PR24

Cost Adjustment Claim: Reservoir dam maintenance

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United Utilities

Water for the North West

Contents

Appendices

Cost Adjustment Claim Submission

Cost adjustment claim submission	
Title:	Reservoir dam maintenance (£186.490 million)
Price Control:	Water resources
Cost adjustment headline:	• Reservoir safety is a legal, social and moral requirement that United Utilities Water (UUW) is entrusted to deliver. As such, dam safety, risk assessment and management is at the heart of our water resources activities and is non negotiable. This document provides advice to regulators about the appropriate means by which they should calculate and provide for the effective cost recovery of this essential activity in line with all legal and regulatory requirements. • The claim is made up of three parts: – Part 1: The relative historic cost of maintaining and operating reservoir and borehole sources; – Part 2: A rise in the number of statutory actions arising from regulatory safety inspections, since the publication of the 2020 Balmforth Report[1] into the Toddbrook Reservoir emergency; and – Part 3: A change in the Environment Agency (EA) flood risk maps[2] requiring additional work to remain compliant with the Health and Safety at Work Act 1974[3].

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[1] Professor David Balmforth (2020) *Toddbrook Part B report*. Available here.

[2] Environment Agency (2022) *Flood risk maps*. Available here. (UUW receives flood risk maps as a GIS shape file)

[3] Health and Safety Executive (1974) *The Health and Safety at Work Act*. Available here.

Description:	• UUW operates significantly more reservoirs than the average of water companies in England and Wales. Those reservoirs are also, on average, older than other companies. • Reservoirs cost more to operate and maintain than borehole sources, but Ofwat's proposed PR24 water cost models do not differentiate cost allowances based on source type. Costs associated with reservoir maintenance are focused on meeting our obligations under the Reservoirs Act 1975[4]. These costs are increasing due to the implementation of the recommendations of the Balmforth independent enquiry into the Toddbrook reservoir emergency (the 2020 Balmforth Report)[5]. • In addition, UUW has legal obligations under Section 3 of the Health and Safety at Work Act 1974 (H&SWA 1974), which relates to public exposure to industrial risks. In this case, the risk is related to dam failure. UUW manages this H&SWA 1974 obligation using a Portfolio Risk Assessment (PRA) approach, pro-actively reducing risk to the community. The EA has recently updated its flood risk maps which has, in the main, increased population numbers downstream of our reservoirs. This has then increased the consequence of a dam failure and led to increased numbers of UUWs reservoirs falling within HSE defined "unacceptable" risk categories (as described in HSE document Reducing Risk Protecting People (R2P2)[6]). It is important to note that this is not a reflection of the asset health condition of the dams in question, but is purely resulting from how the change in consequence impacts on the overall risk assessment. This cost adjustment case considers how we will intervene to reduce risk to ensure that our dams are within HSE defined "tolerable" risk categories in future. As a result, UUW must undertake significant additional investment to mitigate this risk. • This cost adjustment claim seeks an efficient adjustment to UUW's allowances to enable required statutory maintenance activity.

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[4] *The Reservoirs Act (1975)*. Available here.

[5] News report into Toddbrook Reservoir emergency. Available here.

[6] Health and Safety Executive (2001) *Reducing Risk – Protecting People (R2P2)*. Available here.

1. Cost adjustment case summary

Gate	Summary	Location reference
Need for cost adjustment	• United Utilities operates a much larger fleet of reservoirs than industry average.	*3.3.10*
	• Dam operation is a driver of costs, due to the regulated maintenance regime associated with dam safety in the UK, and reservoirs cost more to operate and maintain than boreholes. However the proposed PR24 cost models do not reflect differences in source type, so companies will only receive cost allowances based on an implied presumption that all companies have the industry average mix of source types. This will under-remunerate companies with a relatively high proportion of reservoirs.	*3.4.3*
	• Dam maintenance costs are also increasing due to external factors beyond management control, whereas cost models only reflect historic costs.	*3.5*
	• The number and cost of regulatory maintenance actions has increased since the release of the Independent 2020 Balmforth Report into the Toddbrook Reservoir incident.	*3.5.18*
	• United Utilities had a planned programme of dam failure risk reduction. The 2020 Balmforth Report recommended that risk reduction became part of the regulated inspection process for UK dams. This has caused us to accelerate our risk reduction programme, to align with the regulated inspection schedule. In addition, the scope of which reservoirs require risk reduction measures has increased due to the updating of EA's flood risk maps in 2022.	*3.5.36* *3.5.37*
Cost efficiency	• The future statutory actions element of the programme build is based on outturn unit rates, uplifted for the number of actions received post-2020 Balmforth Report, with frontier shift and catch up efficiencies applied.	*4.2.3*
	• For PRA elements of the business case, we have used historic project costs, scaled for the size of the dam, with frontier shift and catch up efficiencies applied.	*4.3.7*
Need for investment	• We are seeking investment to deliver regulatory driven activity, and to proactively reduce risk to the community.	*5.1.1*
	• The need for investment has increased due to external drivers associated with the national regulatory response to the Toddbrook Reservoir emergency, and arising from changes to the EA's reservoir flood risk maps.	*5.3*
Best options for customers	• Both reactive engineering interventions (driven by inspections carried out under the Reservoirs Act 1975) and pro-active engineering interventions (driven by the Health and Safety at Work Act 1974) are not discretionary. They are regulatory obligations.	*6.3.3*
	• The options we considered as part of our proactive risk reduction programme.	6.2
	• Results of an independent bench-marking exercise.	*6.3.5*
	• Customers have indicated a preference for investing now in critical infrastructure assets, with a focus on long life asset replacement in order to	*6.4*

	reduce the probability of service interruption. The planned programme of reservoir activity matches the customer preferred investment option.	
Customer protection	• We propose that customers will be protected through a price control deliverable mechanism which will link outcomes (risk reduction and / or delivery of statutory actions) to an agreed timescale, with processes to return money to customers in the event of UUW underperformance, or if anticipated actions are not required following reservoir inspections. • Price control deliverables are a new mechanism, which are still under development, and they will mainly apply to enhancement business cases. We propose to submit a suite of price control deliverables (including relating to this cost adjustment business case) covering all relevant business cases as part of our main submission in October 2023. This will ensure consistency of approach across the PR24 business plan.	*7.1* *7.1.5*

2. Introduction

2.1.1 Reservoir safety is a legal, social and moral requirement that UUW is entrusted to deliver. As such, dam safety, risk assessment and management is at the heart of our water resources activities and is non-negotiable. This document provides advice to regulators about the appropriate means by which they should calculate and provide for the effective cost recovery of this essential activity in line with all legal and regulatory requirements.

2.1.2 UUW operates the largest fleet of reservoirs of the water companies in England and Wales, significantly larger than the industry average on a normalised basis. However, PR24 cost models do not fully reflect the dam maintenance requirements associated with an above average reservoir fleet.

2.1.3 The Reservoirs Act 1975 requires that dams are subject to independent safety inspection at least every ten years. The independent Inspecting Engineer (an experienced civil engineer who has passed a Defra selection panel) is empowered to issue dam operators with statutory actions requiring the dam operator to make modifications to a specified scope, and by a specified time. The receipt of statutory actions is not an indication of poor asset health or inappropriate maintenance. It is a normal and regular part of the management of dam safety in England. Every dam operator will expect to receive statutory actions arising from the independent inspections. This process is analogous to a motor car MOT. Actions may arise when the car is subject to its MOT, even if the car has been well maintained and carefully driven.

2.1.4 The number of statutory actions issued, and their scope (and cost) are directly related to the dam in question, not the volume of water being impounded. Since the Toddbrook Reservoir emergency in 2019 UUW has seen an increase of 113% in statutory actions being received due to increasing rigour with which the Reservoirs Act 1975 is being enforced.

2.1.5 The reactive, inspection-led Reservoirs Act 1975 requirements remain a central pillar of UK dam safety management. However this reactive system relies upon an issue being detectable during the inspection process. This may not always be the case, and there have been cases (such as the Toddbrook Dam incident in 2019) where a dam has passed an inspection, only for a structural problem to develop (and potentially cause the dam to fail) before the next scheduled inspection takes place. To overcome this problem, there is a second, proactive pillar of UK dam safety legislation.

2.1.6 Section 3 of the H&SWA 1974 concerns the public exposure to risk from industrial processes (including dam operation). The Health and Safety Executive (HSE) sets risk tolerability thresholds, which operate on a sliding scale dependent upon the number of members of the public exposed to the risk. Industrial operators (in this case dam operators) are required to manage their operations so that their facilities are within the tolerable risk range (set by the HSE). UUW does this through its Portfolio Risk Assessment (PRA) process.

2.1.7 In 2022, the EA published updated reservoir flood inundation risk maps, which indicates more people are living within the inundation zones (where water would flow in the event of a dam failure) of dams than previously. This has created a lower threshold for dam failure risk, requiring us to pro-actively intervene to reduce risk on more dams than we had historically planned for.

2.1.8 These issues disproportionately affect UUW, due to our large reservoir fleet. These Victorian assets continue to give great service, and it is much more cost effective to manage the existing reservoir fleet than construct new reservoirs, or identify other alternative water sources. However, we do need to ensure that we continue to operate this fleet in line with statutory safety obligations.

2.1.9 UUW's cost adjustment claim is comprised of three components:

- **Part 1: The impact of operating reservoirs vs boreholes**. Ofwat's recommended models do not include a driver that reflects source type, meaning UUW does not receive an appropriate allocation of historical costs, commensurate to our large fleet of reservoirs.

- **Part 2: A rise in the number of statutory actions since the publication of the 2020 Balmforth Report.** As we set out in section 3.5.21 to 3.5.23, the 2020 Balmforth Report has led to an enhanced inspection regime, which has increased maintenance costs. These higher costs are not reflected in the historical dataset, which covers the years 2011-12 to 2021-22. This portion of the claim seeks to recover efficient additional maintenance expenditure relating to the stricter legal standards UUW will incur over the course of AMP8.
- **Part 3: A change in the EA flood risk maps requires additional work to remain compliant with the H&SWA 1974.** As a result of changes to the EA's flood risk maps, the H&SWA 1974 requires UUW to undertake additional mitigation at reservoirs deemed to be high risk (in the unacceptable categories). This reflects expenditure incremental to that incurred previously.

2.1.10 These elements along with the implicit allowance for dam maintenance and avoided power are set out in Table 1.

Table 1 - Summary of UUW's claim valuation

Element of claim	£million, 2022-23 CPIH	Source
Part 1: Pre-Balmforth element (historical cost of operating reservoirs versus boreholes)	36.573	Table 7
Part 2: Post-Balmforth element statutory actions (ITIOS)	65.151	Table 7
Part 3: Post-Balmforth PRA (flood-risk map change)	114.843	Table 12
Implicit allowance for dam maintenance	(12.457)	Table 13
Implicit allowance for avoided power	(17.62)	Table 14
Net claim value	**186.49**	

2.2 Our PR19 submission

2.2.1 We submitted a cost adjustment business case relating to reservoir dam maintenance at PR19. Ofwat did not accept this claim in full. Table 2 sets out the reasons why full acceptance was not possible at that time, and how this business case addresses these reasons.

Table 2 – Ofwat's reasons for rejection at PR19

	Reason for rejection at PR19	How we have addressed in this claim
1	"We have carried out further analysis for final determinations and find insufficient evidence to demonstrate that the number of reservoirs in itself is a driver for costs"	We present evidence that demonstrates the number of reservoirs (and in particular, dams) is the key cost driver of reservoir maintenance. This fact was noted by Ofwat in its recent consultation: *"Engineering rationale indicates that the number of high-risk reservoirs is a more appropriate variable than the capacity of reservoirs"*.[7]
2	"The company does not provide sufficient evidence to justify that its own mix of assets cause it to have higher costs than companies that have no reservoirs and which predominantly use abstraction from boreholes or rivers"	We include an implicit allowance to reflect the avoided costs of power relating to pumping from groundwater and river sources. Additionally, the scale of investigations and intervention now required in the post-2020 Balmforth Report era is materially larger than in the past. Finally, Ofwat includes an average pumping head term in its wholesale water models. We show that this will tend to allocate less botex to companies with a high proportion of impounding reservoirs sources. The inclusion of pumping head will reduce historic allocations towards surface water maintenance
3	"Historical expenditure to maintain reservoirs is included in the data we use to derive our base models and therefore in our base allowance"	We present evidence that the claim is material after the deduction of the implicit allowance

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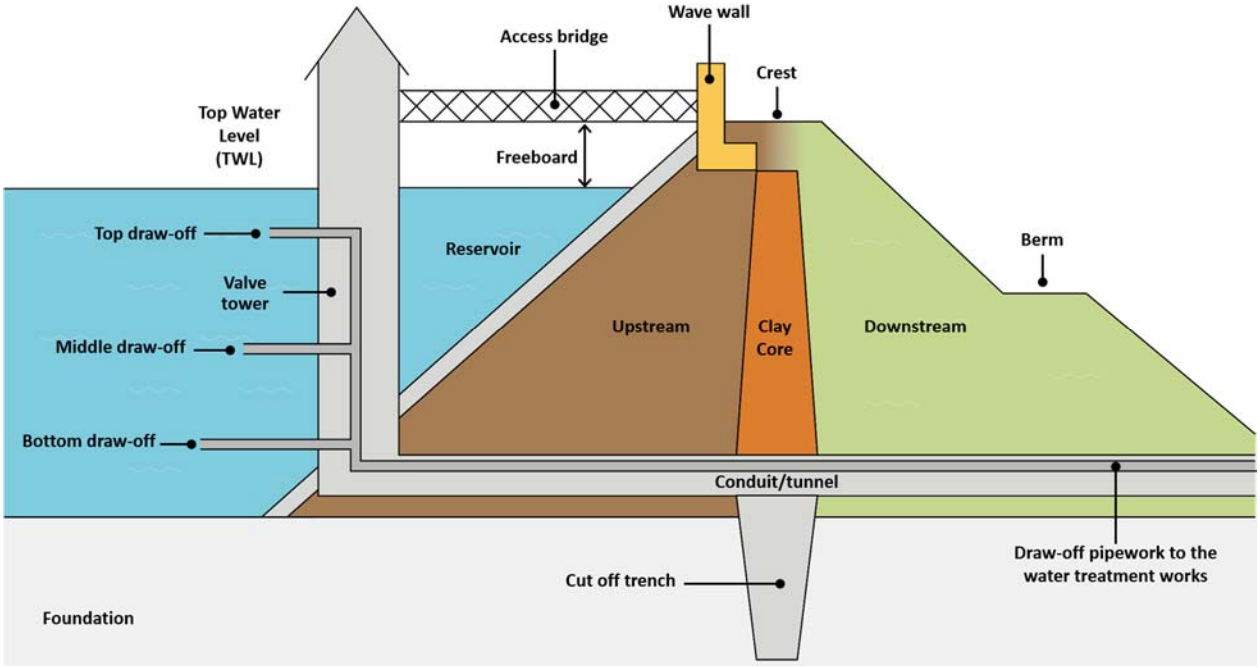
[7] Ofwat, 2023, *PR24 Econometric Base Cost Models Consultation, P27,* Available here

2.3 Reservoir schematic and glossary of terms used in this document

Figure 1 - Reservoir schematic (cross-section through the dam)



Terms used in schematic

- **Access bridge:** Links the valve tower to the crest.
- **Berm**: A shelf of rock or soil adding weight to anchor the toe of the embankment.
- **Clay core**: The water tight element of the dam. The core holds the water in place. The embankment holds the core in place.
- **Conduit-tunnel:** Joined to the valve tower. Hollow and dry to allow access. Contains pipework.
- **Crest:** The top of the dam. Usually flat, often includes a road or footpath for access.
- **Cut off trench:** Water tight core extended into underlying ground, prevents seepage.
- **Downstream:** The ‘dry’ side of the dam, beyond the water retaining core.
- **Draw-off pipework (top, middle, bottom):** pipework and valves that takes (abstracts) water from the reservoir and transports it to the water treatment works.
- **Foundation**: The underlying ground/bedrock beneath the reservoir.
- **Freeboard:** Distance between the top water level and the crest of the dam.
- **Reservoir:** Water stored above the level of the surrounding ground, held in place by a dam.
- **Top water level:** Elevation of the overflow weir, the level at which the reservoir begins overflowing.
- **Upstream:** The ‘wet’ side of the dam, saturated, before the water retaining core.
- **Valve tower:** A hollow, dry tower, with inlet valves to enable us to abstract water at different depths.
- **Wave wall:** Structure at the top of the dam preventing storm waves washing over the crest.

Glossary of terms used in document

- **ALARP** – As Low As Reasonably Practical. A risk category described by the HSE in R2P2 where the risk to the public has been reduced to a point where further investment cannot be justified on a cost benefit basis.
- **Balmforth Report** – An independent report into the Toddbrook Reservoir emergency incident, commissioned by the Department for the Environment, Food and Rural Affairs. Report led by Professor David Balmforth, the President of the Institution of Civil Engineers. This report produced a number of recommendations which led to changes in the application of reservoir safety regulations in the UK. (Link)
- **Environment Agency (EA)** – government agency responsible for the regulation and enforcement of dam safety regulations in England.
- **EA Flood Risk Map** – A series of computer generated maps, produced by the EA, showing areas of England at risk of flooding from different sources. These include maps of the areas that would be flooded in the event of dam failure. (Link)
- **Health and Safety at Work Act 1974 (H&SWA)** – The key UK legislation concerning occupational risk management. Section 3 of this Act places legal obligations on the operators of commercial premises, where an accident could cause offsite consequences, or effect people not directly employed by the site operator. Dam owners are covered by Section 3 of the Act, as flooding could affect the community downstream of the dam. (Link)
- **Health and Safety Executive (HSE) –** government agency responsible for the regulation and enforcement of section 3 of the H&SWA 1974.
- **Impounding reservoirs / reservoir** – Body of water held artificially in place above the level of the surrounding ground, by a dam structure. In the event of a dam failure, water would escape from the reservoir.
- **Inspecting Engineer** – A government appointed senior civil engineer, who has passed a rigorous selection panel, and who is commissioned to carry out independent dam safety inspections under the Reservoir Act. Also known as a Panel Engineer, and an All Reservoirs Panel Engineer (ARPE) and as a Qualified Civil Engineer (QCE) in different reports and publications.
- **(Matters) In The Interests Of Safety (ITIOS or MIOS)** – A legal notice issued by an independent Inspecting Engineer to a dam operator, requiring that the dam operator carries out specified safety improvements to a specified timescale. Also known as Measures In The Interests Of Safety (MIOS) in some publications. There are sub-categories of notices issued by the Inspecting Engineer (actions to be carried out relating to surveillance, actions related to maintenance and so on), these are collectively referred to throughout this document as ‘statutory actions’.
- **Metres above ordnance datum (mAOD)** – A reference measure in dam engineering. Heights above mean sea level measured at the Ordnance Survey datum point at Liverpool.
- **Reducing Risks, Protecting People (R2P2)** – HSE statutory guidance document setting out risk tolerability criteria associated with section 3 of the H&SWA. (Link)
- **Portfolio Risk Assessment (PRA)** – A process by which United Utilities reservoirs are risk assessed, compared to HSE risk tolerability guidelines, and used to produce a risk prioritised programme of risk reduction engineering interventions. Aimed at getting all United Utilities reservoirs to the tolerable risk category.
- **Probable Maximum Flood (PMF)** – Probable maximum flood means the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the drainage basin. The ability of a dam to safely pass the PMF is a key measure of dam safety. As our knowledge of PMF forecasting evolves over time, dams may require

remedial work to ensure that they can pass a newly calculated (higher than previously thought) PMF.

