therefore there will be additional construction costs for external groundwater control in the form of coffer dams for shallow excavations. The prevailing ground conditions have resulted in the need for excavation in rock and piling for all structures on the west of the site.

Due to limited land availability 50% of the excavated material must be removed from site. Made ground is observed up to 2m below ground level and so for excavations up to this level we have applied a percentage of treatment associated with decontamination of material. There is insufficient power on this site for future process assets and therefore the site requires a significant power upgrade including a new High Voltage substation and ring main.

These site-specific factors are leading to efficient costs that are higher than implied by Ofwat's model. In particular, we do not consider that the backwards-looking model will reflect comparable levels of the activity described above. This is because of the different nature of AMP7 and AMP8 phosphorus removal programmes evidenced in section 4.1. The draft determination allowance is less than a third of the scheme level cost we have estimated. It is not sufficient to allow us to deliver the statutory requirements.

Case Study Two – Bridekirk

Table 4: Bridekirk WwTW example

UU Cost	Draft Det.	WINEP Drivers	Solution
£2.03m	£1.79m	WFD_ND (1.5mg/l P)	Primary chemical dosing

Bridekirk WwTW is a small rural work serving 140 population in Cumbria. The scope is to provide a new ferric system to dose upstream of the existing septic tanks. This will be delivered as a package plant with the required ancillaries including washwater and a mixing chamber.

All assets can fit within the current operational boundary. Site has good access and is well screened by mature trees. There are no challenging constraints associated with construction.

Ofwat models assume that primary ferric dosing would be required to meet this new P permit and due to the lack of expected onsite challenges, permit limit and simplicity of the scope, the costs developed match those predicted by Ofwat models.

4.3 AMP8 cost pressures are not appropriately reflected in AMP7-based cost forecasts

We consider that there is a fundamental disconnect between the AMP7 and AMP8 phosphorus removal programme. Ofwat's proposed approach assumes both AMP7 and AMP8 costs are equally capable of reflecting the costs companies will incur in AMP8. This is because it applies equal weight to forward-looking and backward-looking econometric models. However, this section will provide clear evidence that AMP7 costs will be poor predictors of AMP8 costs. As such, UUW considers that more weight should be placed upon forward-looking, AMP8 costs within cost assessment.

Table 5 sets out the number of schemes included within Ofwat's DD phosphorus removal model, across the entire industry. There is a substantial increase in the number of smaller treatment works. We consider this is clear evidence that the AMP8 programme is different to AMP7.

Table 5: The industry will focus upon much smaller treatment works in AMP8 relative to AMP7

	AMP7	AMP8	Percentage difference
Size band 1	26	93	258%
Size band 2	66	120	82%
Size band 3	215	281	31%
Size band 4	242	258	7%
Size band 5	113	114	1%
Size band 6	123	127	3%
Total	**785**	**993**	**26%**

Source: UUW analysis of Ofwat's phosphorus removal model (PR24-DD-WW-p-removal.xlsx)

In addition to working at smaller sites, the industry is targeting much more stringent permit limits, towards the technically achievable level of 0.25mg/l.

The difference is illustrated in Figure 2, which tabulates the inputs to Ofwat's backward-looking AMP7 and forward-looking AMP8 model by i) consent limit; and ii) treatment works size band. Shades of red indicate a higher number of sites within that category – the colour scale is consistent across both AMP7 and AMP8 data. The higher concentration of red towards the upper left corner in AMP8 illustrates that companies are carrying out more stringent work at very small sites in AMP8 relative to AMP7. There is also a higher number of works targeting the technical achievable limit across all size bands.

Figure 2: The industry is targeting substantially more phosphorus removal at smaller sites in AMP8 relative to AMP7

AMP7	Size band 1	Size band 2	Size band 3	Size band 4	Size band 5	Size band 6	Total
0.25mg/l and less	3	4	13	46	33	38	**137**
0.25mg/l to 0.5mg/l	4	13	56	100	46	40	**259**
0.5mg/l to 1mg/l	3	27	87	74	17	35	**243**
1mg/l to 2mg/l	9	12	41	12	16	10	**100**
2mg/l to 3mg/l	2	5	12	4	0	0	**23**
3mg/l to 4mg/l	3	3	4	1	1	0	**12**
4mg/l to 5mg/l	2	2	2	3	0	0	**9**
Above 5mg/l	0	0	0	2	0	0	**2**
Total	**26**	**66**	**215**	**242**	**113**	**123**	**785**

AMP7	Size band 1	Size band 2	Size band 3	Size band 4	Size band 5	Size band 6	Total
0.25mg/l and less	10	32	91	148	74	101	**456**
0.25mg/l to 0.5mg/l	10	21	59	47	15	14	**166**
0.5mg/l to 1mg/l	23	35	63	42	15	10	**188**
1mg/l to 2mg/l	24	21	36	7	10	2	**100**
2mg/l to 3mg/l	10	3	8	2	0	0	**23**
3mg/l to 4mg/l	9	3	12	5	0	0	**29**
4mg/l to 5mg/l	7	5	12	5	0	0	**29**
Above 5mg/l	0	0	0	2	0	0	**2**
Total	**93**	**120**	**281**	**258**	**114**	**127**	**993**

Source: UUW analysis of Ofwat's dataset

Engineering rationale and evidence suggests that targeting stringent permits at smaller sites will drive higher efficient costs, all else equal. We set out this engineering evidence in the remainder of the section. We then show that backwards-looking AMP7 econometric models have a poorer fit against AMP8 costs, which is evidence that AMP7 models are less capable of reflecting ex ante engineering rationale.

Why small treatment works are associated with higher capital costs

Sites of less than 2,000 population equivalent (i.e. bands 1-3) are considered small works and tend to be located in rural areas. These small works tend to have relatively simple treatment processes such as trickling filters, which are incapable of delivering performance in line with more stringent permits. We set out some reasons why costs at small works are expected to be higher, all else equal:

- Trickling filter works with a new phosphorus permit of less than 1 mg/l require tertiary solids removal, which is a step-change in complexity from the trickling filter technology currently used. Installing tertiary solids removal adds substantially to the cost of the scheme.
- Small works often treat a high multiple of dry weather flow and so have a high maximum flow relative to the minimum flows treated at site;
- Peaking factors at small works can be high due to short networks;
- Access is often poor, which means additional costs will result from improving transport infrastructure which will allow the delivery of chemicals and tankering of additional sludge generated when dosing ferric;
- Land on site is constrained and so often an extension of the WwTW is required which requires land purchase;
- Power upgrades are frequently required as many of these works have limited or no current power;
- Sites often have descriptive consents only and so require a major upgrade to meet new numerical permits;
- Many of these sites are within the Lake District National Park and so will need additional features such as environmental impact assessments, use of sensitive materials, sensitive landscaping etc;
- Sites are often close to watercourses which means flooding can be prevalent which will need remediation;
- The sites often have no dosing assets and so will require all dosing ancillary equipment such as dosing, storage, blind tanks, delivery areas, sludge storage etc. In addition these sites often do not have an existing potable water supply, which is required for dosing and bringing this to site adds to the costs; and
- Sites in the Lakes have high tourist populations that must be accounted for in design.

AMP7 models are objectively poorer at reflecting AMP8 cost pressures

As the previous sections have evidenced, the AMP8 WINEP is requiring interventions at small works with stringent permit limits. While there were some examples of such activity during AMP7, we have evidenced that AMP8 represents a fundamental step-change, with stringent permit limits required at a larger number of works, and in particular at the smallest treatment works.