- **Reservoirs Act 1975** – Key UK legislation related to dam safety. Requires every relevant reservoir to be inspected by an independent, government appointed, Inspecting Engineer at intervals of no more than every 10 years. (Link)
- **Risk tolerability** – Different categories of risk, described by the HSE in R2P2. Based on extensive research carried out by the HSE. Provides a consistent, regulatory approved measure of risk management in the UK.
- **Toddbrook** – A reservoir in Derbyshire owned by the Canal and Rivers Trust. In August 2019 the reservoir experienced a serious dam safety emergency. The subsequent independent inquiry and report by Professor David Balmforth led to changes in dam safety regulation in the UK.
- **UUW** – United Utilities Wholesale, the operational arm of United Utilities.
- **Unacceptable risk** –A risk category described by the HSE in R2P2 where at least one person is exposed to a risk probability of 1 in 10,000 or more.
- **Unacceptable societal risk** - A risk category described by the HSE in R2P2 where more than 100 people are exposed to a risk. The tolerability threshold scales with the number of people exposed.
- **Tolerable risk** - A risk category described by the HSE in R2P2. A risk with an annual probability below 1 in 10,000.
- **Willowstick** – A technology used to identify leakage pathways through a dam. An electrical source is placed in a reservoir, and several receptors are placed downstream. Conductivity maps are then generated, showing lines of high conductivity, which correspond to leakage pathways. A critical technology when scoping dam safety interventions. (Link)

2.4 Structure of Document

2.4.1 We have divided our cost adjustment claim into the following sections:

- Section 3 provides an overview of the need for this cost adjustment. It demonstrates UUW operates and maintains an unusually high number of resources and why this will be associated with materially higher costs. It describes the statutory framework of reservoir safety and risk management with which we must comply. It evidences that the modelled allowance is not sufficient in the round to enable UUW to meet these legal obligations. Finally, it sets out UUW's approach to the symmetrical adjustment.
- Section 4 presents how UUW calculated the value of the cost adjustment for each of the claim's three elements: part 1: the pre-Balmforth Report element; part 2: the post-Balmforth Report Reservoirs Act 1975 element; and part 3: the post-EA flood map change H&SWA 1974 element. It also sets out UUW's approach to the implicit allowance.
- Section 5 evidences the need for investment in dam maintenance. It notes that the statutory framework and the 2020 Balmforth Report has led to a more prescriptive and stringent regime, which has caused associated compliance costs to increase.
- Section 6 demonstrates that this claim and the options set out within it are in the best interests of customers. It evidences that continued operation and maintenance of UUW's reservoir fleet is more economical than the development of alternative sources. It sets out the optioneering process by which UUW optimises its PRA programme and associated solutions. Finally, it shows that customers support continued maintenance of our asset base.
- Section 7 sets out how customers will be protected from non-delivery of the activities set out within this claim. We note that we will submit an associated PCD with our wider business plan in October 2023 to ensure our PCDs are internally consistent.

3. Need for adjustment

3.1 Overview of this section

3.1.1 This section presents evidence on the need for an adjustment to Ofwat's modelled allowances:

- Section 3.2 summarises the three different elements of this cost adjustment claim.
- Section 3.3 sets out evidence to support the uniqueness of UUW's water resources.
- Section 3.4 evidences that the recommended model suite will not provide sufficient cost allocation to deliver its legal obligations.
- Section 3.5 discusses the statutory framework and the safety requirements placed upon reservoir owners.
- Section 3.6 evidences that impounding reservoirs are a material cost driver at a company level.
- Section 3.7 sets out UUW's approach to the symmetrical adjustment. We note that the implicit allowance calculations are included as part of section 4.4.

3.2 The basis of this cost adjustment business case

3.2.1 This cost adjustment case is based on three factors:

- **Part 1: The impact of operating reservoirs vs boreholes.** Ofwat's proposed suite of cost models reflect the extra costs of pumping (via the use of pumping head within the water cost models) for companies who are predominantly fed from groundwater. However, the water resources plus cost models do not reflect the extra costs of dam maintenance for those companies which have a higher than average number of reservoir sources compared to groundwater sources. This situation is inequitable for companies with a relatively high proportion of reservoir sources.
- **Part 2: A rise in the number of statutory actions since the publication of the 2020 Balmforth Report.** The costs associated with the regulatory inspections of dams has increased as a result of the recommendations of the 2020 Balmforth Report into the 2019 Toddbrook Reservoir emergency incident. As these are new costs, they will not be accounted for in models based on historic costs.
- **Part 3: A change in the EA flood risk maps requires additional work to remain compliant with the H&SWA 1974.** One of the regulatory obligations for dam operators is to manage the risk associated with their dams in line with Section 3 of the H&SWA 1974. These requirements include an assessment of the likelihood and consequence of a dam emergency. A change to the EA flood risk maps in 2022 has led to an increase in the predicted consequence of a dam emergency, due to larger areas being forecast to be affected and population growth within that area. It is important to note that this change is not related to any change in asset health condition (the likelihood side of the assessment). The changes to the consequence element of the assessment (the flood maps) means that dams which were previously considered to be HSE risk compliant, now require additional risk reduction intervention in order to remain compliant (again, with no change to the physical condition or performance of the dam). These are new costs; they will not be accounted for in models based on historic costs.

3.3 UUW owns and operates a uniquely large number of reservoirs

3.3.1 UUW operates the largest fleet of reservoirs of the English and Welsh water companies. These reservoirs require regular maintenance and inspection. These reservoirs were inherited at privatisation and drive higher water resources costs in the round. It is efficient to continue to operate and maintain reservoirs because the cost of developing alternative sources is prohibitively high.

3.3.2 There are a number of factors associated with dam and reservoir operation which drive costs. These include:

- **The number of reservoirs operated by a company:** Each reservoir will incur regulatory obligations including inspections under the Reservoirs Act 1975 (and the cost of completing statutory actions arising from those inspections), and requirements for risk management under the H&SWA 1974 (and the costs associated with engineering interventions to ensure that the risk of dam failure is within limits set by the HSE). In addition, each reservoir will be associated with routine maintenance activities such as grounds maintenance, security and anti-vandal precautions, activities to keep visitors and recreational users safe, environmental requirements and so on (we note that these costs are not incurred by companies with boreholes to the same extent). Therefore, having more reservoirs increases costs.
- **The number of dams operated at each reservoir:** Some reservoirs are comparatively simple, and are formed by a dam across a valley impounding a river. By comparison some reservoirs are formed by damming complex shaped valleys in multiple locations. An individual reservoir can therefore have more than one dam. The dams associated with a reservoir will have been constructed at the same time, using the techniques available at the time of construction. As such, these reservoirs often require interventions on all of their dams at the same time. A reservoir with two dams requiring a risk reduction intervention under PRA, will require two separate projects, increasing costs and complexity. Therefore, more dams per reservoir will increase associated costs.
- **The age of the dams:** Construction of UUW's oldest dam was completed in 1800. The construction of the youngest dam in the UUW fleet was completed in 1971. The intervening years have seen the techniques and materials used in dam construction significantly evolve. Older reservoirs and their dams are associated with higher capital and maintenance costs as they were constructed at a time before civil engineering materials could be transported over any distance (before the train or canal network was built) and before any mechanical construction tools were available. These dams were hand built, using locally sourced material (regardless of the quality of the material) and were built before soil mechanics or hydraulic engineering were as well understood. They were also built with some inherent safety design flaws e.g. pipes directly through the embankment, which is a potential seepage risk.

  After 200 years these dams have experienced settling, and the effects of weathering, and therefore require higher levels of maintenance. They have also required modifications to align them with modern safety standards e.g. new spillways (which allow water to pass safely from the reservoir to the downstream watercourse) to accommodate larger rainfall events due to climate change. This can be compared to younger reservoirs and their dams, built in the second half of the twentieth century. These dams were built using a plethora of different construction machinery, construction techniques and used good quality material imported from around the world. More recently built dams were designed by engineers with a full working knowledge of flood forecasting, soil mechanics and material science and, as such, were built to higher quality standards than the older dams. They tend to have wider clay cores to prevent seepage, slacker slopes to reduce stability issues and do not have inherent safety design flaws. They also tend to have large enough spillways to cope with the increasing rainfall events due to climate change. Older dams therefore tend to require more significant risk reduction interventions than younger dams. Therefore, having older dam's increases costs. We provide more detail about how dam construction has evolved over time in Appendix A.
- **The size of the dam (length and height):** The physical size of a dam influences what risk reduction measures can practically be carried out in order to ensure continued compliance with HSE risk reduction measures and statutory actions arising from regulatory inspections. Larger dams have fewer options available due to constructability and access considerations, meaning that comparatively lower cost options are not always available for large dams. Additionally, larger dams mean that more material and time is required to complete work. Therefore, larger dams lead to higher costs.

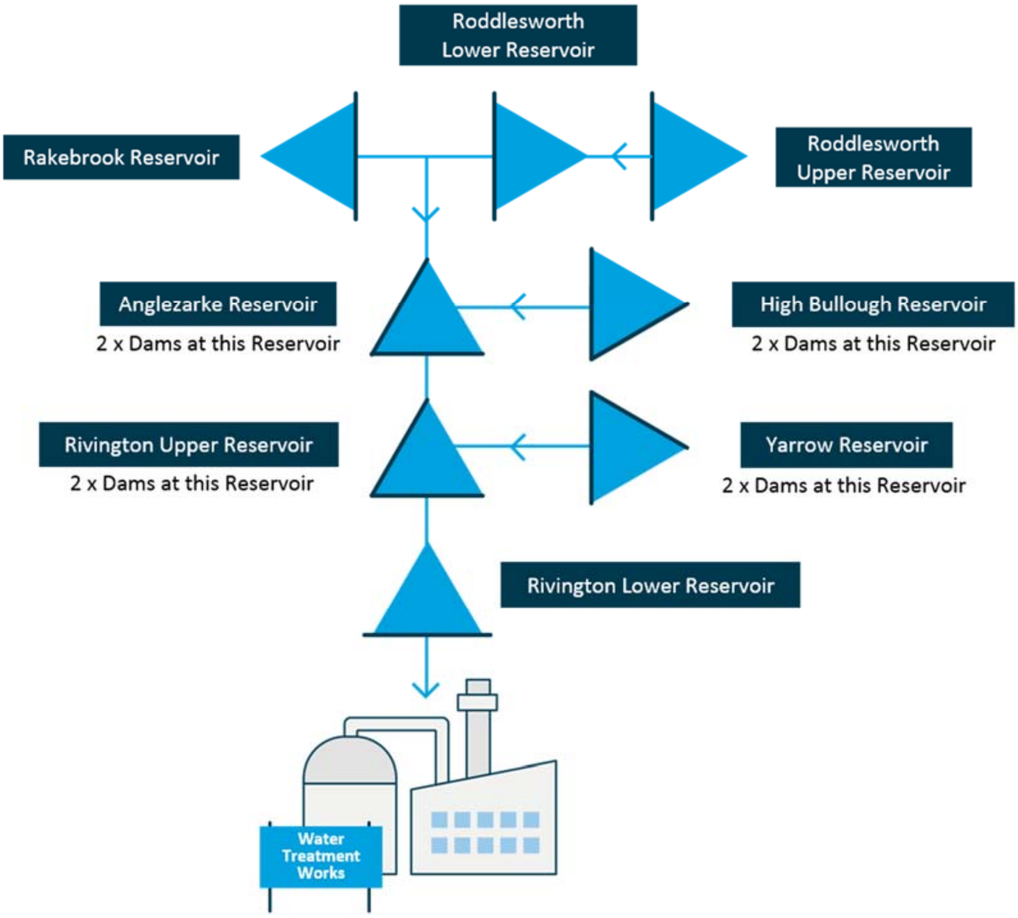
3.3.3 UUW operates a relatively large and old reservoir fleet, with some reservoirs having multiple dams

3.3.4 The North West has numerous long sinuous valleys, close to urban areas that began to develop during the Industrial Revolution. This led Victorian engineers to construct chains of reservoirs along a valley to supply the burgeoning urban population with potable water. Upstream reservoirs provide additional water storage and support to the lowest reservoir in the chain, which often feeds a water treatment works and/or supplies water to the downstream watercourse. This asset structure was inherited by UUW at privatisation. This remainder of this section sets out some examples of reservoir chains.

3.3.5 Figure 2 is an aerial image illustrating the chain of reservoirs in the River Douglas Valley. Showing from bottom left is Rivington Lower, Rivington Upper, Yarrow and Anglezarke. Not clearly visible in this image are High Bullough, Roddlesworth Lower, Roddlesworth Upper, and Rakebrook Reservoirs, which are all part of this chain. Only Rivington Lower Reservoir directly feeds a water treatment works and the downstream watercourse although there are a total of eight reservoirs and twelve dams (some reservoirs having more than one dam). Figure 3 shows the schematic of the whole River Douglas chain of reservoirs.

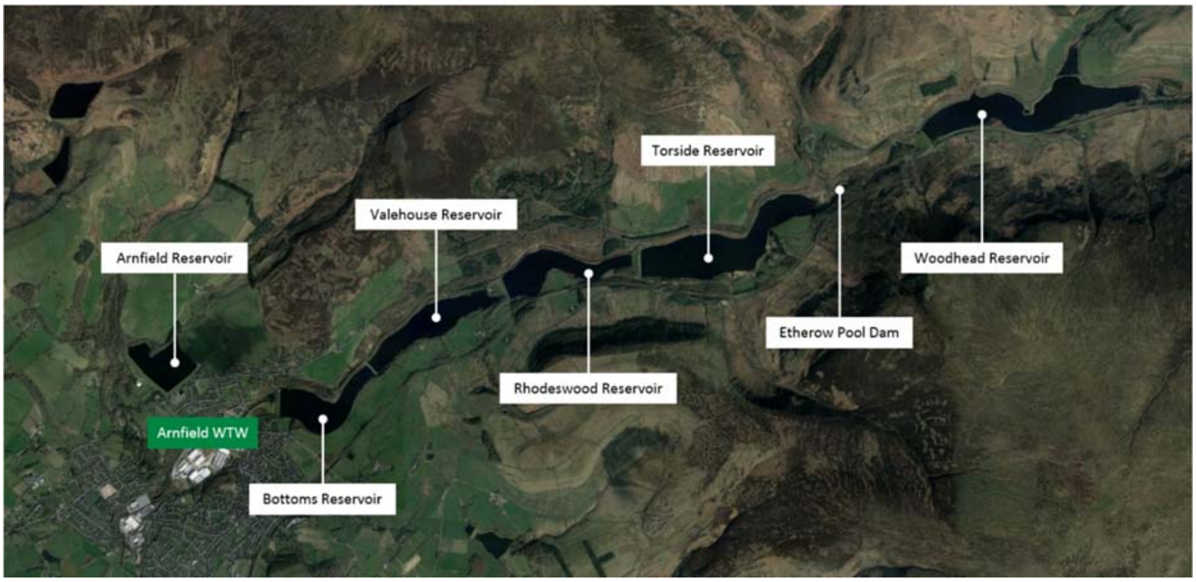
Figure 2 - The River Douglas Valley chain of reservoirs

Figure 3 - The River Douglas Valley chain of reservoirs schematic



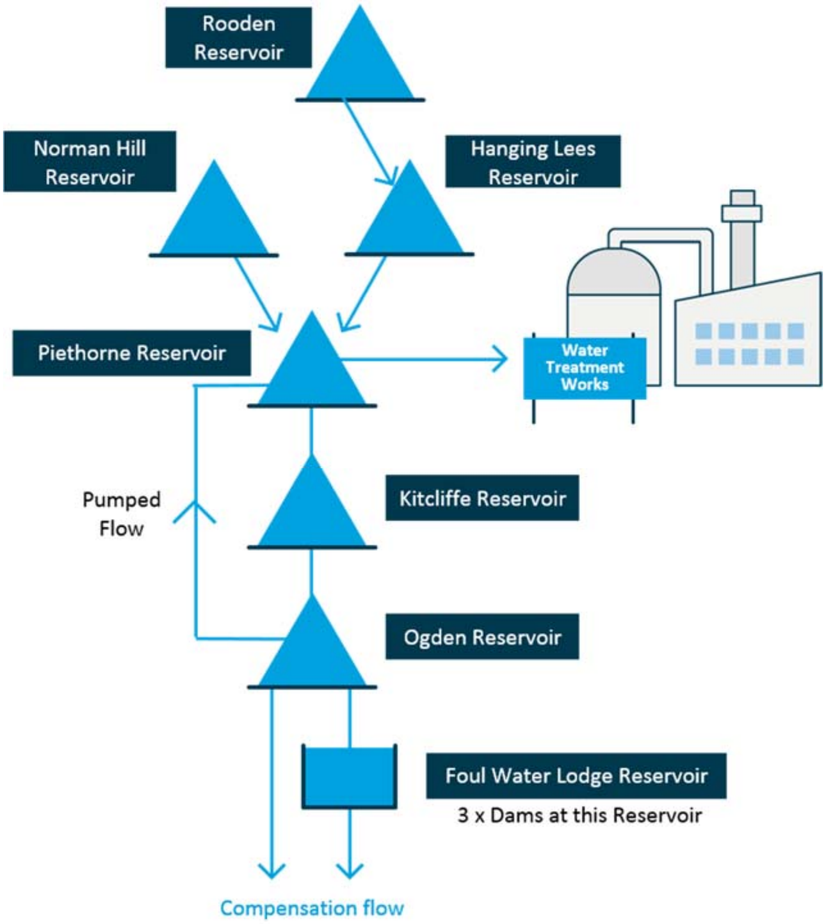
3.3.6 Figure 4 illustrates the chain of reservoirs in the Longdendale Valley. Showing from the left is Arnfield, Bottoms, Valehouse, Rhodeswood, Torside, Etherow Pool, and Woodhead. Only Arnfield and Rhodeswood directly feed Arnfield water treatment works, with Bottoms supplying water to the River Etherow, although there are a total of six reservoirs and ten dams.

Figure 4 - The Longdendale Valley chain of reservoirs



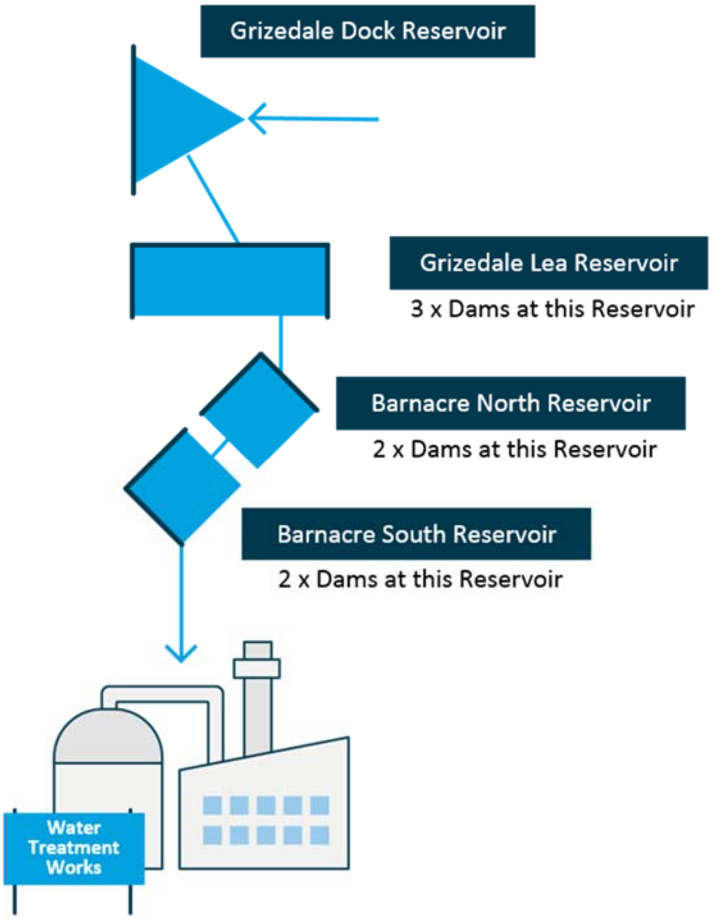
3.3.7 Figure 5 shows a schematic of the Piethorne Valley chain of reservoirs. Showing top to bottom is Rooden, Hanging Lees, Norman Hill, Piethorne, Kitcliffe, Ogden and Foul Water Lodge, which has three dams.

Figure 5 - The Piethorne Valley chain of reservoirs



3.3.8 Figure 6 shows the Grizedale Valley Reservoirs. From top to bottom there is Grizedale Dock, Grizedale Lea, and Barnacre North and South, each of which has two dams.

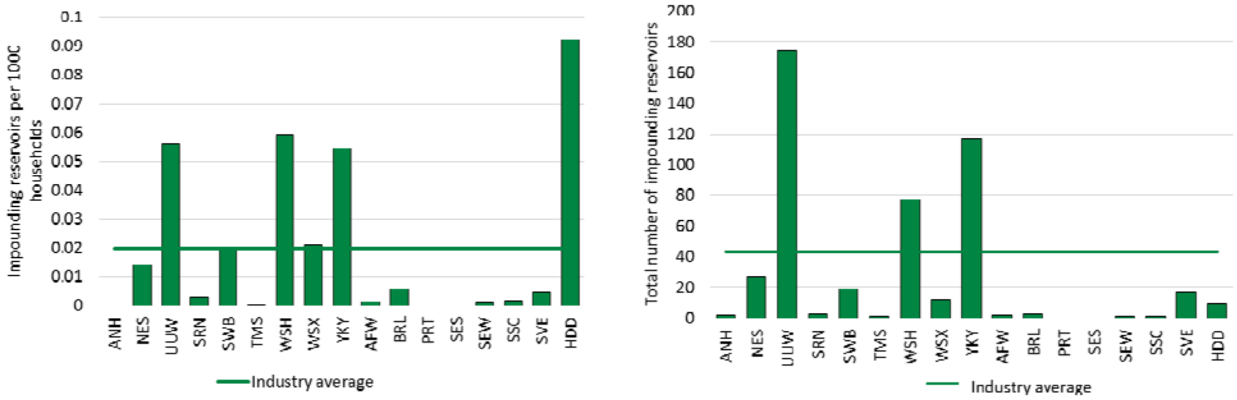
Figure 6 - The Grizedale Valley chain of reservoirs



3.3.9 UUW's historical legacy means we operate and maintain an atypically large number of reservoir dam structures

3.3.10 The historical legacy of the North-West means that UUW operates the largest fleet of reservoirs in the industry and significantly above industry average when normalised by households, as demonstrated by Figure 7. It is also worth noting that some reservoirs have more than one dam.

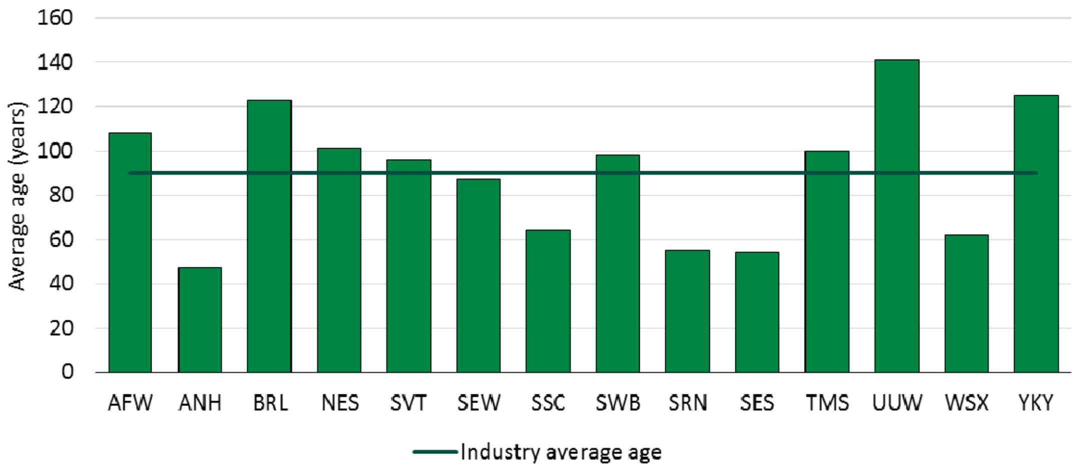
Figure 7 - UUW operates an above average number of impounding reservoirs in absolute and relative terms



Source: UUW analysis using Ofwat's cost assessment dataset. Available here.

3.3.11 Additionally, the average age of our reservoir fleet is one hundred and forty one (141) years, with our oldest reservoir being two hundred and twenty three (223) years old. Figure 8 demonstrates that the average age of UUW's reservoir fleet is the oldest in the industry. Section 3.3.2 explained why older dams drive higher capital and maintenance costs.

Figure 8 - Average age of reservoir fleets across the industry



Source: Environment Agency (2022) Public Register of English Reservoirs

3.3.12 It would not be cost effective in the round to replace our old fleet with a new fleet or develop alternative sources, as discussed in 3.5.3 to 3.5.7, so we consider continued maintenance of our existing older fleet to be the most efficient solution.

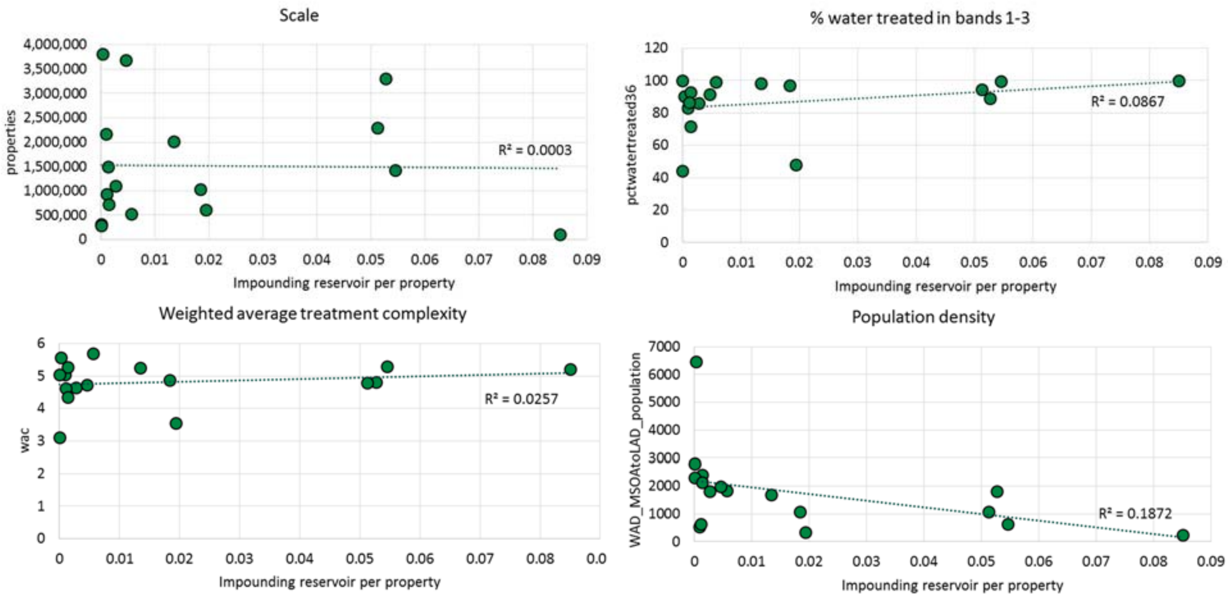
3.4 Ofwat's proposed model suite will not appropriately reflect reservoir maintenance requirements in the round

3.4.1 Ofwat's model suite does not include a cost driver that reflects efficient variation in dam maintenance:

- Ofwat includes a scale driver. However, there is no correlation between company size and number of reservoirs.
- Ofwat includes density drivers. These do not have a strong correlation with reservoirs per property. In fact, there is a slight negative correlation between reservoirs per property and population density. This means that, all else equal, if a reservoir cost driver is excluded then the models would detriment companies with higher than average population density and higher than average reservoirs. This is because population density effectively acts as a weak inverse proxy for reservoirs.
- Ofwat also includes treatment complexity measures. However, these have an extremely weak correlation with reservoirs per property. Additionally, as we discuss in paragraph 3.4.3, the way these measures are calculated places equal weight on surface and groundwater sources. For example, all band one surface water and band one groundwater sources are combined to form an overall band one sources category.

3.4.2 Figure 9 illustrates the lack of correlation between Ofwat's proposed cost drivers and normalised reservoirs. This demonstrates that Ofwat's models will not be capable of allocating sufficient expenditure to companies with dam maintenance requirements.

Figure 9 - There is no correlation between Ofwat's proposed cost drivers and reservoirs



Source: UUW analysis using Ofwat's cost assessment dataset. Available here.

3.4.3 The proposed treatment complexity cost drivers do not distinguish between surface water and groundwater source types. This means that they will not be able to reflect the maintenance requirements associated with surface water sources, which is generally composed of reservoir dam maintenance. Table 3 shows the derivation of the weighted average complexity variable, with both surface water and groundwater sources included within each complexity level. This clearly demonstrates that the variable is not able to distinguish between surface water and groundwater sources, because both are given equal weight within the calculation for each complexity band. The same is the case for the alternative treatment complexity variable, percentage of water treated in complexity bands three to six. Therefore, the models will not reflect any differential impact of reservoir maintenance within the treatment complexity variables.

Table 3 - Weighted average treatment complexity (WAC) measure calculation

Complexity level	0	1	2	3	4	5	6
Weight	1	2	3	4	5	6	7
% water treated	1%	1%	17%	17%	14%	50%	0%
C = A x B	0	0	0.5	0.7	0.7	3	0
WAC = sum(C)				**4.9**			

Source: Ofwat (2023) Econometric base cost models for PR24

3.4.4 Further, as we demonstrate later in the document in Table 5, reservoirs per property is a material driver of botex at an industry level, with a positive, statistically significant coefficient.

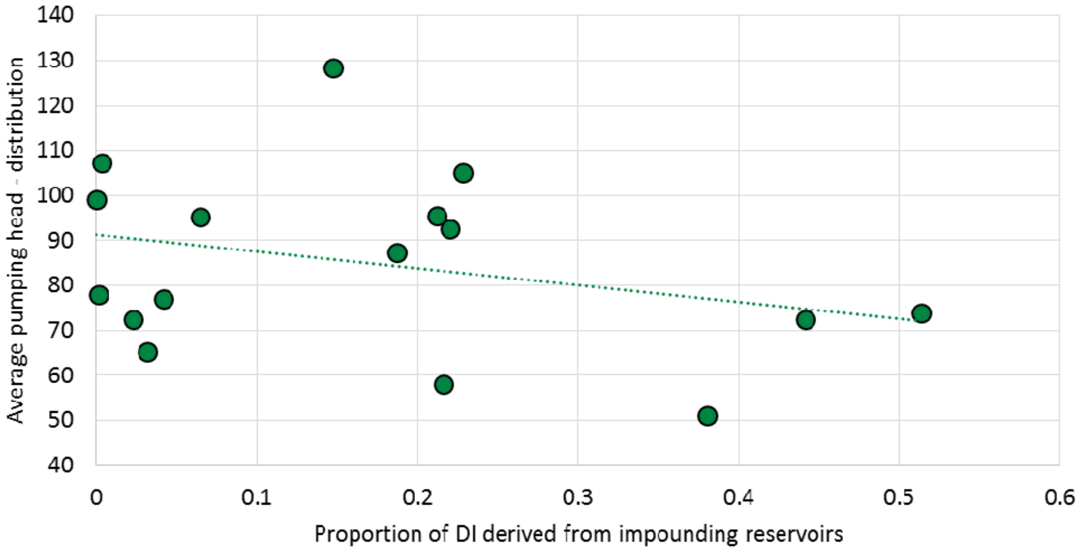
3.4.5 Ofwat's proposed model suite reflects the offsetting benefit of more reservoir sources

3.4.6 Reservoir sources tend to use gravity to move water to the water treatment works, which also helps to pressurise the downstream system to an extent. However, while variation in pumping requirements is reflected within Ofwat's recommended model suite (through the use of topography cost drivers), variation in reservoir maintenance requirements is not. Therefore, the recommended model suite is not appropriately offsetting higher maintenance requirements with lower power costs – the models are only reflecting one side of the equation, lower relative power costs. The remainder of this section evidences this point.

3.4.7 Ofwat's recommended model suite[8] includes a topography cost driver, proxied by two different explanatory variables: booster pumps per length of main; and average pumping head for the distribution element of the value chain. Ofwat uses these variables within both distribution and wholesale water models[9]. The use of topography variables within wholesale water models means that total water power costs are allocated according to pumping requirements. This includes water resources power costs.

3.4.8 Engineering, operational and economic rationale holds that gravity-fed water resources will contribute towards pressure in the downstream system including within the distribution network. This means that companies with a higher proportion of gravity-fed water resources (predominantly impounding reservoirs) will tend to have lower distribution average pumping head. Figure 10 shows a slight negative correlation between distribution pumping head and reservoirs. Assuming that the coefficient on the topography cost driver is positive, this means that econometric models will allocate less botex to companies with a high proportion of reservoir sources. Therefore, the inclusion of topography cost drivers in water cost models means that these companies' allowances will be adjusted downwards to reflect lower power requirements in water resources, without a corresponding increase to reflect higher dam maintenance requirements.

Figure 10 Gravity-fed reservoirs help to pressurise the downstream system



Source: UUW analysis using Ofwat's cost assessment dataset. Available here.

3.4.9 This means that the proposed model suite will reflect UUW's lower downstream power requirements, but the lack of a reservoir cost driver means that it won't reflect the corollary of this – higher upstream reservoir maintenance expenditure.

3.4.10 Therefore, Ofwat's models already account for the offsetting benefits associated with a high proportion of reservoirs sources. We consider that this means netting off the 'avoided power' implicit allowance from the claim could be viewed as representing a double-count of that benefit for companies with a high proportion of groundwater sources. However, to demonstrate stretch and ambition we have still

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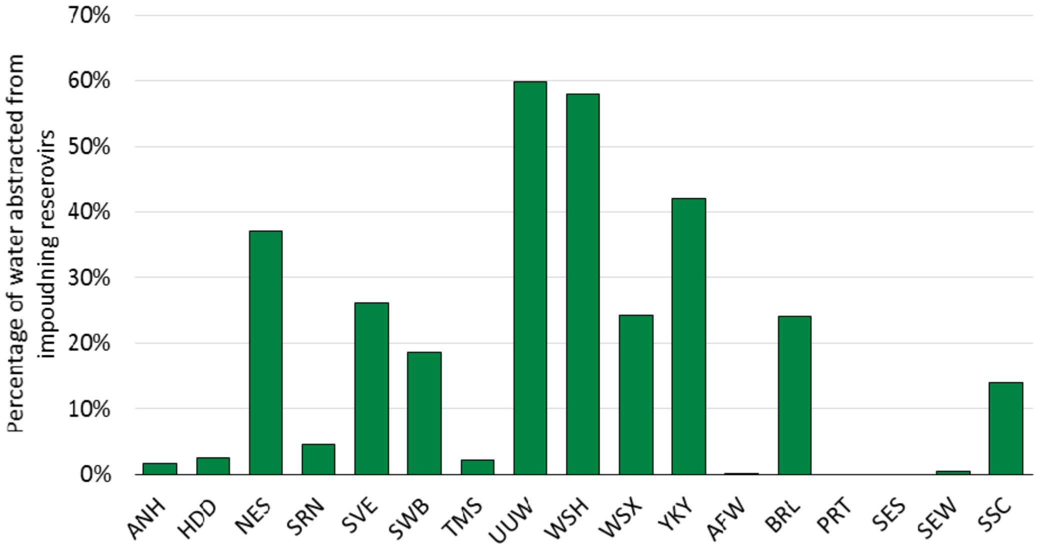
[8] Ofwat (2023) *Econometric base cost models for PR24*. Available here.

[9] As we set out within our response to Ofwat's consultation *"Econometric base cost models for PR24"*, we have significant concerns about the use of average pumping head data within cost assessment due to evidence of poor data quality. As such, we strongly oppose the use of pumping head data within base cost models. However, for the purposes of this cost adjustment claim, we assume average pumping head is used within cost assessment at PR24. This assumption should not be taken as implicit agreement with its use.

included an implicit allowance for the power costs we avoid by operating a higher proportion of impounding reservoir sources.

3.4.11 As Figure 11 shows, UUW abstracts the highest proportion of water from impounding reservoirs sources. This suggests that UUW will be disproportionately affected by the recognition of power requirements but the exclusion of dam maintenance requirements.