This is important because this means that the historical and forecast datasets are fundamentally different. This difference was highlighted in Figure 2, which illustrates that the AMP8 dataset contains more information that will allow the model to establish a robust relationship between costs and:

(a) stringent permits at the technically achievable level (TAL); and

(b) stringent permits at the TAL at very small works.

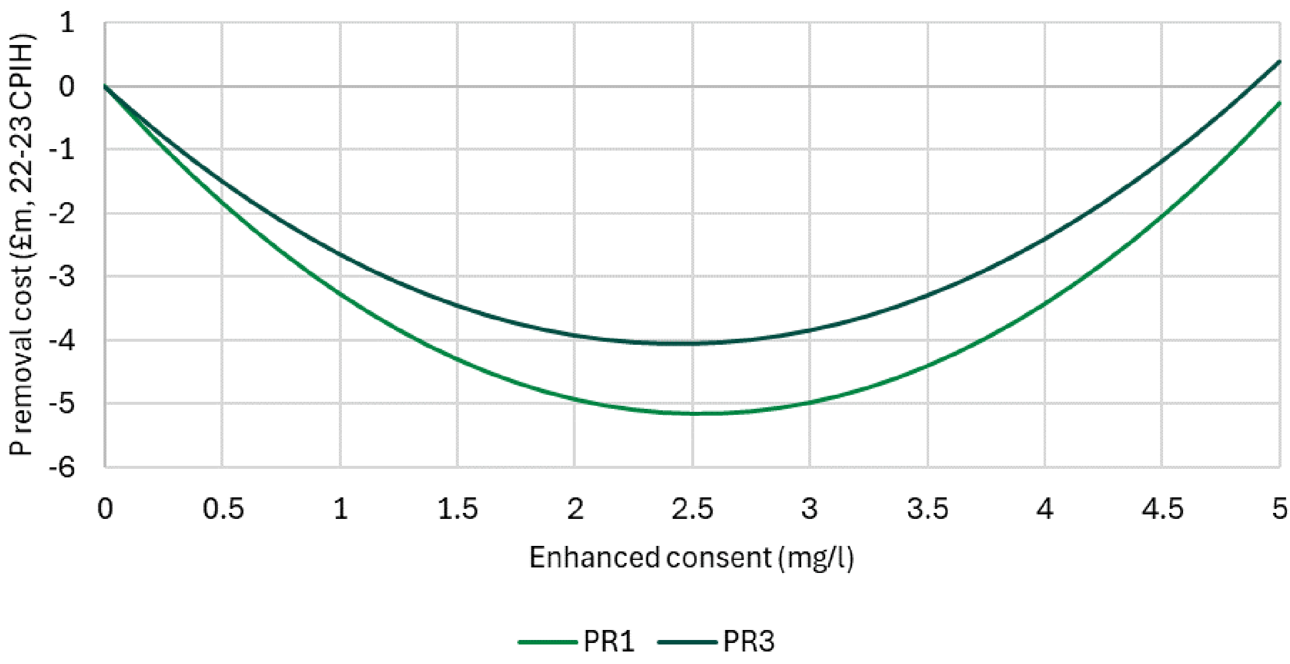
The lack of similar information in the historical AMP7 dataset evidenced in Figure 2 means that backwards-looking models will struggle to form a similarly robust relationship between cost and these cost drivers. This means they will tend to under-represent the costs companies will incur in the delivery of their AMP8 programmes.

We consider that there is clear evidence of this within the DD model suite.

The backwards-looking models suggest that tighter permits have less of an effect on costs, relative to forward-looking models. Figure 3 shows how Ofwat's models PR1 and PR3 models expect P removal costs to vary as the enhanced consent becomes increasingly stringent. PR1 uses forward-looking (AMP8) data while PR3 uses backward-looking (AMP7) data. These models use a squared enhanced permit variable to reflect how costs are expected to exponentially increase as the permit gets increasingly stringent.

It's clear that PR1 expects permit stringency to have a consistently larger impact on costs – PR1's curve is below that of PR3 at all points. Importantly, this means that PR1's slope is steeper as the permit approaches zero. This shows that PR1 expects permit stringency to have a more pronounced effect on costs than indicated by PR3. We consider this suggests that PR3 is understating the costs associated with achieving permits at the TAL. As evidenced in Figure 2, PR3 has less data available to it to help it understand the relationship between cost and permit stringency as permit stringency approaches the TAL.

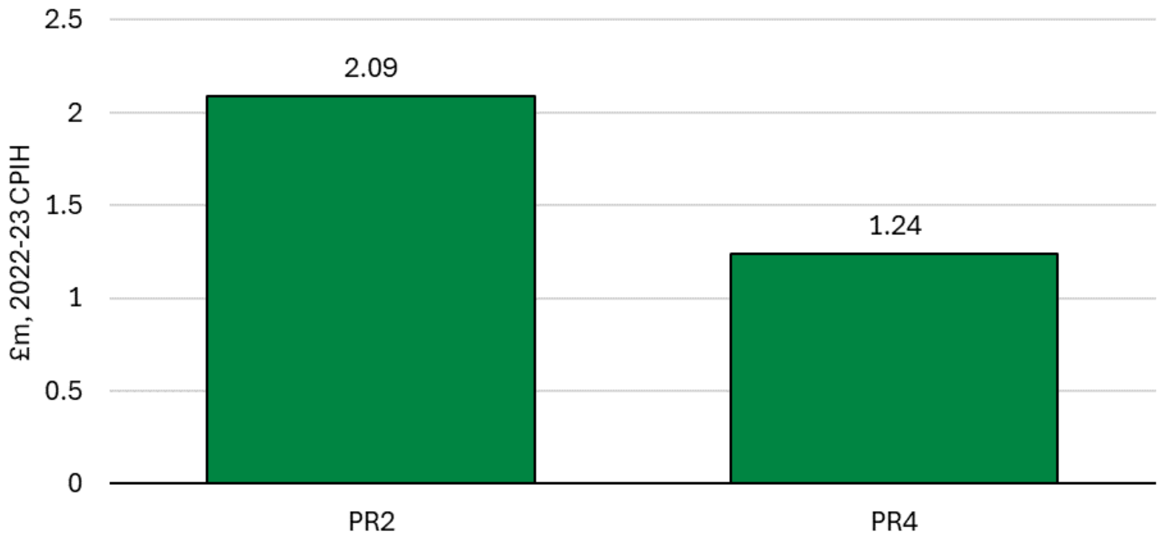
Figure 3: The relationship between P removal costs and the stringency of the enhanced consent within Ofwat's PR1 and PR3 models



Source: UUW analysis of Ofwat dataset.

We also find a similar difference between PR2 and PR4 models. These models use a dummy variable to reflect sites where the permit is at or below the TAL. Again, there is a clear difference between the forward-looking and backward-looking model predictions. The forward-looking model suggests a much stronger relationship between a TAL permit and associated scheme costs – the coefficient is 69% higher in PR2 relative to PR4. This is illustrated in Figure 4.