Figure 11 - UUW abstracts the highest proportion of water from impounding reservoir sources in the industry



Source: APR22

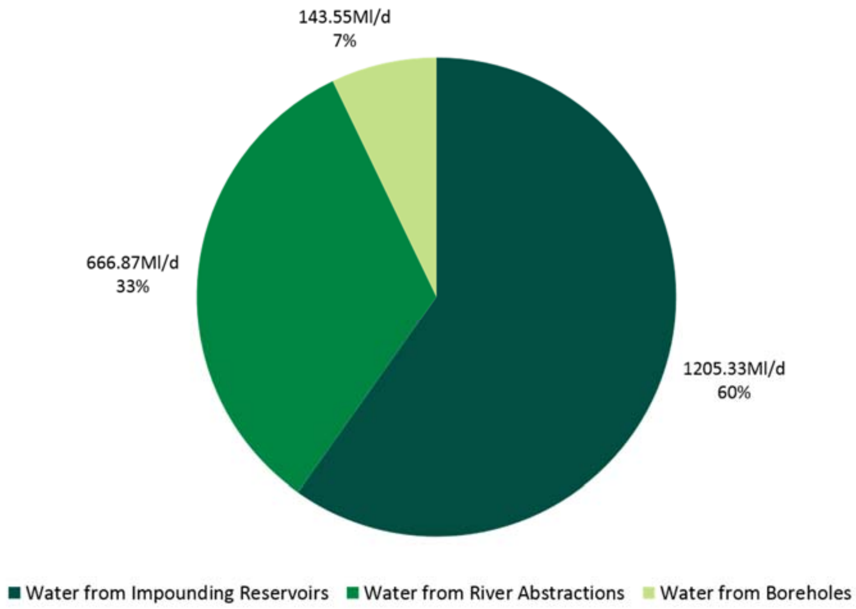
3.5 Management control and the statutory framework surrounding reservoir safety

3.5.1 This section sets out why continued operation and maintenance of reservoirs is the best value for money option. It also discusses the statutory framework surrounding reservoir safety and how this impacts upon UUW.

3.5.2 Operating and maintaining reservoirs represents best value for money

3.5.3 UUW inherited its reservoir fleet at privatisation, which continues to represent the most efficient way to supply our customers with water. It would not be cost effective to decommission our reservoir sources, and replace them with lower maintenance cost groundwater sources to attempt to reduce maintenance costs. We abstract approximately 1,200 megalitres per day from our reservoir sources, shown on Figure 12.

Figure 12 Proportion of abstraction from raw water sources



Source: UUW (2022) Regulatory reporting table 5A, lines 1, 3 & 4

3.5.4 We also do not have sufficient groundwater abstraction licence capacity to substitute abstraction from reservoirs with abstraction from boreholes. Furthermore, our Water Resource Management Plan (WRMP24)[10] identified the cost of developing new groundwater sources to be approximately £3.3 million per megalitre of resource capacity. This suggests that, assuming sufficient groundwater sources exist, the cost of replacing our reservoir sources would be in the region of £4 billion. This is likely a conservative estimate because the marginal cost of new water sources would increase as the stock of groundwater sources reduces. This is clearly far in excess of our net claim value of £186.490 million over AMP8.

3.5.5 Additionally, as part of PR24 Water Industry National Environment Programme (WINEP) development the EA is applying sustainability reductions to our abstraction from groundwater sources in order to protect the environment.

3.5.6 Furthermore, our reservoirs are regulated through abstraction licences, issued by the EA. These abstraction licences contain a number of conditions under which the abstraction of water is permitted, usually including the requirement to maintain an even flow of water (environmental compensation flow) to downstream rivers. Without the reservoirs which support compensation flow we would be prevented from abstracting water by the EA. We are also required to provide compensation flows to downstream rivers regardless of whether the reservoir is being used for abstraction. Therefore we would still be required to maintain our reservoir fleet if we ceased to abstract unless we fully decommissioned and removed the reservoirs in question, which would be extremely expensive.

3.5.7 Therefore, we consider that continued operation and maintenance of our reservoir's dams represents best value for money for our customers.

3.5.8 Regulatory framework for dam safety in England

3.5.9 Reservoir safety standards have been set by the government via the Reservoirs Act 1975 (as amended by the Flood and Water Management Act 2010[11]) and the Health and Safety at Work Act 1974 (H&SWA 1974) and are none negotiable. These represent legal requirements that UUW must comply with and a failure to act risks legal enforcement.

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[10] United Utilities Water (2023) *Water Resource Management Plan WRMP24*. Not published yet.

[11] DEFRA (2010) *Flood and Water Management Act*. Available here.

3.5.10 The EA is responsible for managing, implementing and enforcing, if needed, reservoir safety regulations in England.

3.5.11 Reservoirs Act 1975 (as amended by the Flood and Water Management Act 2010)

3.5.12 The Reservoirs Act 1975 dictates what activity reservoir owners must undertake to ensure dams do not pose a risk to the public.

3.5.13 Reservoirs registered under the Reservoirs Act 1975 must have an appointed independent Inspecting Engineer undertake a detailed inspection and report of findings every ten years, or sooner if required. This is bolstered by the requirement to have a Supervising Engineer that provides supervision through annual inspection and a report on condition. These inspections notify a reservoir owner if they are required to undertake statutory works, maintenance or monitoring in respect of the reservoir in question and within what timescale. These requirements are classed as statutory actions.

3.5.14 The receipt of statutory actions is not an indication of poor asset health or inappropriate maintenance. It is a normal and regular part of the management of dam safety in England. Every dam operator will expect to receive statutory actions arising from the independent inspections. This process is analogous to a motor car MOT. Actions may arise when the car is subject to its' MOT, even if the car has been well maintained and carefully driven.

3.5.15 Statutory actions will only be confirmed as complete if they have been signed off to the satisfaction of the Inspecting Engineer and the EA has been formally notified.

3.5.16 UUW undertakes all inspection and maintenance of the reservoir and associated structures in line with its legal obligations. We note that all reservoirs are subject to the same regulatory risk management regime, regardless of whether: the reservoir is directly connected to a water treatment works; is used to feed reservoirs further down the valley; or is used to provide environmental compensation flow.

3.5.17 There are eighty (80) statutory ten yearly inspections due to be undertaken within the last two years of AMP7 (from January 2023) and the first three years of AMP8 (by 31st March 2028), which will result in statutory actions to be undertaken during AMP8. Additionally statutory inspections undertaken in 2022, which require studies and investigations works, will likely lead to the requirement for capital works to be delivered in AMP8.

3.5.18 The Toddbrook Dam Emergency incident (2019) has increased safety standards

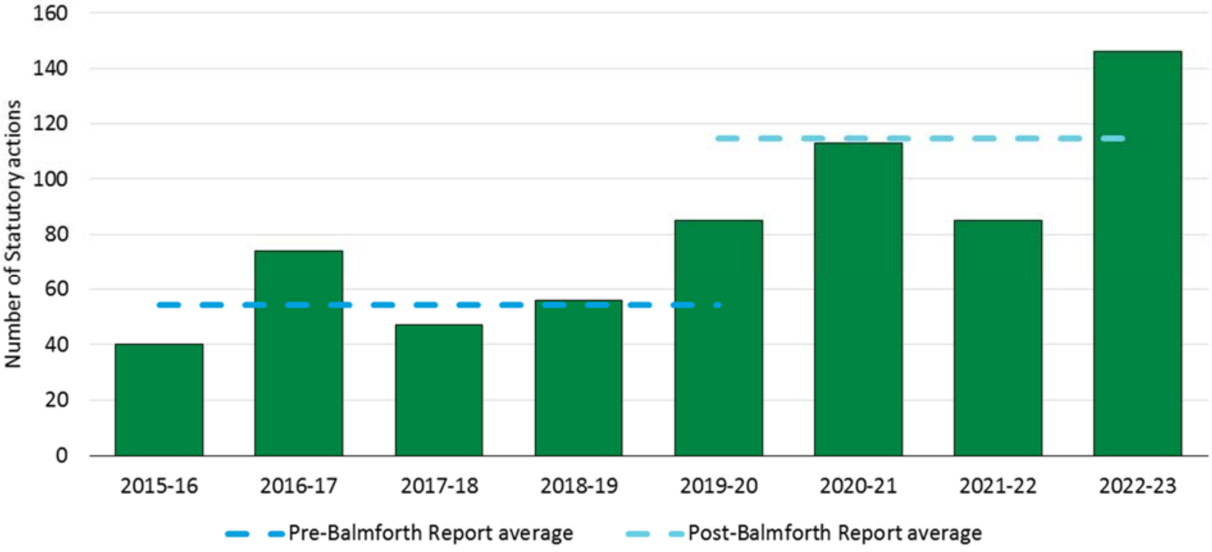
3.5.19 In 2019, following two heavy rainfall events, the auxiliary (secondary) spillway at Toddbrook Reservoir in Whaley Bridge, owned by the Canal and River Trust, failed despite being fully compliant with The Reservoirs Act 1975. See Figure 13. An emergency was declared and 1,500 Whaley Bridge residents were evacuated whilst water levels in the reservoir were reduced and temporary works were undertaken to stabilise the void in the spillway.

Figure 13 - Toddbrook Reservoir - spillway failure - 2019

3.5.20 Following the incident the Government asked Professor David Balmforth to undertake an independent review, to consider the effectiveness of reservoir safety legislation and regulations. The review (The 2020 Balmforth Report) has led to a more risk averse inspection process and more stringent timescales in which reservoir safety regulations are being enforced under the Reservoirs Act 1975. Consequently, this has led to a significant increase in statutory actions which is driving a significant increase in reservoir maintenance costs.

3.5.21 Figure 14 illustrates the effect that Toddbrook has had on statutory actions – those actions identified as legal requirements following a reservoir inspection. It shows the average number of statutory actions per year in AMP7 so far is 115, whereas in AMP6 it was 54 actions. This is an increase of 113%. This average excludes 2019-20, the year of the Toddbrook incident because this year reflects a mix of pre and post-Toddbrook inspections.

Figure 14- Number of reservoir statutory actions received since 2015-16

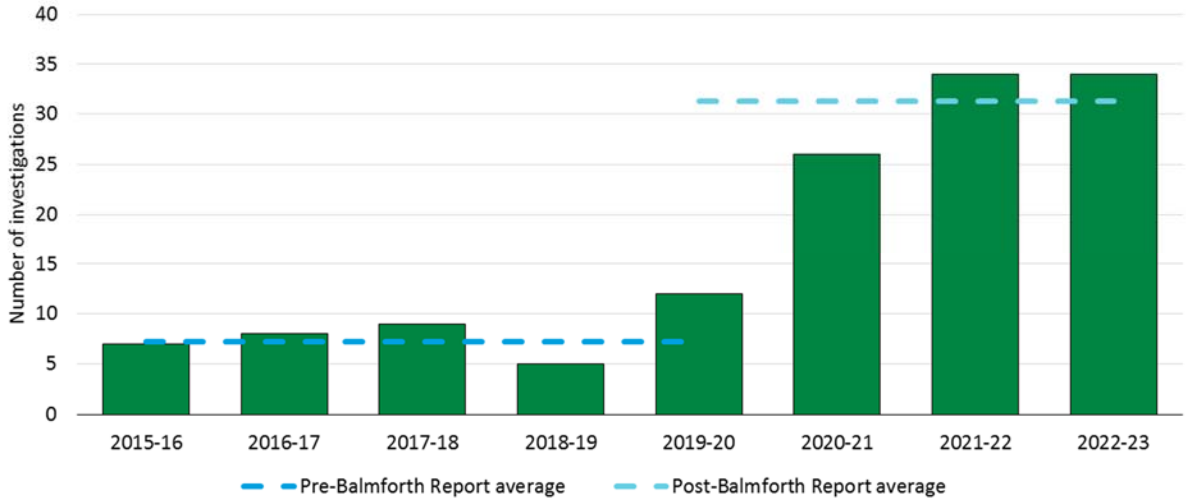


Source: UUW internal data

3.5.22 Additionally, Figure 15 demonstrates the Toddbrook incident has led to a substantial increase in the number of projects requiring studies or investigations as part of the design phase of an engineering intervention. It shows the average number of projects requiring studies per year in AMP7 so far is 31, whereas in AMP6 it was 7. This is an increase of 343%. This average excludes 2019-20, the year of the Toddbrook incident because this year reflects a mix of pre and post-Toddbrook inspections.

3.5.23 From the studies we currently have on-going so far, post Toddbrook, we are seeing the need for future physical engineering interventions. This additional expenditure will not be reflected within the historical dataset.

Figure 15 - There has been a significant increase in the number of studies arising from independent safety inspections



Source: UUW internal data

3.5.24 Health and Safety at Work Act 1974 (H&SWA 1974)

3.5.25 UUW also needs to ensure that it is discharging its risk requirements in accordance with Section 3 of the H&SWA 1974. Following an emergency event in 2002 at Rivington Upper reservoir, owned by UUW, a comprehensive enquiry was held. During the enquiry, UUW was instructed by HSE to comply with the HSE regulatory guidance, entitled "Reducing Risk – Protecting People" (R2P2) 2001.

3.5.26 R2P2 is the UK regulatory guidance for any commercial activity which has the potential to cause non-occupational impacts (affecting members of the general public) if something goes seriously wrong. It is not guidance specific to the water industry, but is used by a wide variety of industries such as chemical manufacturers and fuel storage depots. R2P2 provides a definitive guide on risk "tolerability". A "tolerable" risk can be managed through standard operational procedures, whereas an "intolerable/unacceptable" risk requires the industry in question to make a change, to make the structure in question "tolerable".

3.5.27 This guidance requires UUW, and indeed all other reservoir owners, to take direction from the HSE on the management of risk relating to its reservoir fleet. This entails ensuring we are appropriately mitigating wider societal risk and consequences, including the probability of failure thresholds, set out by the HSE in order to demonstrate the discharge of duties under the H&SWA 1974.

3.5.28 Additionally, the Toddbrook incident and the subsequent 2020 Balmforth Report has impacted upon the way the industry is required to implement HSE guidance:

- Recommendation 10 states: "high risk reservoirs should be managed and operated on the basis of risk to ensure their ongoing safety", as specified in the H&SWA 1974. High risk reservoirs are those where members of the public are potentially exposed to hazards in the unlikely event of a dam failure.
- Recommendation 5c states "Inspecting Engineers (acting under their duties associated with the Reservoirs Act 1975) should undertake or update, as necessary, a risk assessment for the reservoir. Where statutory actions are required as a result of a risk assessment, these should be specified so as

to reduce risk to ALARP (as low as reasonably practicable), and evidence should be provided to demonstrate that".

3.5.29 A dam can be compliant with the Reservoirs Act 1975, (because there is nothing that requires an immediate 'fix' in the opinion of the independent Inspecting Engineer), but the same reservoir can fall within a HSE "unacceptable risk" category based on its forecast future performance under extreme conditions.

3.5.30 The 2020 Balmforth Report's recommendations set out in paragraph 3.5.28 has led Inspecting Engineers to expect reservoir owners to demonstrate a proactive risk management approach to reservoir safety and are requesting this as part of statutory inspections made under the Reservoirs Act 1975. This has effectively made the forward management of reservoir risk a statutory obligation. We provide examples of Inspecting Engineers requiring risk management work in Appendix B.

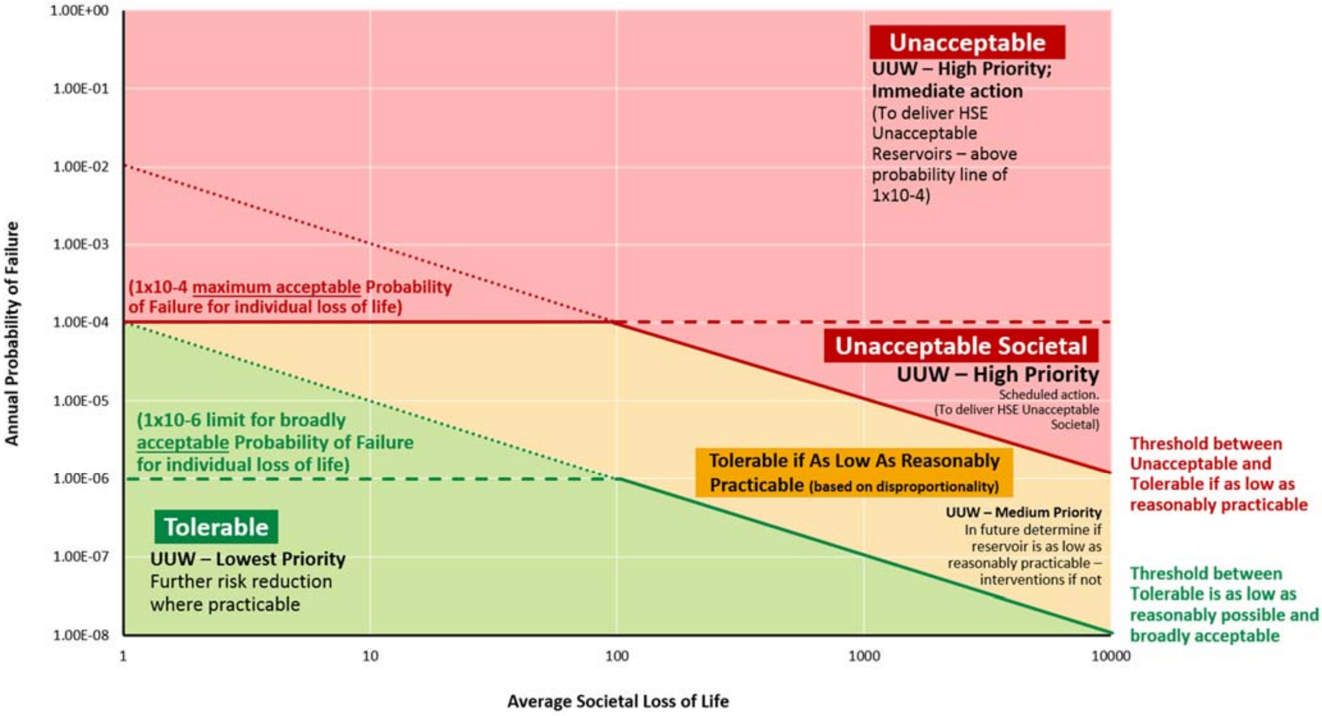
3.5.31 The HSE risk framework and UUW's PRA process

3.5.32 The HSE risk framework defines the tolerability associated with loss of life and its correlation to an activity, practice or process. The HSE risk framework sets out that, for an individual life, a probability of <1*10^{-6} (0.0001%) is "acceptable", >1*10^{-4} (0.01%) is "unacceptable" with a lower probability threshold for multiple lives at risk categorised as "unacceptable societal". Between these thresholds the risk is "Tolerable" "if ALARP" (as low as reasonably practicable); the ALARP designation depends on the disproportionality ratio (i.e. the benefit of reservoir improvements compared to cost – gross disproportionality being a limit) and the potential loss of life.

3.5.33 In order to comply with the HSE risk framework, UUW has adopted the framework set out in Figure 16, whereby annual probability of failure for a reservoir is plotted against the average predicted loss of life for that reservoir if it were to fail. This is known as our Portfolio Risk Assessment (PRA) process.

3.5.34 In Figure 16 the red area above the solid and dashed red line relates to "unacceptable" risk, the red area to the right below the dashed red line relates to "unacceptable societal" risk based on increasing numbers of lives at risk, the amber area relates to "Tolerable – if as low as reasonably practicable" risk, and the green area relates to "Tolerable" risk.

Figure 16 – Risk categories derived from HSE guidance R2P2



3.5.35 In order to ensure we are compliant with the HSE risk framework, UUW worked with international experts on dam safety to develop a methodology to calculate the likelihood and impact of dam failure.

This process, which we named the Portfolio Risk Assessment (PRA), provides a means of calculating the probability of failure, and consequence of failure, for dams in the fleet. We assess the probability of failure across the four key reservoir failure modes (different scenarios that could lead to a dam failure) - **seepage/internal erosion** (water passing through the dam); **stability** (the ability of the dam to remain upright and holding water); **flood** (the ability of the dam to safely store or discharge water in a flood event); and **seismic** (the ability of the dam to withstand an earthquake). The results of PRA are validated by an independent, government appointed, Inspecting Engineer to provide independent assurance of the findings.

3.5.36 Prior to the 2020 Balmforth Report, we were industry leading in our approach to reservoir risk management (PRA), as we evidence in Figure 26 later in the document. However, the 2020 Balmforth Report has led Inspecting Engineers to require reservoir owners to manage forward-looking risk on a statutory basis. This has effectively brought all companies into line with UUW’s approach. Therefore, what was once our industry leading approach, is now an industry standard expected of all dam operators.

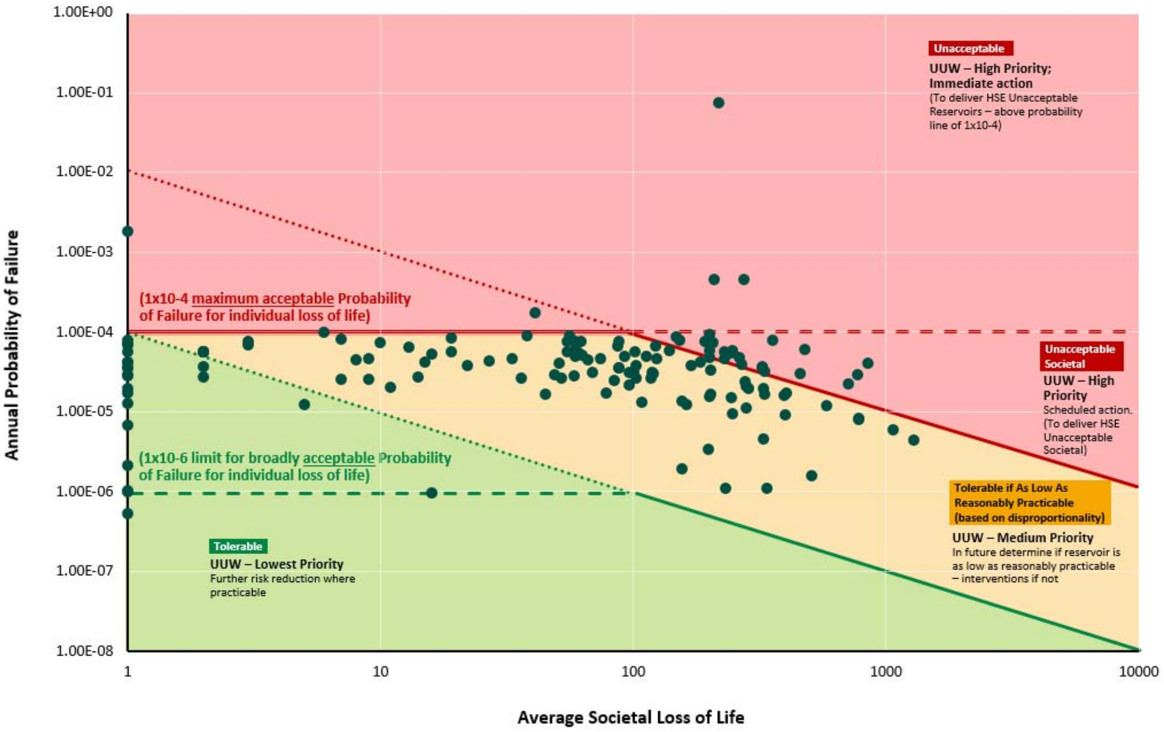
3.5.37 Updates to the EA flood risk maps 2022

3.5.38 The EA flood risk maps are an input to the risk framework (PRA) as it determines the consequence of a dam failure by indicating how many people are classed as ‘at risk’ downstream of the dam. A change in the EA’s flood risk maps may lead to a different risk profile because additional properties (and their occupants) may be judged to be at risk in the event a dam fails.

3.5.39 In 2022, the EA updated its flood risk maps. The update used revised computer modelling and relief maps of topography to improve the forecast of where water would flow in the event of a dam failure. These updates extended the areas at risk. The maps of flood risk areas were compared to household population data, to determine the population that could be affected. Population growth since the last edition of the maps also increased the numbers of people at risk.

3.5.40 As shown in Table 4 and Figure 17, prior to the EA flood risk map changes the majority of UUW’s reservoir sat in a “tolerable” risk category (115 reservoirs). However, there were a number sat in an “unacceptable” category that would have required risk reduction measures in AMP7 and AMP8 (26 reservoirs).

Figure 17 – The risk framework prior to the EA's flood risk map update in 2022



Source: UUW internal data

3.5.41 With the update to the EA flood risk maps there are now 37 reservoirs sat within an "unacceptable" risk category and 104 reservoirs in a "tolerable" risk category, see Table 4 and Figure 18. This is due to the consequence of dam failure (impacts downstream) having increased rather than a deterioration of the asset health condition of the dam (not an increase in probability of failure).

Figure 18 - HSE risk framework after update to EA's flood risk maps

Source: UUW internal data

3.5.42 UUW reservoirs that sit within the HSE defined "unacceptable" categories are subject to operational risk reduction measures (such as enhanced inspection or a temporary reduction in water level) until a permanent engineering risk reduction measure can be delivered.

3.5.43 Appendix D, Table 23 and Table 24 show the HSE defined risk category status of individual reservoirs in the UUW fleet prior to and post the EA flood risk map changes in 2022.

Table 4 - Changes in HSE risk category based on updates to the EA flood risk maps

Risk Category	Pre EA flood risk map changes (No. of Reservoirs)	Post EA flood risk map changes (No. of Reservoirs)	Difference**
Unacceptable	5	5	Same
Unacceptable – Societal	21	32	+11
Tolerable if As Low As Reasonably Practicable (ALARP)	93	75	-18
Tolerable	22	29	+7*

** A number of reservoirs that were in the "Unacceptable / Unacceptable Societal" category prior to the flood risk map changes have now moved to a "Tolerable" category due to changes in loss of life figures.*

*** Reservoir numbers in our PRA tables will not match our APR data as where adjacent reservoirs have an uncontrollable hydraulic link they are assessed as a single potential mode of failure and concrete dams have been excluded as they are not subject to internal erosion failure modes.*

Source: UUW internal data

3.5.44 All our reservoirs are subject to operational mitigation until a permanent engineering fix can be delivered to reduce risk to acceptable levels, this may involve routine 48 hour surveillance, additional monitoring, reduction of water levels etc. These interventions are not appropriate in the long-term for a number of reasons – operational cost, impacts on water resources for customer supplies and appropriate risk management.

3.5.45 Our intervention type and timing of maintenance activity

3.5.46 For statutory actions falling under the Reservoirs Act 1975, we must abide by third party instruction from independent Inspecting Engineers in line with the Reservoirs Act 1975. The independent Inspecting Engineers set the actions and timescales. This means there is limited scope for UUW to seek alternative strategies such as a stronger risk appetite or adopting a revised maintenance timetable.

3.5.47 When Toddbrook experienced its emergency, it was fully compliant with the Reservoirs Act 1975 regulations. This has led to a change of approach to the enforcement of dam safety regulations. One of Professor Balmforth's recommendations (Recommendation 5c) was that "Inspecting Engineers should undertake or update, as necessary, a risk assessment for the reservoir. Where statutory actions are required as a result of a risk assessment, these should be specified so as to reduce risk to ALARP (as low as reasonably practicable), and evidence should be provided to demonstrate that". This effectively places the responsibility for pro-active risk assessment and risk reduction (PRA activity), as per H&SWA 1974 guidance, in the remit of the independent Inspecting Engineer and their statutory powers under the Reservoirs Act 1975.

3.5.48 For obligations under the H&SWA 1974 (PRA) it was formerly within management control to deal with the highest risks (probability x consequence) first, as part of a long term, multi-AMP approach to the delivery of PRA projects. This allowed UUW to spread the impact of projects (e.g. in terms of customer bill impact and impacts on supply outages) to minimise disruption. That ensured that we were using customer's money to achieve the greatest risk reduction and hence value for money.

3.5.49 However, since the publication of the 2020 Balmforth Report Part B, and the risk assessment duties falling within the remit of the independent Inspecting Engineer, UUW has lost the discretion to be able to take decisions based on risk appetite, for example by deferring PRA projects across multiple AMPs. This means that PRA projects are now timed at the discretion of the independent Inspecting Engineer. This removes our ability to optimise our investment programme as we will have to abide by timescales dictated to us by the Inspecting Engineer. Dates of statutory inspections have been a key driver in determining our AMP8 and AMP9 PRA programme.

3.5.50 In order to avoid double counting, our costings for statutory requirements falling under the Reservoirs Act 1975 do not include PRA requirements falling under the H&SWA 1974.

3.5.51 UUW is unable to balance AMP8 maintenance requirements across multiple AMPs

3.5.52 In some cases, it is possible for a company to balance expenditure over the long-term. For example, higher maintenance requirements now may be offset by lower maintenance requirements later, meaning that an adjustment to current allowances is not necessary.

3.5.53 However, it is not possible to balance reservoir maintenance expenditure over the long-term in this way. As we have demonstrated (see Figure 14 and Figure 15 for example), maintenance requirements are increasing and are not expected to become less stringent in future. This was made explicitly clear by the Parliamentary Under-Secretary of State for Defra, Rebecca Pow, in the forword to the second report published by David Balmforth on reservoir safety, published in March 2021: *"This Government is committed, now and in the future, to ensure our reservoirs can and do operate safely, without posing a risk to the public… These recommendations provide an opportunity to explore developing a new risk-based approach, engender a continuous improvement culture to safety across the industry and secure a robust, and proportionate regulatory approach"*[12].

3.5.54 Maintenance requirements allocated under the Reservoirs Act 1975 have timescales set by an independent Inspecting Engineer that legally have to be adhered to. Additionally, the age of our reservoir fleet means that we will need to undertake continuous remedial work to mitigate the risk of an issue at the reservoir or the reservoir risks falling into the HSE defined "unacceptable" risk category. Finally, the 2020 Balmforth Report has led inspectors to adopt a more proactive approach (our PRA

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[12] Foreword to Report (2021) *Independent reservoir safety report.* Available here.

process) to reservoir safety, which has led to them requiring reservoir owners to manage forward-looking risk as part of the wider statutory framework.

3.5.55 As a result, UUW requires an uplift to its AMP8 base cost allowance to facilitate capital and maintenance activity in AMP8. Further maintenance expenditure will also be required in AMP9.

3.5.56 The difference between statutory actions under the Reservoirs Act 1975 and risk reduction (PRA) interventions under the Health and Safety at Work Act 1974

3.5.57 A dam can be compliant with the Reservoirs Act 1975 (because there is nothing that requires an immediate 'fix' in the opinion of the independent Inspecting Engineer), but the same reservoir can fall within a HSE "unacceptable risk" category based on its' forecast future performance under extreme conditions. This is because the two risk management frameworks aim to achieve subtly different objectives.

3.5.58 Statutory actions under the Reservoirs Act 1975 are actions identified by an independent Inspecting Engineer during their 10 yearly safety check inspection of the dam. Historically these actions have focussed on the proactive maintenance of matters, which are immediately identifiable and visible. The ten yearly safety check inspection is analogous to an MOT test on a motor car; it is an independent check of safety items. We have forecast future statutory actions based on the historic run rate observed since the publication of the 2020 Balmforth Report.

3.5.59 Risk reduction (PRA) measures are not directly concerned with the current condition of the dam. This is an assessment of the forecast future performance of the dam structure under extreme environmental conditions (such as stability during an earthquake). This process uses risk factors such as the steepness of the embankment slope, in comparison to forecast maximum ground acceleration during seismic events. Risk reduction measures are typically engineering changes to the dam, to make it better able to accommodate extreme conditions at some point in the future. This process is analogous to a routine health check-up, it involves making prioritised changes based on risk factors. We have forecast future PRA activity based on the results of risk assessments carried out on dams in the UUW fleet.

3.5.60 We have kept future forecasts of statutory actions separate from forecasts of future PRA activity. Our statutory actions forecast is based on run rate, with no PRA projects included in the historic run rate. Our PRA forecast is based on the results of risk assessments of dams in the UUW fleet. This approach has ensured that no projects are included in both categories.

3.6 Materiality

3.6.1 The costs set out within this claim are driven by the need to maintain UUW's large fleet of relatively old reservoirs. As we set out in 3.3.2, reservoir maintenance is a function of the number of dams a company has within its reservoir fleet and as we set out in 3.5, there are clear legal requirements to ensure our dams are maintained to a safe standard.

3.6.2 We are able to demonstrate that impounding reservoir dam maintenance is a material driver of cost at a company level by including it within Ofwat's proposed water resources plus model from its April 2023 consultation. A positive and statistically significant coefficient demonstrates that dam maintenance is a material cost driver at an industry level, even after offsetting benefits have been accounted for.

3.6.3 We created a reservoir cost driver using the following methodology:

(1) Sum the total number of impounding reservoirs (BON code: BN4830S) and total number of pumped storage reservoirs (BON code: BN4849). This is appropriate because both impounding reservoirs and pumped storage reservoirs have dam maintenance requirements.

(2) Where the calculation in Step 1 returns a zero for a company/year, we replace that instance with the total number of water reservoirs line (BON code: BN10190). This is necessary because some companies report zero under BN4830S and BN4849 but report a positive value for BN10190. Therefore, this step ensures we do not omit a company's reservoir

maintenance requirements due to data quality issues. We note that if Ofwat collects more consistent data on reservoirs (as suggested in its recent consultation), we would use it as part of this analysis in future.

(3) We divide the total number of reservoirs calculated in Step 1 and Step 2 by the total number of properties connected (BON code: BN2221 + BN2161).

3.6.4 Table 5 presents the results of including this reservoirs factor within Ofwat's recommended model suite. It's clear that the coefficient on reservoirs per property is statistically significant and of an intuitive sign. We consider this to be clear evidence that reservoir maintenance drives material costs at an industry level.

Table 5 - Impounding reservoirs per property is a statistically significant cost driver

	WRP1	WRP2	WRP3	WRP4	WRP5	WRP6
ln(Properties)	1.052***	1.044***	1.010***	1.007***	1.023***	1.019***
	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
% water treated in bands 1-3	0.004**		0.003**		0.004**	
	{0.020}		{0.043}		{0.021}	
ln(WAD, MSOA to LAD)	-1.104*	-0.948				
	{0.069}	{0.140}				
ln(WAD, MSOA to LAD) squared	0.075**	0.064				
	{0.050}	{0.115}				
ln(Impounding reservoirs per property)	**0.145****	**0.154*****	**0.181****	**0.185*****	**0.163****	**0.167*****
	{0.016}	**{0.006}**	**{0.014}**	**{0.007}**	**{0.012}**	**{0.005}**
ln(Weighted average treatment complexity)		0.329		0.312		0.332
		{0.213}		{0.239}		{0.191}
ln(WAD, MSOA)			-2.046	-1.824		
			{0.303}	{0.391}		
ln(WAD, MSOA) squared			0.135	0.12		
			{0.247}	{0.338}		
ln(property per km of main)					-5.218*	-4.557
					{0.087}	{0.138}
ln(property per km of main) squared					0.608*	0.529
					{0.078}	{0.127}
Constant	-3.621	-4.173	10.959	10.149	12.885*	11.508
	{0.102}	{0.188}	{0.229}	{0.346}	{0.089}	{0.205}
Sample size	165	165	165	165	165	165
R squared	0.911	0.912	0.906	0.907	0.908	0.911
RESET test	0.249	0.219	0.526	0.563	0.54	0.249

WAD = weighted average density, MSOA - medium layer super output area, LAD - local authority district
* indicates statistical significance at the 10 percent level, ** indicates statistical significance at the 5 percent level, *** indicates statistical significance at the 1 percent level

Source: UUW analysis using Ofwat's cost assessment dataset. Available here.

3.6.5 We note that there has been a slight deterioration in the statistical results associated with some population density cost drivers e.g. a slight reduction in the t scores. While the robustness of the coefficients' sign means this is not a material issue, it does suggest that there is a slight correlation between our reservoir cost driver and population density. In fact, as we demonstrated earlier in paragraph 3.4.2 there is a slight negative correlation between reservoirs per property and population density. This means that, all else equal, if a reservoir cost driver is excluded then the models would detriment companies with higher than average population density and higher than average reservoirs. This is because population density effectively acts as an inverse proxy for reservoirs.

3.6.6 However, the slight correlation between impounding reservoirs and population density led us to consider it would be inappropriate to value our claim through reference to the models set out in Table 5. We do still consider that the statistically significant results on the reservoirs cost driver provides good evidence that dam maintenance costs are material in the round. We also draw upon the output of this model to determine the relative net effect of dam maintenance on company costs, which forms the basis of our symmetrical adjustment.

3.7 Adjustment to allowances

3.7.1 UUW's cost adjustment claim is comprised of three components:

- **Part 1: The impact of operating reservoirs vs boreholes**. Ofwat's recommended models do not include a driver that reflects differences in source type, meaning UUW does not receive an appropriate allocation of historical costs, commensurate to our large fleet of reservoirs. However, UUW does avoid an element of (implicitly allowed) power expenditure as we pump less water from groundwater sources than other companies. Additionally, as companies with reservoirs have historically carried out dam maintenance, the models will provide an implicit allowance for this activity - however, the lack of an appropriate cost driver means this is not allocated to companies appropriately. We net off an implicit allowance from this element of the claim to reflect avoided pumping costs and the implicit allowance for dam maintenance provided by Ofwat's recommended model suite.
- **Part 2: A rise in the number of statutory actions since the publication of the 2020 Balmforth Report.** As we set out in section 3.5.19 to 3.5.23, the 2020 Balmforth Report has led to an enhanced inspection regime, which has increased maintenance costs. These higher costs are not reflected in the historical dataset, which covers the years 2011-12 to 2021-22. This portion of the claim seeks to recover efficient additional maintenance expenditure relating to the stricter legal standards UUW will incur over the course of AMP8.
- **Part 3: A change in the EA Flood risk maps requires additional work to remain compliant with the Health and Safety at Work Act 1974.** As a result of changes to the EA's flood risk maps, the H&SWA 1974 requires UUW to undertake additional mitigation at reservoirs deemed to be high risk (in the unacceptable categories). This reflects incremental expenditure on that incurred previously.

3.7.2 We set out how we have calculated the gross value of each element in section 4, Cost Efficiency.

UUW's approach to the implicit allowance and symmetrical adjustment

3.7.3 We provide more detail on our approach to the implicit allowance in section 4.4.

UUW's approach to the symmetrical adjustment

3.7.4 A symmetrical adjustment seeks to mimic the effect of including a cost driver within an econometric model i.e. reallocating historical costs across the industry. For some companies, the resulting re-allocation may be positive, while for others it may be negative. As Ofwat noted in its Final Methodology, the symmetrical adjustment should in principle only apply to costs the industry has incurred in the past.