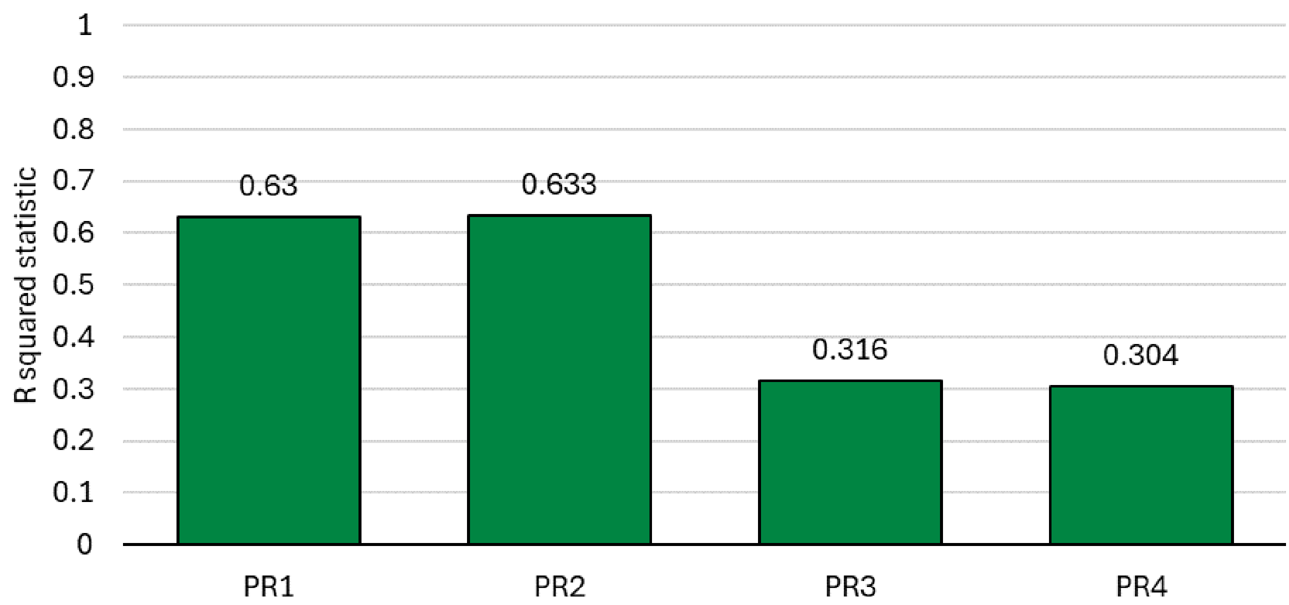
Figure 4: The relationship between P removal costs and the Technically Achievable Limit (TAL) dummy within Ofwat's PR2 and PR4 models



Source: UUW analysis of Ofwat dataset.

Finally, there is a clear reduction in the model fit (denoted by R squared) for the backwards-looking models. This is illustrated in Figure 5. This suggests that the cost drivers chosen to explain AMP8 costs (e.g. a squared term to capture the exponential increase in cost as permit stringency increases) are less adept at explaining AMP7 costs.

Figure 5: Model fit in Ofwat's backwards-looking models (PR3 and PR4) is objectively poorer



Source: UUW analysis of Ofwat dataset.

We note that the r squared values in Figure 5 relate to each specific model, meaning that the r squared value for PR3 and PR4 sets out the explanatory power of the model relating to historical costs. However, we are primarily interested in the power of the model to explain AMP8 costs. As such, we have also calculated the r squared between forecast costs and the historical models. This can be interpreted as informing to what extent historical P removal models PR3 and PR4 explain variation in forecast costs. This is set out in Table 6. It is clear that the explanatory power of models PR3 and PR4 is low for AMP8 costs.

Table 6: Explanatory power of models RP3 and RP4 relating to AMP8 costs

	RP3	RP4
R squared between forecast costs and modelled costs	0.233	0.229

Source: UUW analysis

These findings are important because they demonstrate that the more powerful treatment complexity coefficient in forecast AMP8 models is not due to companies submitting inefficient cost forecasts. Instead, **it reveals that the variables Ofwat has selected to reflect AMP8 cost pressures are objectively poorer predictors of AMP7 costs**. As highlighted in Figure 2, the AMP7 and AMP8 programmes are fundamentally different. As such, it is not surprising that AMP7 data is less able to support the relationship between cost and cost driver that engineering rationale suggests will exist in AMP8.

We consider that this is compelling evidence to suggest that backwards-looking models are poorer at predicting the costs of the AMP8 P removal programme, in particular the costs of meeting permits at the TAL at all works, but also particularly at small works.

We do not consider it is plausible that companies have collectively influenced the cost benchmark

In its DD, Ofwat considers several potential reasons that may explain why AMP8 modelled predictions are higher than AMP7:

- Companies may have different risk appetites;
- Companies have submitted higher business plan cost forecasts;
- PR24 WINEP/NEP programme is much larger than at PR19;
- Data reporting issues; and
- Prevalence of tighter permits.

In our view, Ofwat has not appropriately considered the key factor driving differences in cost estimates between the forward-looking and backward-looking approaches – the inability of AMP7 cost data to reflect efficient cost variation in delivering stringent consents at small treatment works (as discussed in the previous section).

However, we do want to address Ofwat's concern that companies may have submitted higher cost forecasts to:

"…Attempt to obtain a higher allowance under the assumption we will use these costs to set efficient cost allowances."[2]

We would like to make clear that UUW's cost estimates are motivated solely by UUW's view of the efficient level of cost required to deliver our obligations. We reject any statement that implies our cost estimates are the result of any attempt to influence the process by which Ofwat identifies the efficient cost benchmark.

We note that for Ofwat's statement to be true, **the following conditions would need to hold simultaneously at an industry level**:

- **The BPA would have to provide weak ex ante incentives.** We note that Ofwat's methodology creates powerful incentives for companies to submit efficient costs, through the Business Plan Assessment (BPA) process. Ofwat does not recognise or acknowledge this incentive when it suggests companies may have submitted inefficient phosphorus removal costs. The implication of Ofwat's statement is that the incentives created by the BPA process are insufficient to offset the incentive for companies to attempt to influence cost assessment with inefficient cost forecasts. Ofwat may wish to consider the implications of this statement further, particularly given the widespread use of forecast costs in PR24 cost assessment. In any case, we are clear that the BPA represents a strong incentive to provide efficient cost forecasts.
- **A majority of companies would have to be complicit in submitting inefficient cost forecasts.** Ofwat's methodology compares the costs of different companies to identify an efficient benchmark. All other

[2] Ofwat (2024) *Expenditure allowances – enhancement cost modelling appendix.*

companies are then expected to deliver in line with the benchmark. This process is explicitly designed to protect customers from inefficient costs. Countering the incentive structure of the benchmarking framework would require a substantial number of companies to independently consider it a worthwhile strategy to submit inefficient costs. However, the *'prisoner's dilemma'* nature of the process creates a clear disincentive against this type of action. We have not seen any evidence that would lead us to suspect a majority of companies are actively targeting a poorer BPA score in return for taking the risk their inefficient cost forecasts are rewarded through cost assessment.

- **Ofwat's models would have to have captured all sources of regional and scheme-level variation in costs.** Ofwat notes that it tested company dummy variables in its model suite. It took the fact that these dummy variables are higher in its forward-looking models as evidence that submitted AMP8 cost forecasts are inefficient. However, Ofwat doesn't acknowledge other reasons that might cause company-specific effects in AMP8 to be higher. For example, companies that have had small capital programmes historically may have to rapidly scale up their capital delivery departments to deliver a much larger AMP8 programme. This would lead to a higher fixed cost estimate for that company, which would be reflected in the dummy variable. Another example could be the effect of regional exogenous factors – UUW's phosphorus removal programme includes a larger number of works in the Lake District, relative to AMP7. These small, rural sites are associated with higher costs, as evidenced above, and as such, the UUW-specific dummy would likely be higher when estimated using AMP8 data. Ofwat has not presented any evidence to suggest that relative efficiency is the only driver of scheme-level variation its models do not capture. Therefore, we do not consider it is appropriate for Ofwat to cite its dummy variable tests as evidence of relative inefficiency in AMP8 delivery.

As stated above, all these factors must be true if Ofwat's stated suspicion of inefficient cost forecasts is appropriate. If Ofwat considers this is likely, this may be something that should be engaged with when considering future regulatory frameworks.

As a result of the arguments set out in this section, we consider it would be legitimate to drop the AMP7 models entirely. However, we recognise the merits of assessing using outturn data. While we disagree that there is risk that companies are choosing to submit inefficient costs to influence benchmarking, we do consider that outturn costs can provide a legitimate alternative view on efficient delivery. On balance, we would place more weight on AMP8 data because AMP7 data include less evidence on delivery to stringent consents and in particular at small sites, as evidenced in this section. **Therefore, we consider a pragmatic compromise would place 75 percent weight on AMP8 models and 25 percent weight on AMP7 models.**

4.4 Ofwat should reflect the higher construction costs of biological solutions in its cost benchmark

Historically, UUW has relied on chemical treatment to meet specific permit requirements. In AMP6 and AMP7, we changed our strategy to embrace biological phosphorus removal, leading the way with delivering innovative Nereda plants for four wastewater treatment works and mobile organic biofilm (MOB) at Macclesfield.

Chemical phosphorus removal uses a chemical such as ferric to bind the phosphorus into a floc making it heavier and allowing it to settle out and be removed in the sludge. Biological phosphorus removal creates the environment for bacteria to take up phosphorus within the activated sludge process. This is removed from the process in the surplus activated sludge (SAS). More detail on the processes for chemical and biological phosphorus (Bio-P) removal can be found in Appendix A – Chemical and Biological Phosphorus Removal.

The introduction of the Environment Act 2021 long term phosphorus (P) target means that UUW needs to remove another 1,000 tonnes per day of phosphorus to achieve its share of the industry's target by 2038. Those sites with a EnvAct_IMP1 driver in AMP8 such as Low Marple WwTW contribute to this. This is a significant change that puts added focus on the sustainability and resilience of the chemical supply chain as well as the logistics of frequent chemical delivery to sustain wastewater treatment and the ever-increasing quantity of phosphorus rich sludge that needs to be recycled to a land-bank under pressure.

There is a global shortage of rock phosphorus. Biological phosphorus removal presents an opportunity in the longer term to build a circular economy to put phosphorus back into the supply chain through phosphorus recovery. At the same time, the North West has a surplus of phosphorus that contributes to the growing pressure we see around recycling biosolids to land thereby making the ability to move phosphorus out of the North West attractive.

Biological phosphorus removal is most cost effective at scale especially when the sewage strength is strong enough to sustain the bacteria. We therefore evaluated the option to install biological phosphorus removal at many of our large works using a best value approach which resulted in biological phosphorus removal being the preferred solution at six of our largest sites: Dukinfield, Wigan and Partington WwTW, where biological phosphorus removal is the recommended solution for phosphorus drivers within AMP8, and at Davyhulme, Salford and Eccles, aligned to achieving the longer-term targets for phosphorus. It should be noted that post submission, the phosphorus permit has been tightened at Eccles and Salford.

Many of these sites have existing trickling filters which are not suitable for biological phosphorus removal. These sites are attracting extremely stringent permits for sanitary drivers such as BOD and ammonia which the trickling filters could not meet, therefore the decision to install a new activated sludge plant (ASP) is often driven by the need to meet these tight standards. In addition, for most of these sites there is a significant tightening of the permits in a single AMP rather than incremental increases. These factors therefore provide the perfect one-off opportunity to significantly upgrade the existing works to activated sludge and embrace biological phosphorus removal at the same time and this should not be missed.

This move to Bio-P is supported by the Environment Agency (EA) which in the PR24 WINEP driver guidance – Nutrients and Sanitary Determinands (surface water) (p18) states that "*Water companies are encouraged to take opportunities, where possible, to make greater use of biological phosphorus removal techniques and to recycle or recover phosphorus from WwTW when designing actions to meet environmental targets*"

Ofwat notes that:

> *"We assessed the costs of chemical and biological treatment together as the number of biological schemes was relatively small and dominated by a small number of companies. The cost drivers are also the same."*

We disagree with this approach. Implementing biological solutions is associated with higher upfront costs. Given the wider benefits of biological solutions, we do not consider it is legitimate for Ofwat to ignore biological solutions within cost assessment. Otherwise, there is a risk that companies are incentivised to ignore best value solutions in favour of less sustainable and less resilient chemical solutions. Companies may also need to undertake additional capital work to transfer a chemical site across to a biological site e.g. demolition of existing assets. This type of activity will not be reflected in Ofwat's cost models (particularly the models based upon AMP7 costs) but is entirely necessary to enable the site to meet the new stringent permits set out in the AMP8 WINEP.

Additionally, Ofwat's approach effectively treats the additional capital costs of biological solutions as inefficiency. This has wider implications across a company's determination. For example, it impacts the ambition assessment and informs the shallow-dive efficiency challenge. It would be entirely inappropriate to penalise companies that have adopted the optimum solution to meet their AMP8 statutory obligations.

This section evidences that biological treatment is the optimum solution across some of our larger sites. We consider that they will facilitate a better investment for customers and the environment in the longer-term and provide substantial resilience against shocks in the chemical supply chain.

Benefits of Biological phosphorus removal

Bio-P represents a best-value, sustainable and resilient way to achieve the stringent permit limits within AMP8. It has the following benefits:

- **Resilience:** Bio-P significantly reduces the reliance on chemicals and on large plants such as Davyhulme and Wigan: it will minimise chemical deliveries and their impact on neighbouring communities. This is evidenced at UUW's largest Bio-P plant i.e. the Nereda® process at Blackburn WwTW which currently uses no ferric sulphate for phosphorus removal to meet the AMP6 1 mg/l P permit. Production of such large quantities of chemicals is extremely challenging and reducing the reliance on chemicals eliminates the risk to compliance associated with any issues with supply. Unloading of large quantities of chemicals introduces a health and safety risk for our operational colleagues and the storage facilities required to ensure we do not run out would be excessive. Further details of our discussions with supply chain and consideration of associated risks can be found in the next section of this document.