3.7.5 Therefore, we have based our symmetrical adjustment on the element of the claim that relates to the relative cost of operating boreholes versus reservoir sources because this represents the backwards-looking element of our claim (i.e. the symmetrical adjustment only applies to part 1 of our claim, but not to parts 2 or 3). We used the following methodology to calculate the symmetrical adjustment:

(1) As per our implicit allowance calculations, we calculated the total water wholesale allowance using Ofwat's recommended model suite. This is the base comparator scenario and is set out in column A in Table 6.

(2) We then supplemented Ofwat's recommended model suite with the reservoir driver we described in paragraph 3.6.3 and calculated the total water wholesale allowance. The results of this model suite were presented in Table 5. The resulting allowance is set out in column B.

(3) We then calculated the difference between the two allowances. This is set out in column C. This difference reflects the relative reallocation in costs that would result from the addition of a reservoirs driver to the model suite. Due to the issues set out in paragraph 3.6.5, we do not use the numbers in column C directly in our claim valuation. However, we do use the relative reallocation suggested in column C as the basis for our symmetrical adjustment.

(4) We express the difference for each company calculated in column C as a percentage of the difference across the entire industry. This calculates each companies' relative cost reallocation. This is set out in column D.

(5) We then multiply each companies' percentage reallocation by the backwards-looking, pre-Balmforth element of our claim (£36.573 million) divided by UUW's percentage reallocation (54%). This has the effect of calculating an adjustment equivalent to UUW's pre-Balmforth cost for each company, calibrated by the relative reallocation suggested by the introduction of a reservoir variable to the model suite. This is set out in column E.

(6) We then subtract the dam maintenance implicit allowance and the avoided power implicit allowances from the symmetrical adjustment. We discuss how we calculate these implicit allowances in section 4.4. The total implicit allowance is set out in column F.

(7) This calculates a net symmetrical adjustment. This approach is set out in Table 6. We consider the overall increase in costs across the industry to be not material (£32 million) so we do not make adjustments to force the overall adjustment to zero as we did in our drainage symmetrical adjustment.

3.7.6 We note that the calculation of symmetrical adjustments is a relatively new idea and as such there is little precedent to base them on. We did consider an approach whereby we calculate a unit cost per reservoir and base the symmetrical adjustment on this, similar to the growth adjustment applied by Ofwat at PR19. However, overall we considered an approach based upon a model reallocation to be most aligned to the underlying rationale behind symmetrical adjustments i.e. it best reflects the relative reallocation of costs resulting from the inclusion of a variable into a model suite.

Table 6 - UUW's approach to the symmetrical adjustment

Company	Base comparator allowance	Allowance from model suite in Table 5	Difference	Difference as percentage of total adjustment	Combine backwards-looking element with percentage reallocation	Dam maintenance and avoided power implicit allowance	Net symmetrical adjustment
	a	b	c	d	e	f	g
			a – b	c / sum(c)	d x (37/54%)		e - f
ANH	1,708	1,663	-45	-60%	-41	-4	-38
NES	1,390	1,406	16	21%	15	-3	18
UUW	2,324	2,364	40	54%	**37**	30	6
SRN	853	862	9	12%	8	-2	11
SWB	830	834	4	6%	4	5	-2
TMS	4,485	4,504	19	25%	17	-14	31
WSH	1,282	1,282	0	0%	0	1	-1
WSX	537	540	2	3%	2	-5	7
YKY	1,688	1,712	24	32%	22	23	-2
AFW	1,227	1,235	8	10%	7	4	3
BRL	415	423	8	11%	8	0	8
PRT	186	183	-3	-4%	-3	0	-3
SES	199	195	-5	-6%	-4	-2	-2
SEW	756	748	-8	-10%	-7	-9	2
SSC	543	548	4	6%	4	2	3
SVE	2,908	2,907	-1	-2%	-1	9	-10
HDD	133	135	1	2%	1	1	0
Total	**21,464**	**21,539**	**75**	**100%**	**68**	**36**	**32**

4. Cost efficiency

4.1.1 This section sets out how we calculated the value of our cost adjustment claim. Where necessary, please refer back to the reservoir schematic in Figure 1 and associated glossary of terms, as the discussion in the following section involves technical detail.

4.1.2 This section demonstrates how we calculated the value of our cost adjustment claim:

- Section 4.2 sets out how we calculated part one of our claim, the costs associated with Reservoirs Act 1975 compliance, for the pre-Balmforth Report era, which covers the majority of the period covered by the historical data used in the models, and also for part two of our claim, for the post-Balmforth Report era, which we consider is most relevant to our AMP8 costs.
- Section 4.3 sets out how we calculated part three of our claim, the additional costs associated with complying with the Health and Safety at Work Act 1975 following the change to EA's flood maps, which we do through our PRA programme. (We set out how we optioneered our proposed PRA programme in detail in section 6.2.)
- Section 4.4 sets out how we approached the implicit allowance calculations.
- Section 4.5 summarises the value of the three different elements of our claim and the implicit allowances.

4.2 How we calculated the cost of complying with Reservoirs Act 1975 (parts one and two of our claim)

4.2.1 As discussed in section 3.5.11, reservoirs under the Reservoirs Act 1975, have a ten yearly Statutory Inspection undertaken by the independent Inspecting Engineer, who will then detail out any required statutory works, maintenance or monitoring in respect of the reservoir in question and within what timescale. By its nature, this type of work is reactive and until we receive a statutory inspection report we cannot be fully certain of reservoir safety requirements we will be asked to deliver at a site and within what timescale. However, we are able to form reasoned expectations based upon past experience. (This is discussed further in Appendix C, and through extrapolating the volume of actions we are receiving since the publication of the 2020 Balmforth Report.)

4.2.2 As we have evidenced in Figure 14 and Figure 15, the 2020 Balmforth Report has led to a much more stringent inspection regime. We have observed an increasing number of statutory actions requiring investigations and capital interventions since the report's publication. We have also observed these investigations and capital interventions becoming more expensive as the regime seeks to mitigate as much risk as possible.

4.2.3 How we calculated the statutory actions (ITIOS), resulting from the Reservoirs Act 1975, value of our claim

4.2.4 To calculate our expected AMP8 expenditure on statutory actions, we have used internal historical cost information to derive an average unit cost for a) investigations and b) engineering works, before and after the 2020 Balmforth Report's publication.

4.2.5 It would be inappropriate to apply a more stretching point estimate than the average for the unit cost (e.g. the upper quartile) because our cost information includes a large number of Very Small Projects (VSPs), which range in cost from <£1,000 to £250,000. These differences in costs aren't reflecting differences in efficiency – they are reflecting differences in scale and/or scope. Therefore, the use of an upper quartile unit rate would not be reflective of upper quartile efficiency but instead reflect the unit costs of smaller size projects. This would be an inappropriate benchmark. Therefore, the use of an average provides an indication of the overall expenditure we can expect to incur across the entire spectrum of statutory actions.

4.2.6 We combine these internal unit costs with the average number of statutory actions we received both before (for part one of our claim) and after the publication of the 2020 Balmforth Report (for part two of our claim) to calculate an expected cost of compliance with the Reservoirs Act 1975 in AMP8. Table 7 sets out this calculation.

Table 7 - UUW calculation of AMP8 Statutory compliance cost for ITIOS studies and actions only (excluding all PRA)

	Annual number		*Unit cost (£million)*		*Annual cost (£million)*		**Valuation and application of efficiency (£million)**		
	Studies	**Engineering Actions**	**Studies**	**Engineering Actions**	**Studies**	**Engineering Actions**	**AMP cost (£m)**	**Catch-up efficiency**	**Frontier shift efficiency**
label	a	b	c	d	e	f	g	h	**I**
calculation					a x c	b x d	f x 5	g * 0.978	h * 0.984
Pre-2020 Balmforth Report	4	32	0.08	0.23	0.31	7.30	38.04	37.186	36.573
Post-2020 Balmforth Report	17	49	0.10	0.40	1.66	19.51	105.81	103.429	101.725
Memo - % change	*344%*	*51%*	*21%*	*77%*	*440%*	*167%*	*178%*	*178%*	*178%*
AMP8 estimate	**17**	**49**	**0.10**	**0.40**	**1.66**	**19.51**	**105.81**	**103.429**	**101.725**

Note: Post-2020 Balmforth Report number of studies and actions will not align to those presented in Figure 14 and Figure 15 because these graphs relate to actions received whereas the numbers above relate to projects that have been and/or are being delivered.

4.2.7 It's clear that there has been a substantial increase both in the average number of actions we see each year and in the unit cost of addressing these actions.

- As we evidence in Figure 14 and Figure 15, there is no reason to suspect that statutory actions received by reservoir owners will fall from current levels in the future.
- The higher unit cost is driven by a more stringent inspection regime, with subsequent statutory actions being more detailed and requiring specific fixes. Table 17 in Appendix B sets out clear examples of statutory actions becoming more prescriptive since the 2020 Balmforth Report's publication.

4.2.8 This calculation provides an indication of statutory expenditure before the 2020 Balmforth Report's publication (for part one of our claim - £36.573 million), which forms the backward-looking element of UUW's cost adjustment claim. As discussed in section 3.7, this backwards-looking value is the only element of our claim subject to a symmetrical adjustment.

4.2.9 The calculation also derives an expected cost of statutory compliance in AMP8, by multiplying the annual average number of statutory actions (studies and engineering actions) we are receiving since the 2020 Balmforth Report's publication by the unit cost of addressing these actions. Given this element of the calculation represents an extrapolation into the future, we have applied a catch-up and frontier shift efficiency challenge (for part two of our claim - £65.151 million). This will ensure that we are challenged to deliver statutory compliance actions as efficiently as possible.

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

- **Catch-up efficiency challenge.** We have implemented an upper quartile catch-up challenge based upon the wholesale models within Ofwat's recommended model suite (as discussed in paragraph 4.3.27). The catch-up challenge relies upon a spread of residuals around the line of best fit estimated by the models. This means that when the catch-up challenged is strengthened, it becomes increasingly influenced by a smaller number of outlier observations. This increases the risk that the catch-up challenge is subject to statistical noise or bias i.e. the benchmark company may be one that is subject to particularly benign regional operating circumstances. As such, we consider the upper quartile is the maximum catch-up challenge that should be considered in cost assessment. The CMA concurred with this view in its redetermination: *"we decide that the upper quartile is the appropriate level of the efficiency benchmark. This balances our objective of setting a challenging benchmark while acknowledging the limitations of the econometric modelling (and the consequent risk that the company will have insufficient allowed revenue)."*[13]
- **Frontier shift efficiency challenge.** We implement a slightly stronger challenge than the mid-point of the range Economic Insight identified in a study[14] it carried out on behalf of a consortium of companies. The range identified by Economic Insight was 0.3% to 0.7%, meaning the mid-point is 0.5% per year. We consider that the mid-point is justified because the frontier shift estimate produced by EU-KLEMS data is potentially subject to both upwards and downwards bias. There is a risk of downwards bias (i.e. the estimate being too low) due to question marks over the extent to which embodied technical change is reflected in the estimate. There is a risk of upwards bias (i.e. the estimate being too high) due to the presence of catch-up efficiencies within the EU-KLEMS data, the presence of which would produce a double count in the catch-up efficiency challenge. However, there is no robust way to quantify these opposing factors. Therefore, we consider the mid-point to be an appropriate and pragmatic estimate for frontier shift. We do not net off any Real Price Effects (RPEs) against the frontier shift challenge. We added an additional stretch to the mid-point to reflect the uncertainty inherent in estimation of the frontier shift, resulting in an overall frontier shift challenge of 0.55% per year.

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

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

4.2.11 While we have based our cost of compliance on the observed unit rate of statutory schemes and statutory actions received since the 2020 Balmforth Report[15], we also have expectations on the statutory actions we are likely to receive during AMP8 and the cost of these actions. This is set out in Appendix C.

4.3 How UUW calculated the cost of complying with the Health and Safety at Work Act 1974 (part three of our claim)

4.3.1 Risk categorisation has been derived from HSE guidance, as explained in sections 3.5.32 to 3.5.34. Risk categorisation is not a reflection of current asset health, it is a reflection of the forecast future performance of the dam structure under extreme environmental conditions, and hence is not indicative of the effectiveness of the historic maintenance regime.

4.3.2 A dam can be compliant with the Reservoirs Act 1975, (because there is nothing that requires an immediate 'fix' in the opinion of the independent Inspecting Engineer), but the same reservoir can fall within a HSE "unacceptable risk" category based on its' forecast future performance under extreme conditions.

4.3.3 The adjustment claim arises from a step change in the population at risk assessment imposed by the new EA flood risk maps introduced this AMP, as described in Section 3.5.38. This was the first update by the EA for 13 years and so the change is very significant. The changes indicate more people are living within the inundation zones (where water would flow in the event of a dam failure).

4.3.4 The change in requirement increases the risk category of the majority of our reservoirs and in accordance with our risk based hierarchy we improve resilience and reduce risk of those "Unacceptable" and "Unacceptable Societal" reservoirs first.

4.3.5 The scale of the EA flood risk map changes, will necessitate reduction of risk (PRA work) for about two thirds of the "Unacceptable" and "Unacceptable Societal" reservoirs from 2025-2030, see Table 24; undertaking greater numbers increases risk to water resources for customer supply and consequently adverse customer impact.

4.3.6 The 2020 Balmforth Report has meant that the delivery of the PRA pro-active risk reduction programme is now inextricably linked to the regulatory inspections carried out under the Reservoirs Act 1975, as discussed in paragraphs 3.5.47 to 3.5.50. As dams are inspected at intervals of no more than ten years, all of the UUW fleet of reservoirs will be inspected during the next two AMP periods, and therefore our PRA activities will also need to be delivered across this same timescale.

4.3.7 How UUW derived an efficient cost for delivering PRA in AMP8

4.3.8 Paragraph 3.5.24 to 3.5.44 set out the process by which we determined our AMP8 PRA programme. Paragraph 6.2.1 to 6.2.10 in best option for customers section sets out how we arrived at our options for each reservoir. The section below sets out how we calculated the cost of delivering this programme.

4.3.9 Our cost estimate for the PRA programme used the following high-level methodology:

(1) Identify an efficient unit rate of intervention. This assessment used a mix of outturn unit rates from projects we have already delivered, supplemented by a forward-looking assessment where appropriate.

(2) Apply Ofwat's catch-up and frontier shift efficiency challenges from PR19 to provide additional stretch and ambition.

(3) Identify the scale of works required in AMP8, which we identified through the PRA assessment outlined above.

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[15] Professor David Balmforth (2020) *Toddbrook Part B report*. Available here.

(4) Multiply the efficient unit rate by the scale of interventions to arrive at a total PRA programme cost.

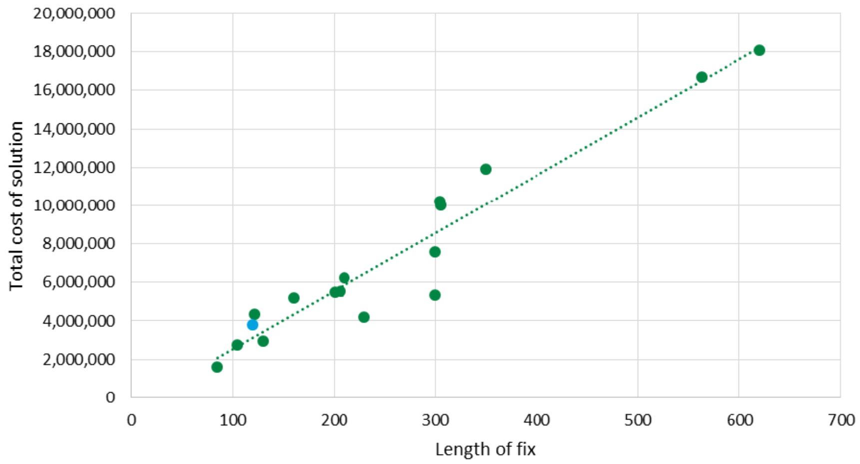
4.3.10 The following sections evidence and justify these separate components.

4.3.11 How we identified an efficient unit rate of intervention

4.3.12 Where possible, we sought to use cost information from similar schemes we have delivered previously to identify an efficient unit rate of intervention. However, as discussed above, the 2020 Balmforth Report has led to the need to implement different solutions to those typically adopted in the past. This has restricted the sample size we can use to identify an efficient cost of intervention. Therefore, where appropriate we have supplemented our historic cost information with forecast engineering estimates. As a general rule, we use whichever approach (i.e. backward-looking only, forward-looking only or a mix) results in a lower unit cost to ensure we are challenging ourselves to deliver our interventions efficiently.

4.3.13 Our unit rates are based upon a cost per metre of fix (e.g. cost per metre grouted or cost per length of slurry trench. This is because the length of fix is the key cost driver, as illustrated in Figure 19.

Figure 19 - There is a clear relationship between total cost and total length of fix



Source: UUW internal estimating data

4.3.14 TAM grouting

4.3.15 Table 8 sets out the two historic TAM grouting schemes used in our unit rate calculation, which were implemented in AMP6. We calculated the total cost of each scheme and divided by the length grouted. Finally, we applied an upper-quartile catch-up efficiency challenge and the average frontier shift challenge. The efficiency assumptions we used are the same as those set out in paragraph 4.2.10.

Table 8 - Unit costs from historic TAM grouting schemes delivered by UUW

	Units	Torside	Rhodeswood	Chelburn	Overall
Total cost of scheme (2022-23 CPIH prices)	£	2,415,530	991,239	3,247,580	6,654,349
Total length grouted	Metres	80	201	180	300
Unit rate (2022-23 CPIH prices)	**£/metre**	**30,194**	**4,932**	**18,042**	**22,181**
Unit rate after catch-up challenge	£/metre	29,515	24,223	17,636	21,682
Unit rate after frontier shift challenge	£/metre	29,352	24,090	17,539	21,325
Calculated unit rate	**£/metre**	**29,352**	**24,090**	**17,539**	**21,325**

Source: UUW internal estimating data

4.3.16 There is a large variance in the unit rate of each scheme. This is because the issue being fixed, geology, and embankment material and make-up of the dam is very site specific. Some embankments sit on fractured rock, which needs a lot more grout to fill the voids than if a dam was sat on finer more compacted material. We recognise this is a material discrepancy so we validated these figures with forward-looking engineering estimates.

4.3.17 Table 9 sets out the Torside, Chelburn and Rhodeswood historic schemes, supplemented by two forecast TAM grouting schemes. We calculated an upper quartile unit cost based upon these schemes. We also applied the frontier shift challenge.

Table 9 - Supplementary assessment of efficient TAM grouting unit cost

Reservoir		Length of fix	Cost	Unit cost
Wayoh	forecast	117	1,818,038	15,539
Audenshaw No1	forecast	560	9,253,924	16,525
Torside	outturn	80	2,415,530	30,194
Chelburn	outturn	180	2,750,710	15,282
Rhodeswood	outturn	40	991,239	4,932
Total		977	17,229,441	17,635
Upper quartile unit cost of all schemes in table, with frontier shift applied				**15,283**

Source: UUW internal estimating data

4.3.18 The unit rate calculated from the historic schemes in Table 8 was higher than the supplementary calculation in Table 9. Therefore, we use the lower **£15,283 per metre** as the basis for our TAM grouting in AMP8 calculation.