- **Best Value:** Bio-P has been shown to be most cost-effective at large sites where, although there is a higher capital cost associated with initial installation of the plant, this is recovered over the life cycle of the asset due to significant savings associated with operating costs. Thus, at these large sites it has been shown to drive the best value and lowest whole life cost. This is enhanced when there is also a need to replace existing fixed film processes with an activated sludge process due to the tightening of sanitary determinates such as ammonia, BOD and cypermethrin, as seen at for example at Eccles, Salford and Wigan. For examples see the case studies in Table 7. Lower ongoing costs will mean a lower uplift in ongoing phosphorus removal costs at PR29, meaning the savings can be passed back to customers.
- **Reduction in chemical ongoing operating expenditure:** Even with a trim dose the reduction in chemicals used on a Bio-P would be anticipated to reduce by >80% of the metal salts of a comparable chemical dosing solution and reduce or possibly eliminate the need for alkalinity compensation. The predicted usage rates for both chemicals at all plants can be seen in Appendix B. From this it can be seen that the average ferric sulphate usage tonnes per day for Bio-P vs chemical P is 88% less over the six sites (207.3 t/d chemical, 24.8 t/d bio-P). This reduction in chemicals has a positive effect on vehicle movements and deliveries and operational carbon and therefore represents a more sustainable solution for the future. Chemicals are delivered in a large, cylindrical trailer that carries liquid chemicals in bulk quantities. The daily quantity of chemicals associated with each option can be found in Appendix B. At Davyhulme WwTW this amounts to 4 tankers of ferric and 2 tankers of caustic soda every day for a chemically dosed solution which reduces 4 and 1 per week respectively with the Bio-P option. The storage facilities required to ensure we do not run out would be excessive and would be challenging to optimise around existing assets.
- **Sludge Opex:** Precipitation of phosphorus by metal salts leads to an increase in sludge solids, resulting in a higher number of vehicle movements for sludge transfer and lower gas yield in digestion. As shown in Appendix B it is estimated that use of Bio-P reduces sludge production by >25% on average when compared to chemical phosphorous removal. This has clear benefits given the ongoing uncertainty over the future of the land bank.
- **N_2O emissions:** Nitrous Oxide (N_2O) is produced when we treat wastewater biologically and has 298 times the greenhouse gas potential of carbon dioxide (CO_2). We can minimise these emissions by allowing adequate N_2O removal pathways. Global evidence shows that maximising denitrification and optimising process aeration minimises N_2O production. By necessity a new Bio-P activated sludge process would be designed to fully denitrify which would not be the case for a standard chemically dosed ASP and this therefore would significantly reduce N_2O emissions in the case of Bio-P solutions.
- **Potential for phosphorus recovery:** Phosphorus is easily released from Bio-P waste sludge and can be precipitated and recovered as a slow-release fertiliser. This represents an opportunity to develop a circular economy solution to put phosphorus back into the supply chain, presenting a remedy to address the serious concerns over shortage of world reserves of phosphorus. In addition, recovery removes the phosphorus from the sludge thereby reducing the quantity of phosphorus rich sludge and alleviating land bank pressures. Any associated financial benefits would be passed back to customers through the price control.
- **Impact of iron on the environment:** Use of Bio-P reduces the residual iron in final effluent from the site, providing environmental benefits particularly where the watercourse is sensitive.

WwTW where we are installing biological phosphorus reduction

Adopting Bio-P has been a multi-AMP strategy with four medium size plants (Kendal, Failsworth, Morecambe, Macclesfield) and one large scale plant (Blackburn) being installed in AMP6 and AMP7. All five Bio-P plants have been a success, achieving low levels of phosphorus with low or no chemicals. As a result, we are now planning to expand our use of biological phosphorus removal in AMP8.

UUW has selected Bio-P as the preferred option at six sites within the PR24 submission, these being Davyhulme, Wigan, Eccles, Salford, Dukinfield and Partington WwTWs. Table 7 gives a high-level description of the solution and the reasons for choosing this option. This table also shows a comparison of the costs for a chemical versus a Bio P solution and the expected ongoing operational costs for both solutions. The values in table 7 are Engineering estimates used in the development of the AMP8 programme as part of the options appraisal process. The values presented were developed in FY20/21 prices and pre-efficiency. For this reason and due to the delivery dates and the impact of Opex the values will not fully reconcile to our Draft Determination data tables.

This demonstrates that in all cases the additional capital outlay leads to a lower whole life cost, almost entirely due to reduction in chemical operating expenditure. The benefits from lower ongoing operating expenditure is passed back to customers in future price controls.

Table 7: BioP solutions are associated with significantly lower whole life totex

Site	Solution	Main drivers for installing Bio-P		Capex	Opex (£m per year)	Totex (30 year WLC)
Davyhulme	P recovery, new build Bio-P ASP and Bio-P conversion of existing ASP	• Tight BOD permit • Adaptive plan to low P • Large site • Unacceptable logistics associated with chemical delivery	Chem	402	43	670
			Bio	534	18	508
			Delta	*132*	*-25*	*-162*
			% delta	***33%***	***-58%***	***-24%***
Wigan	New build Bio-P ASP	• Tight ammonia permit • Low P permit • Integrated solution for catchment overflows • Trickling filter beds that cannot meet sanitary drivers or increase in flows • Large site • Unacceptable logistics associated with chemical delivery • Benefits associated with removing cypermethrin	Chem	190	11	241
			Bio	243	-1	123
			Delta	*53*	*-12*	*-118*
			% delta	***28%***	***-109%***	***-49%***
Eccles	New build Bio-P ASP	• Tight BOD and ammonia permit (6mg/l & 1mg/l) • Low P permit (0.25mg/l) • Tight cypermethrin permit • Trickling filter beds that cannot meet sanitary or chemical drivers • Large site	Chem	147	11	192
			Bio	180	8	183
			Delta	*33*	*-3*	*-9*
			% delta	***22%***	***-27%***	***-5%***
Salford	New build Bio-P ASP	• Tight BOD and ammonia permit (6mg/l & 1mg/l) • Low P permit (0.25mg/l) • Trickling filter beds that cannot meet sanitary drivers • Large site	Chem	234	10	236
			Bio	232	6	193
			Delta	*-2*	*-4*	*-43*
			% delta	***-1%***	***-40%***	***-18%***
Dukinfield	New build Bio-P ASP	• Tight ammonia permit (1mg/l) • Low P permit (0.25 mg/l) • Trickling filter beds that cannot meet sanitary drivers	Chem	65	4	86
			Bio	76	2	67
			Delta	*11*	*-2*	*-19*
			% delta	***17%***	***-50%***	***-22%***

Site	Solution	Main drivers for installing Bio-P		Capex	Opex (£m per year)	Totex (30 year WLC)
Partington	New build Bio-P ASP	• Tight BOD and ammonia permit (10mg/l & 2mg/l) • Low P permit (0.25mg/l) • Secondary treatment assets (submerged biological contactor) that are obsolete thus maintenance is not supported	Chem	20	1	28
			Bio	22	1	26
			Delta	*2*	*0*	*-2*
			% delta	***10%***	***-22%***	***-7%***
			average % delta	18%	-51%	-21%

Source: UUW optioneering

All costs are in Price Basis FY20/21 and were inflated to FY22/23 prior to submission. This would not have affected choice of the preferred solution.

'Saving' percentages may not match due to rounding

The OPEX costs given include items such as manpower, maintenance, chemical and power usage and sludge treatment and are the site OPEX growth associated with the options.

The costs for Davyhulme include scope to meet the future Environment Act 2021 low P permit and Bio-P plant is based on use of a more efficient design (MOB) which has been developed since our original submission.

The Bio-P option for Wigan is aligned with a more efficient design (MOB) which has been developed since our original submission but does not include any scope to facilitate an increase of flows to the treatment works to address spill and quality drivers within the catchment associated with Pennington Flash. We have assessed that this is a similar scope for both options (i.e. a new validated UV plant) and so is not a differentiator when choosing the preferred option. The savings in OPEX at Wigan mainly come from the fact that currently the existing trickling filters require a lot of manual intervention and double pumping to meet permit. As this plant is replaced in in the Bio-P ASP option this cost would be avoided in this solution.

The costs for Eccles are associated with meeting the low P permit as per the latest agreements with the EA.

Our latest proposal for Salford is to align the BOD and ammonia drivers with the low P permit and we are working with the EA to bring the 0.25mg/l P limit forward into AMP8. The costs given above reflect this latest position.

Supply chain risk for large quantities of ferric

To understand the risk around the volume of chemicals which would be required if we were to pursue a chemical only (not BioP option) for the six identified WwTW, we contacted our chemical supply chain to understand if the volumes of chemical would be available within the UK. If we were to change the preferred option for these sites as a consequence of not pursuing a Biological P removal option, UUW requirements for Ferric Sulphate would increase by 66,575 tonnes per annum and Caustic Soda would increase by 28,531 tonnes per annum (all AMP8 sites), these are based on the quantities contained in Appendix B.

Following this potential increase we have engaged extensively with the supply market to fully understand the capacity available alongside the demand from the UK Utility industry. The Utility industry's demand across all companies for AMP8 is anticipated to be in around 567,500 tonnes per annum, prior to the above demand increase. The 3 UK ferric sulphate manufacturers (ICL, Feralco, Kemira) are planning to increase their manufacturing output to 615,000 tonnes per annum by the end of AMP8, giving a 47,500 tonnes per annum buffer capacity. Therefore, the predicted 66,575 tonne per annum increase from these six sites would use up and exceed all of the buffer capacity within the supply chain. This presents clear risks to the ongoing resilience of our permit compliance.

In terms of impact on the local environment, additional tankering requirements to deliver to the sites required would need to increase by at least 3,400 extra deliveries each year and therefore, resulting in significantly more vehicles on the road. The total cost increase for the chemicals is likely to be £26.9m pa based on current market prices.

How Ofwat should reflect biological phosphorus removal within cost assessment

We have evidenced that biological treatment is the most appropriate solution for the sites set out within this section. Biological treatment increases the resilience of our operations and safeguards compliance against shocks in the chemical supply chain. Lower ongoing operating expenditure will mean that customers share in the best-value benefits provided by biological treatment. Biological treatment also removes the need for complex logistical operations associated with managing a large number of chemical deliveries by tanker, which would also have a detrimental impact upon local communities and wider road congestion. Biological treatment also unlocks wider environmental benefits, like lower nitrous oxide emissions and the potential for recovery of phosphorus with the increased scope for an associated circular economy.

Despite these benefits biological treatment is associated with higher up-front capital costs. Ofwat may consider that these investments are net neutral over the lifetime of the assets and therefore cost assessment does not need to accommodate biological solutions. However, we note that Ofwat's DD approach considers biological treatment's additional costs as inefficiency. For example, it informed Ofwat's ambition assessment and Ofwat's shallow dive challenge, which impacts on cost assessment across a wide number of areas. This has wider implications for UUW's determination.

This means that biological treatment cannot be assumed to be net neutral and must be appropriately reflected within cost assessment. The benefits evidenced within this section demonstrate that biological treatment is the most appropriate solution for the sites highlighted. As such, we consider that Ofwat must seek to ensure that companies implementing biological treatment solutions are not penalised.

Ofwat may identify two alternative ways to achieve this:

(1) Provide an additional allowance for biological treatment enhancement within AMP8. Savings associated with lower ongoing opex can then be passed back to customers at future price reviews. We consider the least complex way to reflect higher enhancement expenditure would be to uplift modelled allowances by 18 percent, which is the average additional cost of a biological treatment solution relative to a chemical dosed ASP as set out in Table 7.

(2) Do not reflect the additional enhancement cost for biological treatment in AMP8 and at future price reviews assume ongoing opex in line with a chemical removal solution. This allows appropriate recovery of costs over the lifetime of the assets. At PR24, the wider cost assessment framework should ensure that the additional cost gap in AMP8 is not treated as inefficiency and penalised within

the Final Determination. For example, the shallow dive efficiency challenge should exclude the gap relating to biological treatment solutions.

In theory, both alternatives should enable companies to recover efficient costs associated with biological treatment. However, we consider option 1 is most appropriate. This is because it is more likely to ensure that the lower whole-life costs of biological solutions are passed back to customers. It also avoids the need to introduce additional complexity into the price review process by ensuring that a companies' choice of biological treatment doesn't negatively impact on its wider determination.

However, whichever approach is adopted by Ofwat we are clear that it is unacceptable to do nothing. This approach would actively penalise companies that have identified the best-value, lowest whole life cost solution to meeting the obligations within their WINEP. It would be equally unacceptable to ignore the higher capital costs of biological solutions in AMP8 and then pass through lower associated ongoing operating expenditure in future reviews.

4.5 Price Control Deliverable for phosphorus schemes

We note that in the draft determination Ofwat includes a scheme level price control deliverable with a time incentive rate for P with the outcome measure being population served. We have assessed our agreed WINEP schemes and the associated population against these targets in Table 8.

Table 8: PCD proposed delivery profile to set time incentives and UUW current delivery profile

(%PE)	25/26	26/27	27/28	28/29	29/30
PCD target in DD %	0	5	35	65	100
PCD outputs (cumulative PE 000s)	0	65.86	461.05	856.42	1317.30
WINEP Scheme profile %	1.29	1.29	1.29	41.56	100

Source: DD Wastewater scheme level PCD and UUW analysis

As demonstrated in Table 8 the PCD time incentive is not in line with the WINEP regulatory date. As this PCD is based on PE served, a proportion of this cannot be claimed ahead of the regulatory date; all of the PE is completed once the scheme has been completed and claimed with the EA. Ofwat also state in the guidance that it will use WINEP delivery to track this PCD. This measure would therefore penalise the company for a scheme that it is not required to delivery yet.

The delivery profile of P removal schemes in the WINEP is in blocks, with the initial projects in FY26, a project at our largest WwTW Davyhulme in FY29 and then all of the other schemes in FY30 (i.e. most of the delivery of P reduction schemes) is at March 2030. The PCD delivery profile is therefore out of step with the delivery date. We would expect this PCD to track the WINEP delivery dates. The PCD set out in DD limits opportunity and penalises delivery in line with the WINEP regulatory dates. This should be updated to align with - and therefore not penalise for - on time delivery.

4.6 We have identified additional stretch and challenge as a result of Ofwat's DD

Following receipt of DD we have reassessed the scope and costs of several of our sites which were shown to be high costs schemes using the Ofwat models, in an effort to challenge our initial assumptions and improve cost efficiency. The section below lists the sites included in this exercise and provides a high-level description of the change to the preferred solution.

- Altrincham – Removal of preliminary treatment, removal of additional caustic dosing, humus tanks and sludge storage.

- Hyde – Increased reliance on reuse of existing assets such as primary ferric, caustic dosing and the existing TSR, reduction in the size of the new TSR and removal of infrastructure upgrades such as the access road.
- Garstang – removal of all plant upgrades originally deemed necessary to improve phosphorus removal across all assets which puts a higher reliance on new chemical dosing assets to achieve the new P permit
- Bassenthwaite – Alignment of costs to Ofwat allowance but inclusion of essential infrastructure, such as improvement to access, deemed necessary to ensure compliance with the new P permit
- Barton – Implementation of an alternative solution to transfer flows associated with growth in the catchment to Garstang resulting in the need for a smaller chemical dosing solution at Barton

It should be noted that most of these opportunities have consequences such as additional operational risk and increased maintenance, which UUW will manage so that we can deliver increase cost efficiency to customers. Opportunities for other sites were considered but rejected as the risks were deemed unacceptable.