4.3.19 Slurry trench

4.3.20 We followed the same process to calculate an efficient slurry trench unit cost. However, we have only carried out one slurry trench scheme in the past, which reduces the information we have in these calculations. The installation of a slurry trench is intended to prevent seepage from affecting the integrity of the dam in the long term. Following the 2020 Balmforth Report, independent Inspecting Engineers are increasingly including in their focus an assessment of the future performance of the dam over the long term. As a result we are seeing more statutory actions associated with long term performance that tend to require more substantial interventions than statutory actions that have been visible on the day of inspection. Actions to address long term performance were formerly part of our PRA programme. Table 10 shows the calculation and resulting unit rate. We also apply a catch-up and frontier shift efficiency challenge. The efficiency assumptions we used are the same as those set out in paragraph 4.2.10.

4.3.21 It is clear that the unit rate is significantly higher than for TAM grouting. This is to be expected because slurry trenching is a more expensive intervention as it involves excavating a large amount of material from a dam, the associated disposal costs of the material, and the replacement of excavated material with concrete. This requires a bigger set-up, bigger machinery and generally more material to undertake the work than with TAM grouting. With TAM grouting no material is being excavated and a smaller amount of concrete is being used, as it is only being pumped into the embankment in order to fill voids within the existing embankment material. Despite its higher cost slurry trenching has other benefits that makes it a preferred solution: there is more surety of the fix thereby reducing the potential need to go back in the future for further fixes, and also reservoir water levels do not need to be reduced whilst undertaking the work, therefore not impacting on water resources for customer supplies.

Table 10 - Unit costs from historic slurry trench schemes delivered by UUW

	Units	[✄]
Total cost of scheme (2022-23 CPIH prices)	£	[✄]
Total length grouted	Metres	[✄]
Unit rate (2022-23 CPIH prices)	**£/metre**	[✄]
Unit rate after catch-up challenge	£/metre	[✄]
Unit rate after frontier shift challenge	**£/metre**	[✄]

Source: UUW internal estimating data

4.3.22 We recognise that there may be scope to improve the robustness of this cost estimate. Therefore, we supplemented this backwards-looking assessment with forward-looking engineering estimates of each slurry trench scheme planned in AMP8.

Table 11 - Supplementary assessment of efficient slurry trench unit cost

Reservoir		Length of fix	Cost	Unit cost
[✄]	forecast	[✄]	[✄]	[✄]
[✄]	forecast	[✄]	[✄]	[✄]
[✄]	forecast	[✄]	[✄]	[✄]
[✄]	forecast	[✄]	[✄]	[✄]
[✄]	forecast	[✄]	[✄]	[✄]
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[✄]	forecast	[✄]	[✄]	[✄]
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[✄]	forecast	[✄]	[✄]	[✄]
[✄]	forecast	[✄]	[✄]	[✄]
[✄]	outturn	[✄]	[✄]	[✄]
		[✄]	[✄]	[✄]
Upper quartile unit cost (inc frontier shift)				[✄]

Source: UUW internal estimating data

4.3.23 We note that while there is some variation in the unit cost, the range is much lower than for TAM grouting. This evidences the higher average cost of slurry trenching.

4.3.24 The unit rate calculated in the supplementary assessment in Table 11 is lower than the unit rate based on outturn schemes in Table 10. Therefore, we use the lower **£[✄]**as the basis for our slurry trench forward-looking cost calculation.

4.3.25 Apply a catch-up and frontier shift challenge

4.3.26 The efficiency challenge is applied as part of the previous step. See the previous section for more details. Our efficiency assumptions are the same as those set out in paragraph 4.2.10.

4.3.27 We found that the large spread of residuals in water resources plus models leads to an upper quartile challenge greater than one when the full triangulated model suite is used in the efficiency assessment. Therefore, we have calculated the upper quartile challenge using models WW1-WW12 in Ofwat's recommended model suite.

4.3.28 Identify the scale of works required in AMP8

4.3.29 The PRA screening and option selection process identified in section 6.2 and 6.2.5 set out the scope of the optimum intervention at each reservoir. The 'length of fix' was detailed in Table 9 and Table 11.

4.3.30 Total PRA programme cost

4.3.31 We multiply the appropriate efficient unit cost by the length requiring work at each reservoir to calculate an overall PRA programme cost. This calculation is set out in Table 12.

Table 12 - UUW's total PRA programme cost

Reservoir	Intervention	Length of fix	Efficient unit cost	Intervention cost
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]				[✂]

Source: UUW internal estimating data

4.3.32 We note that if any requirements under the Health and Safety at Work Act 1974 are not carried out as part of our PRA programme, then they will be picked up as part of a statutory reservoir inspection and will become a statutory requirement. Therefore, if Ofwat does not allow the PRA element of this cost adjustment claim in full our expenditure on statutory actions, under the Reservoirs Act 1975, will necessarily increase without an appropriate upwards adjustment to our allowances.

4.4 Implicit allowance calculation

4.4.1 We have calculated an implicit allowance for part one of our claim relating to the relative impact of operating reservoirs versus boreholes. We do note that the historical dataset contains two years of expenditure after the publication of the 2020 Balmforth Report. However, our approach to the implicit allowance will account for any increase in dam maintenance expenditure during this period.

4.4.2 Our implicit allowance calculations align to Ofwat's Example 1 in Appendix 9[16] of its Final Methodology (page 160). We calculated the implicit allowance for avoided power and dam maintenance separately. This is because calculating a combined implicit allowance was not possible because removing such a large proportion of expenditure simultaneously from the dependent variable in the water resources plus models caused model instability.

4.4.3 UUW calculated the implicit allowance relating to dam maintenance in the following way:

(1) Calculate the total AMP8 water wholesale allowance using Ofwat's recommended model suite. This is the base comparator scenario.

(2) Calculate an alternative total AMP8 water wholesale allowance by removing all IRE (BON code: BN3391WR) and infrastructure capital maintenance (BON code: BN1012WR) from water resources costs. These cost categories capture all activities relating to reservoir dam maintenance.

(3) Compare the allowance between the base comparator and the alternative scenario. The difference is the implicit allowance for dam maintenance.

(4) This approach suggests UUW's implicit allowance for dam maintenance is £12.46 million over the course of AMP8.

4.4.4 Removing all IRE and infrastructure capital maintenance is appropriate because dam maintenance tends to be the sole source of water resources infrastructure maintenance. This has the effect of removing all dam maintenance costs from the modelled allowance. It will likely include a small element of non-dam maintenance related activity but we do not consider this to be a problem. This is because it will overstate the implicit allowance, which has the effect of reducing the net claim value further.

4.4.5 Additionally, this method estimated a negative implicit allowance for some companies, meaning that these companies received a higher allowance as a result of removing dam maintenance expenditure. This does not make intuitive sense, as removal of costs from the dependent variable should logically reduce all companies' expenditure. However, it appears to be a model stability issue driven by correlations within the model suite. As a result, in order for us to use the recommended model suite within these calculations, we have implemented a pragmatic solution to avoid undue upward adjustments to companies' allowances. This solution overrides all instances of a negative implicit allowance with zero.

4.4.6 Our overall approach to the dam maintenance implicit allowance is set out in Table 13.

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

Table 13 - UUW's approach to calculating the implicit allowance relating to dam maintenance

Company	Base comparator	Alternative scenario (minus WR infrastructure maintenance)	Implicit allowance
ANH	1,708	1,688	20
NES	1,390	1,384	5
UUW	2,324	2,312	12
SRN	853	854	0
SWB	830	826	4
TMS	4,485	4,503	0
WSH	1,282	1,269	12
WSX	537	535	2
YKY	1,688	1,679	9
AFW	1,227	1,230	0
BRL	415	417	0
PRT	186	187	0
SES	199	201	0
SEW	756	753	3
SSC	543	545	0
SVE	2,908	2,896	12
HDD	133	133	0
Total	**21,464**	**21,414**	**81**

4.4.7 UUW developed the implicit allowance relating to avoided pumping costs in the following way

(1) Calculate the total water wholesale allowance using Ofwat’s recommended model suite. This is the base comparator scenario.

(2) Calculate an alternative total water wholesale allowance by removing all power costs (BON code: WS01001WR) from water resources costs. This cost category captures all costs relating to pumping from groundwater sources.

(3) The difference in allowances between the base comparator and the alternative scenario provides an estimate of the implicit allowance for power.

(4) However, this is not the implicit allowance for *avoided* power, which is our focus here. Taking the implicit allowance calculated in step (3) would assume that UUW (and other companies with reservoir sources) do not incur any power costs in water resources. This is not true – UUW operates borehole sources (7% of distribution input) and has some abstraction from rivers, lakes and streams (33% of distribution). All these source types require an element of pumping. Additionally, the inclusion of treated water distribution average pumping head within the recommended model suite means that the allowances calculated in (1) and (2) will already include an allocation relating to power requirements. Therefore, there is a significant risk that the implicit allowance calculated in (3) would be a material overstatement of avoided power.

(5) Therefore, to calculate the implicit allowance for avoided power, we calculated average water resources power expenditure over the 2011-12 to 2021-22 period and multiplied this by five to reflect the average power expenditure over an AMP period.

(6) We then subtracted the average power expenditure over an AMP calculated in (5) from the power implicit allowance calculated in (3). This provides an estimate of the avoided power

implicit allowance in water resources. We note for some companies this provides a negative implicit allowance. The interpretation of this is that the company is not avoiding power expenditure, but is spending above the industry average. This needs to be taken into account in the calculation, otherwise these companies may receive an unduly low allocation. However, we do note that the use of average pumping head within the recommended model suite does mitigate this risk somewhat. Our approach is set out in Table 14.

Table 14 - UUW's approach to calculating the implicit allowance relating to avoided power costs

Company	Base comparator	Alternative scenario (minus WR power expenditure)	Power implicit allowance	Average power expenditure over 5 year period	Avoided power expenditure implicit allowance
ANH	1,708	1,685	22	46	-23
NES	1,390	1,360	29	38	-8
UUW	2,324	2,283	42	24	18
SRN	853	835	18	20	-2
SWB	830	815	15	14	1
TMS	4,485	4,418	67	81	-14
WSH	1,282	1,268	14	25	-11
WSX	537	531	6	13	-7
YKY	1,688	1,660	28	15	14
AFW	1,227	1,202	25	22	4
BRL	415	405	11	11	0
PRT	186	180	6	5	0
SES	199	193	6	9	-2
SEW	756	742	13	25	-12
SSC	543	530	13	12	2
SVE	2,908	2,865	43	47	-3
HDD	133	132	1	1	1
Total	**21,464**	**21,105**	**359**	**404**	**-45**

4.4.8 The approach set out in Table 13 and Table 14 suggests there is an implicit allowance of £30.08 million.

4.5 Overall claim value

4.5.1 Table 15 sets out a summary of the value of each element of our claim.

Table 15 - Our cost adjustment claim valuation

Element of claim	£million, 2022-23 CPIH	Source
Part 1: Pre-Balmforth element (historical cost of operating boreholes versus reservoirs)	36.573	Table 7
Part 2: Post-Balmforth element statutory (ITIOS)	65.151	Table 7
Part 3: Post-Balmforth PRA (flood risk map change)	114.843	Table 12
Implicit allowance for dam maintenance	(12.457)	Table 13
Implicit allowance for avoided power	(17.62)	Table 14
Overall net claim value	**186.49**	

5. Need for investment

5.1.1 This section presents evidence to support the need for investment in reservoir dam maintenance:

- Section 5.2 reiterates our legal obligations surrounding reservoir safety and risk management.
- Section 5.3 shows that the 2020 Balmforth Report has meant that the timing and nature of reservoir maintenance is now largely outside of management control.
- Section 5.4 shows that this investment will not overlap with any other activities funded at this or previous price reviews.
- Section 5.5 presents information that suggests customers support continued maintenance of our assets.

5.2 Dam maintenance is a statutory obligation

5.2.1 UUW has legal obligations related to the management of dams and reservoirs. These were set out in detail in section 3.5.9 and are summarised below.

5.2.2 The Reservoirs Act 1975 requires certain reservoirs to be registered with regulators (the EA in England). Registered reservoirs must be subject to a comprehensive safety inspection by an independent, government appointed Inspecting Engineer at intervals no greater than every ten years.

5.2.3 Independent Inspecting Engineers have the power to issue legal notices to dam owners, concerning matters ‘In the Interests of Safety’ (ITIOS). These are statutory actions that the dam owner must undertake, within specified timescales, to ensure the ongoing safe operation of the dam. Dam operators have no discretion over the delivery of statutory actions, nor the timescale over which they are delivered. The delivery of actions related to statutory notices are a major driver of costs for all operators of large reservoirs. ITIOS actions are referred to throughout this document as statutory actions, to avoid confusion between ITIOS sub-categories.

5.2.4 In addition, section 3 of the H&SWA 1974, places regulatory obligations on the operators of commercial activities, which have the possibility of affecting people outside of the operator’s work force, if something went wrong. Section 3 of the H&SWA 1974 does not specifically apply to dam operation, nor to the water industry. It applies to all industries operating in the legal jurisdiction of the UK, in those circumstances where an accident could have consequences beyond the boundary of the site, or could impact upon people not directly employed by the operator of the site.

5.2.5 In the unlikely event of dam failure, water would escape beyond the boundary of the water company site, and would flow downstream. Such an event would have the possibility to impact upon members of the public who are not working for the water company. It is this set of circumstances that gives rise to the legal obligations for dam operators under Section 3 of the H&SWA 1974.

5.2.6 The H&SWA 1974 is accompanied by a statutory guidance document, “Reducing Risks, Protecting People” (also known as R2P2). R2P2 sets out the extensive research carried out by the HSE into the public tolerability of risk, and codifies this into a set of ‘risk tolerability’ criteria. R2P2 provides a formula by which the risk to the public can be assessed, based on a sliding scale of the number of people potentially impacted.

5.2.7 In summary, the investment is required due to dam safety regulation, and is not at the discretion of UUW.

5.3 The 2020 Balmforth Report has meant timing of intervention is largely outside of management control

5.3.1 The operators of commercial activities which have the potential to cause offsite, non-occupational impacts, are obliged to assess the probability of an accident occurring, and the likely consequences of such an accident, and to compare the result of that analysis to the risk tolerability criteria in R2P2. Where risks are found to be outside of tolerable categories, the operator must reduce risk by either reducing the probability of an accident occurring, or reducing the impact of any potential accident.

5.3.2 Responsible dam operators have been undertaking pro-active risk assessments, and making interventions to reduce risks to tolerable levels, for many years. Previously, dam operators had the discretion to phase any necessary risk reduction interventions over time, in order to minimise the impact of site outages, and the impacts on customer bills. However, since the publication of the 2020 Balmforth Report into the Toddbrook reservoir emergency, the flexibility around the delivery of risk reduction measures has been narrowed.

5.3.3 In August 2019 the Canal and Rivers Trust owned Toddbrook reservoir in Derbyshire experienced a major dam safety emergency. Following this incident, David Balmforth (the president of the Institution of Civil Engineers) was commissioned by the government to carry out an independent report into dam safety in the UK. The independent 2020 Balmforth Report made a number of recommendations which affected how dam safety was regulated in the UK, from 2020 onwards:

- Recommendation 5c of the 2020 Balmforth Report stated: “For class 1 and 2 reservoirs, Inspecting Engineers should undertake or update, as necessary, a risk assessment for the reservoir (see recommendations 1 and 10). Where MIOS (statutory actions) are required as a result of a risk assessment, these should be specified so as to reduce risk to ALARP, and evidence should be provided to demonstrate that.”
- Furthermore, Recommendation 10a to 10c stated “RECOMMENDATION 10. Class 1 and 2 high risk reservoirs should be managed and operated on the basis of risk, to ensure their ongoing safety”.
- *a) Reservoir owners should manage the safety of these reservoir(s) by ensuring the risks that they pose are managed to be as low as is reasonably practicable (ALARP). The assessment of risk should include a quantification of the probability of failure of the dam and other significant reservoir structures, based on an appropriate assessment of potential failure mechanisms, the consequences arising from an uncontrolled release of water on the area downstream of the reservoir, and the effectiveness of the RSMP. It should also take the owners competence into account.*
- *b) The risk assessment should be based on recognised good practice. The Environment Agency should give guidance to owners on the appropriate approach to risk assessment, which should include an assessment of uncertainty. However, it should recognise that some owners already have robust risk assessment methods in place. Owners should not be unduly constrained in the methods that they use.*
- *c) MIOS implemented as a result of the risk assessment should be such as to reduce the risk to be both tolerable and ALARP.”* (in this context MIOS refers to “Measures In The Interests Of safety”, the term used for statutory ITIOS actions in the 2020 Balmforth Report).

5.3.4 The effect of these recommendations is that the assessment of risk tolerability, (and the issuing of notices to achieve risk tolerability) is now part of the regular independent Inspecting Engineer assessment of dam safety. Dam operators must now deliver risk reduction, to tolerable levels, to timescales set by the independent Inspecting Engineer.

5.3.5 In 2022 the EA’s flood risk maps were updated, based on populations downstream of reservoirs. This has increased our reservoirs that sit in the “unacceptable” and “unacceptable societal” categories. See Table 4 coupled with the Balmforth recommendations to risk reduction means we have a large AMP8 PRA programme that needs delivering to reduce reservoir risk.

5.3.6 The risk reduction (PRA) element of this cost adjustment business case covers those reservoirs that are due to receive an independent Inspecting Engineer safety inspection before the end of AMP8.

5.3.7 In summary, the scale and timing of this investment is justified, given the changes in regulations resulting from the 2020 Balmforth Report into UK reservoir safety.

5.4 The cost adjustment claim does not overlap with activities funded elsewhere in PR24 or at previous price reviews

5.4.1 As part of this cost adjustment business case, we have taken into account the likely implicit allowance made for reservoir operation in Ofwat cost models, see section 4.43.7 for details. The investment outlined in this business case does not overlap with any common or bespoke performance commitments, enhancement cases, or other elements of our business plan submission. UUW submitted a separate cost adjustment business case related to the size of our reservoir fleet at PR19, but that claim was not accepted by Ofwat, and did not result in funding adjustments in relation to this area of activity. **This cost adjustment claim does not overlap with any other activity already funded, or funded through other price Review processes.**

5.5 Customer research suggests that customers support appropriate maintenance of our assets

5.5.1 The maintenance of the UUW reservoirs fleet is in the best interests of customers. There are no alternative sources of water available in the North West to meet customer demand (alternative to the existing reservoir fleet), and costs of developing new sources would be significantly higher than maintaining the existing sources (see section 3.5.4 for details). Customers have also expressed a preference for funding the maintenance of existing critical assets today, to reduce the probability of major outages and incidents, but in a cost controlled manner that targets the worst performing assets first (see section 6.4.6 for details). **The planned scale of investment in this business case, tied to regulatory obligations likely to arise in AMP8 (and not going further), with investment focussed on critical assets, matches the customer priorities described in the Price Waterhouse Cooper's customer research described in section 6.4.6.**

6. Best option for customers

6.1 Section overview

6.1.1 This section presents evidence that demonstrates this cost adjustment claim represents the best option for customers:

- Section 6.2 demonstrates the process we followed to determine the most appropriate options for our PRA programme. It explores different engineering solutions and their applicability to the reservoirs in question.
- Section 6.3 covers alternative options and why operation and maintenance of our reservoir fleet is the only practicable solution for water resources. It also evidences the results of an independent benchmarking exercise undertaken by Jacobs which explored the advantages of UUW's approach to reservoir safety.
- Section 6.4 discusses customer support for our proposed approach to investment

6.2 How we optimised our PRA programme

6.2.1 PRA is UUW's internal process for risk management of the reservoir fleet aligned to the H&SWA 1974. This process has been independently verified and bench-marked (see Figure 26 and is in line with HSE requirements. It identified, analysed and prioritised the probability and consequence of an issue at a reservoir associated with the four major failure modes: **seepage/internal erosion** (water passing through the dam); **stability** (the ability of the dam to remain upright and holding water); **flood** (the ability of the dam to safely store or discharge water in a flood event); and **seismic** (the ability of the dam to withstand an earthquake).