This has resulted in a £56m reduction in costs from that submitted in our business plan across five projects.

5. Approach for final determination

We consider that Ofwat must make the following changes to its approach for FD:

- As set out in section 4.3, **Ofwat should place a weight of 75% on forward-looking models and 25% on backward-looking models** in its cost assessment approach. This reflects the inability of backward-looking data to capture the AMP8 cost/cost driver relationship. We also provided evidence in section 4.2 that our approach to cost forecasting produces accurate estimates. If Ofwat has concerns that this may allocate too much expenditure to a low cost company, then it could take action to asymmetrically cap that company's allowances where these are judged to be excessive in comparison to its business plan.
- Ofwat should reflect the higher cost of bio-P solutions within its AMP8 benchmark. As evidenced in section 4.4, **a reasonable uplift would be 18 percent against the modelled benchmark** (see Table 7). This could be applied through a post-modelling adjustment if Ofwat did not wish to update its models for FD.
- Ofwat should act to ensure that the time element of the PCD is updated to align with the WINEP delivery profile to ensure companies are not penalised for delivery of schemes on time.

Appendix A Chemical and Biological Phosphorus Removal

Chemical Phosphorus Removal

Traditionally the water industry has removed phosphorus (P) from wastewater via dosing of metal salt solutions, such as ferric sulphate. Depending on the permit requirement and configuration of the existing assets the chemical is dosed at one or two locations in the treatment process. The metal salts react with the soluble phosphorus to form solid precipitates which are then removed, along with the other solids present in the crude sewage, via solids separation processes. These processes are already integral to most sewage works (i.e. primary tanks) and for low P permits (<0.5- 0.75 mg/l) a tertiary solids polishing stage is also added to remove excess particulate phosphorus which would otherwise be present in the final effluent.

Due to the acidic nature of metal salt solutions, alkalinity dosing is often required to balance alkalinity consumed and ensure sufficient alkalinity levels to allow other treatment processes, such as ammonia removal, to operate effectively. This is especially an issue for United Utilities due to low levels of alkalinity present in the reservoir water which makes up most of our potable water system. Typically, caustic soda is used for alkalinity control which therefore requires additional site chemical deliveries and storage facilities.

The phosphorus precipitated by the addition of chemicals leaves the treatment process in the sewage sludge. This results in an increase in sludge volumes, leading to additional storage requirements and tanker movements to remove this sludge from site. Due to the reactions that take place once the chemicals have precipitated phosphorus into the sludge stream it becomes difficult to release the phosphorus again should this be required.

Biological Phosphorus Removal (Bio-P)

Biological phosphorus removal (Bio-P) can only occur in suspended growth processes, typically activated sludge plants (ASPs). Bio-P requires extension of the activated sludge process by the inclusion of unaerated zones which encourage the uptake of phosphorus into the bacterial biomass. This biomass (and hence phosphorus) is then removed by separation processes and leaves the plant via the sludge stream. In addition, if the crude sewage does not contain enough chemical oxygen demand (COD) to sustain the phosphorus loving biomass a fermentation must be added.

Typically, Bio-P technology can reduce the phosphorus levels to between 0.5-1.0mg/l and hence it is necessary to add a chemical trim dose for low P permits along with tertiary solids removal as additional capture of solids is often required. Due to lower metal salt usage, the need for additional alkalinity dosing is significantly reduced. Plus, due to the phosphorus being retained in the biomass, it can be readily re-released and potentially recovered.

Biological phosphorus removal can be intensified by the use of floating fixed film technology such as mobile organic biofilm (MOB). This provides a surface area for the growth of additional bacteria and so allows for a greater number of bacteria per unit of aeration basin and hence the physical size of the ASP can be reduced.

Appendix B Comparison of chemical usage and sludge production for chemical and biological phosphorus removal

Table 9: Comparison of chemical usage and sludge production for chemical and biological phosphorus removal

	Chemical P Removal (Nitrifying ASP)											Biological P Removal										
Site	Average Ferric Sulphate used t/d	Average Ferric sulphate deliveries per day	Average Ferric sulphate deliveries per week	Average Caustic use t/d	Average Caustic deliveries per day	Average Caustic deliveries per week	Additional sludge produced t/d	Peak ferric sulphate tanker deliveries (tankers/d)	Peak 47% caustic tanker deliveries (tankers/d)	Ferric storage required (tonnes)	47% Caustic storage required (tonnes)	Average Ferric Sulphate used t/d	Average Ferric sulphate deliveries per day	Average Ferric sulphate deliveries per week	Average Caustic use t/d	Average Caustic deliveries per day	Average Caustic deliveries per week	Additional sludge produced t/d	Peak ferric sulphate tanker deliveries (tankers/d)	Peak 47% caustic tanker deliveries (tankers/d)	Ferric storage required (tonnes)	47% Caustic storage required (tonnes)
Wigan and Skelmersdale WwTW	33.0	1.18	8.2	4.6	0.2	1.2	41.8	2.2	1.2	461.4	64.8	4.2	0.2	1.1	0.0	0.0	0.0	33.9	0.4	0.0	58.8	0.0
Salford WwTW	15.5	0.55	3.9	4.0	0.1	1.0	13.2	1.7	1.0	216.5	83.0	2.3	0.1	0.6	0.3	0.0	0.1	9.6	0.3	0.1	32.1	7.3
Eccles WwTW	15.4	0.55	3.9	10.0	0.4	2.5	14.6	1.1	0.8	216.0	140.1	2.4	0.1	0.6	0.8	0.0	0.2	11.0	0.3	0.2	33.9	16.0
Partington WwTW	1.5	0.05	0.4	0.9	0.0	0.2	1.4	0.1	0.1	20.5	13.0	0.1	0.0	0.0	0.1	0.0	0.0	1.0	0.0	0.0	1.5	2.9
Dukinfield WwTW	11.2	0.40	2.8	6.0	0.2	1.5	8.2	1.0	1.0	157.2	87.0	1.3	0.0	0.3	1.8	0.1	0.5	5.4	0.2	0.5	17.7	37.9
Davyhulme WwTW	130.7	4.67	32.8	58.0	2.1	14.5	147.8	11.3	7.8	949.5	651.7	14.5	0.5	3.6	2.3	0.1	0.6	115.9	2.2	2.0	181.8	167.4

Source: UUW Analysis

All usage rates are based on plants meeting the long term 0.25mg/l target for P
All Bio-P calculations are based on the assumption that there is a 75% denitrification
All conventional ASP calculations are based on the assumption that there is 50% denitrification
For Davyhulme it has been assumed that ASP 2 will remain carbonaceous therefore no denitrification will occur
All Bio-P plants assume ASP effluent is on average 0.5mg/l and peak 1mg/l
Calculations based on asset standard of requirement of 14 days storage under average flow conditions except for Davyhulme where we have used approx.7 days as storage volumes become impractical above this value.

Appendix C Glossary

Acronym	Meaning	Definition
ASP	Activated Sludge Plant	A secondary treatment process using suspended naturally growing bacteria and micro organisms to metabolise and break down the principle contaminants of wastewater
NH4	Ammonia	A wastewater contaminant, an inorganic chemical compound of nitrogen and hydrogen that readily dissolves in water.
ADH	Asset Data Hierarchy	A logical index of equipment, machines, and components, and how they work together
AACE	Association for the Advancement of Cost Engineering	A professional association
BOD	Biochemical Oxygen Demand	A measure of the amount of oxygen required to stabilise a waste biologically, synonymous with biological oxygen demand
BAFF	Biological Aerated Flooded Filter	A submerged fixed-bed reactor that biologically degrades components by passing the water vertically through a flooded media bed and with a continuous supply of oxygen
EBPR or BioP	Enhanced Biological Phosphorus Removal	The removal of phosphorus by accumulating it within biomass
CAPEX	Capital Expenditure	Money spent on acquiring or maintaining fixed assets, such as land, buildings, and equipment
COD	Chemical Oxygen Demand	A measure of the amount of oxygen required by reactions in a solution
CSMG	Common Standard Monitoring Guidance	Guidance documents on setting as assessing conservation objectives to assist in undertaking site monitoring and assessment
CPO	Compulsory Purchase Order	A legal mechanism used by certain bodies ('acquiring authorities') to acquire land or property without requiring the consent of the owner
COUF	Continuously Operated Upward flow Filter	A filter that utilises upward flow of water through a media, typically used for removing suspended solids
DWMP	Drainage and Wastewater Management Plan	A government initiative requiring wastewater companies to outline long-terms plans (2025-2050) on their long-term approach for sustainable drainage and wastewater management
EQS	Environmental Quality Standards	A set of standards and conditions set out by the UK Government requiring legal compliance to maintain and protect the environment

Acronym	Meaning	Definition
FST	Final Settlement Tank	A settlement tank typically used in the activated sludge process to remove solids (sludge) from the effluent stream, the removed sludge is then either returned to the activated sludge process or removed for further treatment
FTFT	Flow To Full Treatment	The level of incoming flow that a wastewater treatment works is required to treat before it is permitted to discharge excess flow
GHLS	Generic High level solution	An approach to design that focuses on the overall picture before refining finer details
HF	Horizontal Flow	A process design that utilises the sideways flow of a volume
HMI	Human Machine Interface	A user interface or dashboard that connects a person to a machine, system or device
HST	Humus Settling Tank	A settling tank used to clarify effluent by the removal of humus solids, typically after trickling filters
IETG	Integrated Environmental Technology Group	Multi-disciplinary support services company operating within the water and waste water industries
IFAS	Integrated Fixed-film Activated Sludge	An enhanced activated sludge treatment process used to increase treatment capacity by utilising additional biomass attached to media
kg/d	Kilograms per day	A rate unit equal to one kilogram of matter over a 24 hour period
Very Low Total Phosphorus	Less than 0.5mg/l Total Phosphorus	A condition that requires the concentration of Total Phosphorus to be lower than 0.5 milligrams per litre
Low Total Phosphorus	Less than 1mg/l Total Phosphorus	A condition that requires the concentration of Total Phosphorus to be lower than 1 milligrams per litre
MAHP	Major Accident Hazard Pipeline	A pipeline that transports flammable and toxic materials with the potential to cause major accidents if accidently released
MSF	Measure Specification Form	A standard template use to report findings of investigations to the Environment Agency
mg/l	Milligrams per litre	A measurement of concentration, given as a weight of a substance per unit volume
MLSS	Mixed liquor suspended solids	The concentration of suspended solids, in an aeration tank during the activated sludge process
NBS	Nature based solution	Solutions that utilise biodiversity (such as plants, soil or bacteria) to remove pollutants from wastewater

Acronym	Meaning	Definition
NPV	Net Present Value	The difference between the present value of cash inflows and the present value of cash outflows over a period of time, used to determine the value of an investment opportunity
NTF	Nitrifying Trickling Filter	A wastewater treatment process that removes organic matter, nitrogen and ammonia by filtering through a media bed
OPEX	Operational Expenditure	The ongoing cost to run or maintain a given process
Ortho P	Orthophosphate	A soluble form of phosphate, used as a measure of the organic fraction of Phosphorus in water
P	Phosphorus	A chemical element naturally found in water and present as a contaminant in wastewater
POA	Point of Application	The specified location where a chemical is added to the treatment process
PE	Population Equivalent	A metric to characterise the pollutant load of a certain group by expressing it in terms of a number of people that would produce the same amount of load
PST	Primary Settlement Tank	A large tank designed to remove a portion of suspended solids and organic matter from wastewater by exploiting differences in density
PBD	Process Block Diagram	A simplified schematic outlining the key stages of a process and how they interact
RGF plant	Rapid Gravity Filter	A method of filtration in which typically an open ended container filled with porous media is utilised to remove solid matter and often biological or chemical contaminants in water utilising gravitational flow through the media
SSSI	Site of Special Scientific Interest	A conservation designation denoting a protected area in the United Kingdom and Isle of Man
SAF	Submerged Aerated Filter	A submerged fixed-bed reactor typically used to remove nitrogen or carbon by passing the water vertically through a flooded media bed with a continuous supply of oxygen
SuDS	Sustainable Drainage System	Innovations designed to manage stormwater locally or as close to the source as possible
SCAMP	Sustainable Catchment Manage ment Programme	An initiative that aims to benefit both water and wildlife through improved catchment management
TAL	Technically Achievable Limit	The absolute maximum a wastewater treatment process can achieve with regards to removal of the target wastewater constituent

Acronym	Meaning	Definition
TSR	Tertiary Solids Removal	A tertiary wastewater treatment process that is designed to remove suspended solids and other remaining pollutants usually to bring contamination down to compliant levels before safe discharge into a watercourse
TOTEX	Total Expenditure	The total cost of a project that accounts for both capital expenditure and operational expenditure
Total P	Total Phosphorus	A measure of all forms of phosphorus in a given sample
TSS	Total Suspended Solids	A portion of the total solids retained on a filter with a specified pore size, measured after being dried at a specific temperature
UV	Ultra Violet Light Disinfection	A process of eliminating harmful microorganisms through exposure to ultra violet light
UTL	Upper Tier Limit	The use of the percentile limit (concentration limits for samples to be complied with at least 95% of the time) alongside the maximum limit (a concentration limit no sample can exceed)
UWWTD	Urban Waste Water Treatment Directive	A European Union directive concerning the collection, treatment and discharge of urban wastewater
VF	Vertical Flow	A process design that utilises the upward or downward flow of a volume
WwTW	Wastewater treatment works	A facility designed to remove contaminants of wastewater through a series of physical, biological or chemical processes
WFD	Water Framework Directive	A European Union directive that outlines rules to halt deterioration in the status of EU water bodies and achieve good status for Europe's rivers, lakes and groundwater.
WIMES	Water Industry Mechanical and Electrical Specification	Defines the requirements for a wide range of mechanical and electrical equipment used in the UK water industry
WRMP	Water Resources Management Plan	A UK government initiative requiring water companies to outline how they intend to achieve a secure supply of water for their customers and a protected and enhanced environment
WLC	Whole Life Cost	The total cost of a project or asset that accounts for the designed lifespan
WEO	Wider Environmental Outcome	The 4 wider environmental outcomes that water companies seek to deliver when developing and assessing options for the WINEP: natural environment, net zero, catchment resilience and access, amenity and engagement.

Acronym	Meaning	Definition
BioMAG	WW treatment process (Evoqua)	A treatment process where addition of a ballast to the secondary treatment results in better settlement in the final tanks
I-Phyc	WW treatment process (Industrial Phycology)	A Nature Based Solutions Company which produces a treatment process based on use of algae to remove contaminants
WINEP	Water Industry National Environment Programme	The programme of actions water companies need to take to meet environmental obligations