6.2.2 Risk management, in line with the H&SWA 1974 (UUW's PRA activity), is now enforced as part of the independent Inspecting Engineer assessments of dam safety under the Reservoirs Act 1975. Risk management has become a part of statutory inspection requirements following the 2020 Balmforth Report. This change in approach ensures consistency across dam operators, but it also reduces our ability to prioritise investment based on risk.

6.2.3 The build-up of the PRA block and associated costs has been through a robust process as detailed below:

(1) A review of the updated 2022 EA flood risk maps, indicating numbers of people at risk downstream, was undertaken to understand how this affected our reservoirs' PRA risk scores, as per Figure 18. The updated flood risk maps have increased our reservoirs in the "unacceptable" and "unacceptable societal" categories from 26 to 37 (see Table 4).

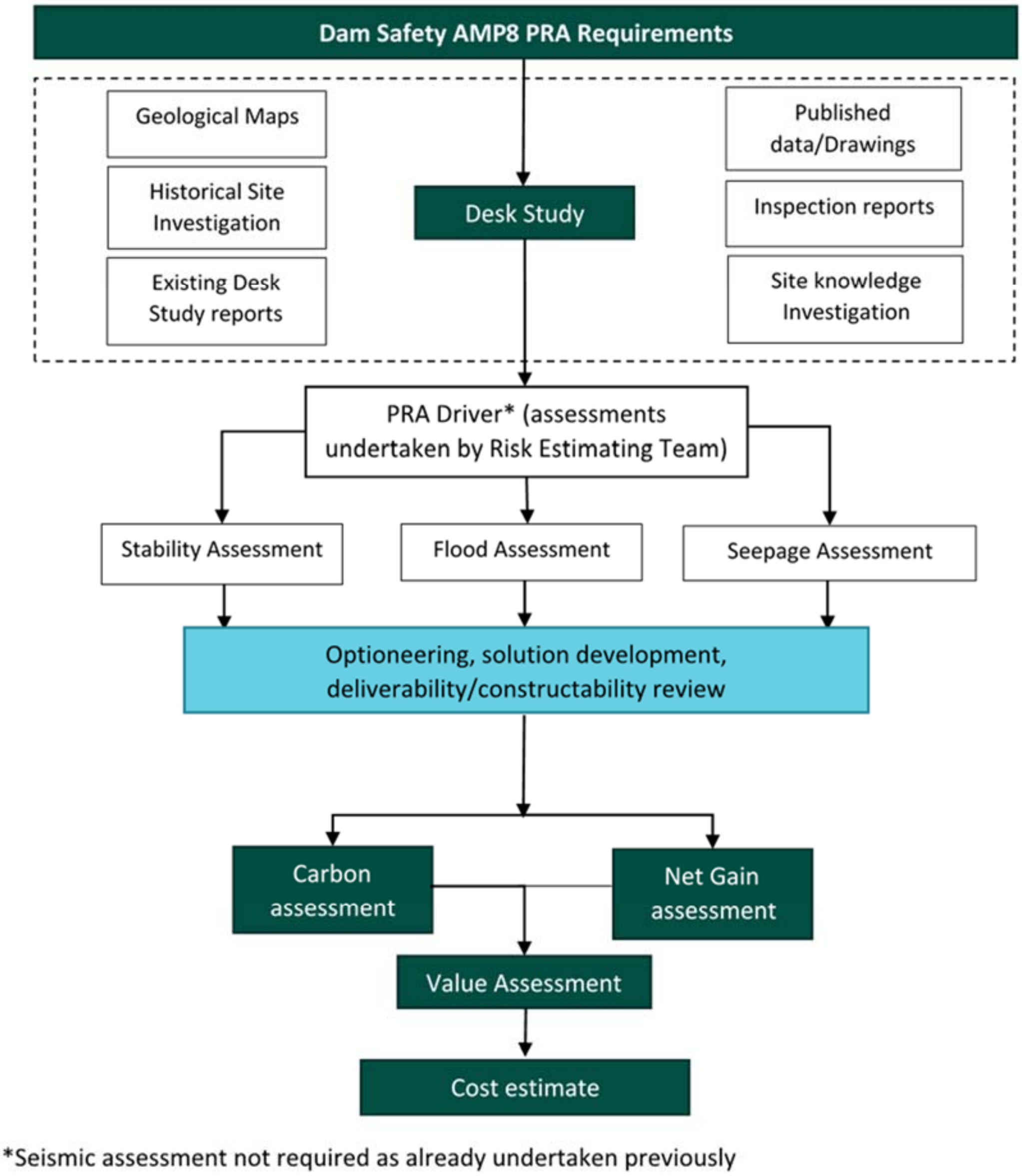
(2) For all reservoirs falling into the "unacceptable" and "unacceptable societal" categories the PRA screening process was initiated in order to review the probability of failure scores, illustrated in Figure 20, which is in line with HSE guidance. The process commences with an engineering assessment undertaken by the appointed Risk Estimating Team comprised of, The Reservoir Safety Manager, the Reservoir Supervising Engineer, the Project Geotechnical Engineer and the Reservoir Inspecting Engineer, all of which have a detailed knowledge of the reservoir being reviewed.

(3) The engineering assessment evaluates the probability of failure of a reservoir against the four failure modes: **seepage/internal erosion** (water passing through the dam); **stability** (the ability of the dam to remain upright and holding water); **flood** (the ability of the dam to safely store or discharge water in a flood event); and **seismic** (the ability of the dam to withstand an earthquake).

(4) Each failure mode assessment follows a robust risk assessment methodology that is industry best practice, for example, for seepage/internal erosion the University of New South Wales

Method (UNSW)[17] is used. This method rates the various attributes and conditions of the dam (type of dam, materials making up the dam, it's construction, the geology it is sat on, frequency of inspections/monitoring etc.) against the following failure mechanisms: piping (water eroding and displacing material) through the dam; piping through the foundations; and piping from the dam into the foundation. Alongside the UNSW method the Stanford Method (McCann et al 1985)[18] is used to estimate the probability of piping along the pipework that runs through the dam.

Figure 20 - The PRA screening process



6.2.4 The outcome of the PRA driver assessments indicates which failure mode(s) the reservoir is at risk of. The main drivers for remedial solutions in AMP8 all relate to:

- Internal erosion risk/seepage – specifically the failure mode related to poorly compacted or highly permeable layer in the dam structure (indicating a risk that water can travel through the dam and cause erosion through it)

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[17] University of New South Wales (2004) *Methods for Estimating the Probability of Failure of Embankment Dams by Internal Erosion and Piping through the Embankment*. Available here.

[18] McCann et al (1985) *Preliminary Safety Evaluation of Existing Dams, volume I*. Available here.

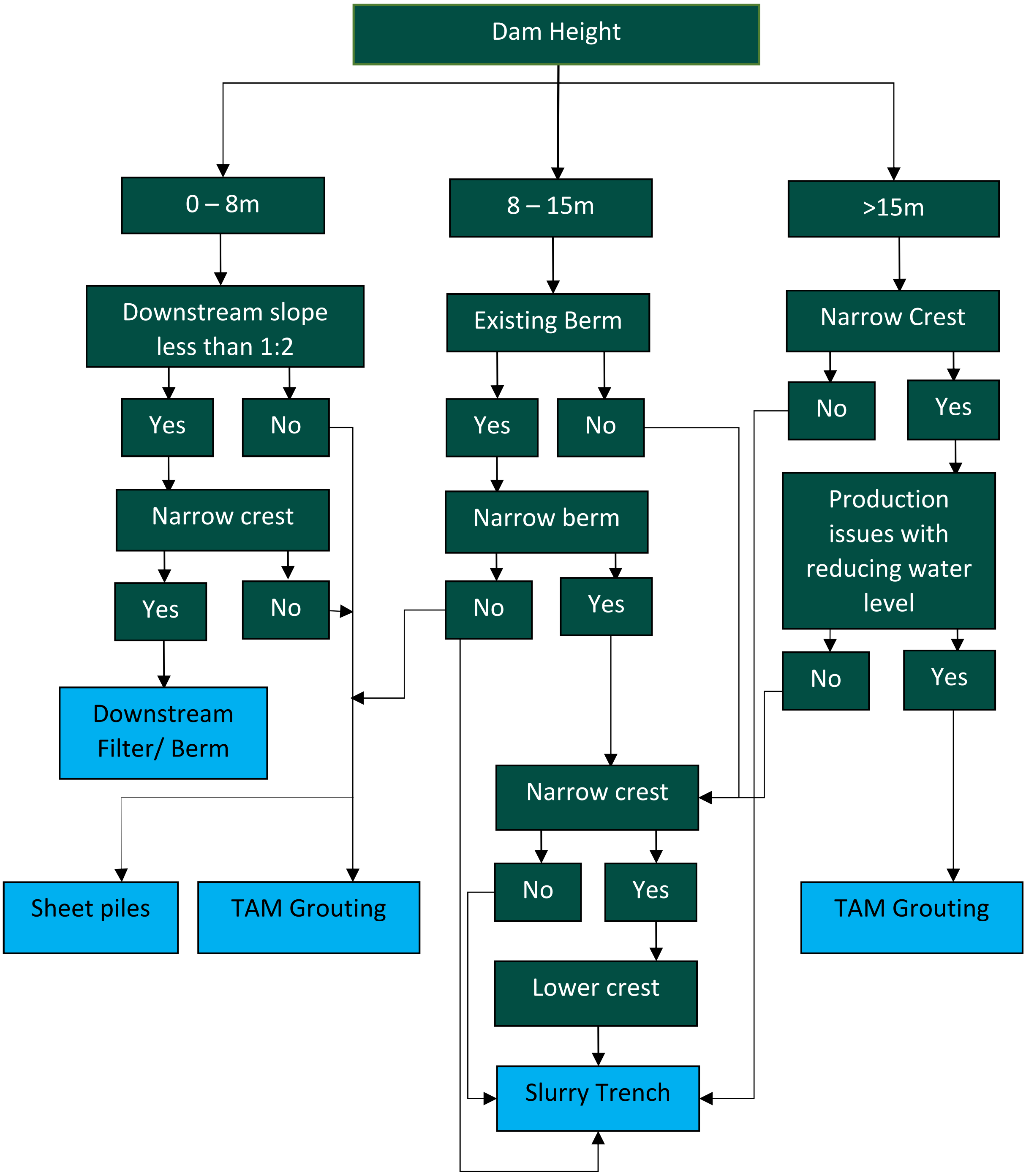
- Slope stability, an assessment of the potential for the embankment to suffer a landslip under extreme conditions.

6.2.5 Figure 21 indicates how the solution for each reservoir has been arrived at based on the relevant solutions available for internal erosion and slope stability risks. The aim of the optioneering process is to identify the best solution to achieve the risk reduction that is required for that site. There are many factors which are taken into account when determining the preferred solution, namely the relative cost efficiency of the risk reduction interventions being considered, site specific characteristics, such as constructability issues etc. and impact on water resources etc.

6.2.6 We provide a description of the relevance of each of the stages of the optioneering process below. After the figure, we provide a description of each type of solution and the activities involved.

- **Dam height.** The height of the dam helps to determine the type of interventions available as certain techniques become less effective or unviable over certain heights i.e. the maximum height for undertaking sheet piles is around 15m and the installation of a filter berm is only viable up to circa 8m. Whereas slurry trench and TAM (Tube-a-manchette, a process of deep grouting under pressure using very long steel syringes) grouting solutions are feasible on dams over 8m. Slurry trenching is more expensive than other options so if a dam was lower in height a cheaper technique would be used. However for tall dams cheaper solutions are not viable so this narrows down the options to slurry trenching or TAM grouting. Slurry trenching is more costly than TAM in the main however it does have other benefits – there is more surety of the fix and reservoir water levels do not need to be reduced while undertaking the work, therefore reducing the need to return in the future for further fixes and not impacting on water resources for customer supplies.
- **Narrow crest.** Certain techniques require a wide crest in order to have a suitable working area and room to utilise the equipment required for the fix. Therefore a narrow crest will limit the options available to be used i.e. slurry trenching requires a certain crest width as the fix requires large machinery and room to pile the excavated material as it comes out of the trench. Therefore in some circumstances a narrow crest and limited working areas / access to site would drive us to use a TAM grouting solution over slurry trenching.
- **Downstream slope less than 1:2.** A downstream filter berm solution is only viable for low height, shallow sloped embankments. This is to ensure the material can be placed (within the extent of the reach of a machine arm) and stay in place (so the material does not roll off the slope)
- **Existing berm.** A berm is a shelf of additional material laid at the bottom of the dam in order to improve stability. It also provides a benefit of an additional flat surface up the dam where machinery can be placed in order to undertake work. This effectively reduces the overall working height of the dam, which may allow lower height techniques to be utilised on tall dams.

Figure 21 - Flow chart to determine appropriate solution based on characteristics of the reservoir



6.2.7 We now provide a description of each type of intervention:

Downstream filter berm. See Figure 22. This is where three layers of granular material (in a sandwich arrangement – sand, gravel, sand) are placed on the downstream (i.e. not the water side) dam face in order to prevent erosion of the dam by capturing any eroding dam material and holding it in place. This solution is the last in line defence i.e. mitigating the effects of the erosion problem rather than fixing the source of the issue. Therefore this is not always a preferred fix.

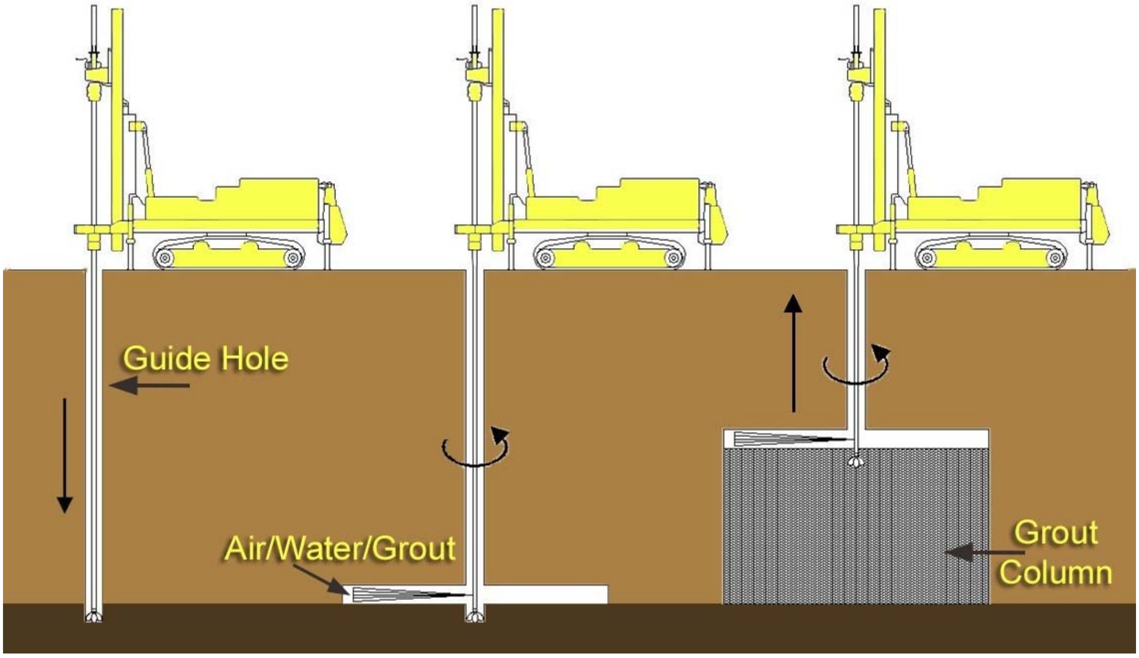
Figure 22 - Downstream filter berm installation

Sheet piles. See Figure 23. These are interlocking steel sheet piles that are gently vibrated down into the clay core of the dam to strengthen it and prevent material eroding through the dam. This solution fixes the erosion and stability issue at source.

Figure 23 - Sheet pile installation

TAM (Tube-a-manchette) grouting. See Figure 24. This is targeted injection of grout into an embankment on the upstream side of the core (water side of embankment), downstream side of the core (dry side of embankment) and into the embankment core itself. A guide hole (borehole) is drilled into the dam, which then allows the grout to be injected. The grout fills the voids within the embankment material. Grouting is usually undertaken at 1m spacing in 3 offset rows for the length and depth of the fix required. This solution fixes the issue at source by preventing material eroding through the dam.

Figure 24 - TAM grouting diagram



Slurry trench. See Figure 25. This is where material is excavated out of the core of the reservoir in a 600mm trench and as deep as is required for the fix. The excavated material from the core is then replaced with a strong concrete mix, which forms the new core of the reservoir. This solution fixes the erosion issue at source by strengthening the core of the reservoir and preventing material eroding through it.

Figure 25 - Slurry trench installation

6.2.8 A small number of other solutions are available for internal erosion and slope stability fixes i.e. diaphragm walls and secant piles. However these options were discounted due to the high cost of the works and the potential for damage to the dam, due to the very large machinery that is required for these fixes.

6.2.9 Equally sheet piles could have been picked as a solution over TAM grouting. However, our optioneering determined that the quantity of sheet piling needed at our reservoirs meant it was not a cost effective solution and therefore TAM grouting was taken forward as the solution.

6.2.10 Table 16 sets out the optimal solution at each reservoir in the AMP8 PRA programme based upon the process outlined above.

Table 16 - The optimum solution for each PRA scheme planned in AMP8

Reservoir	Optimum solution
[✄]	[✄]
[✄]	[✄]
[✄]	[✄]
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6.3 Alternative options to continued maintenance of our reservoirs

6.3.1 UUW reservoir fleet continues to provide great service, enabling us to reliably abstract over 1,000 megalitres per day for supplies to homes and businesses across the North West. While the operation of the reservoir fleet does lead to dam maintenance costs, the continued operation of our reservoirs is a much more cost effective option than swapping to alternative sources.

6.3.2 As described in section 3.5.4 the development of new groundwater sources as an alternative to the existing reservoir fleet would incur in excess of £4 billion construction costs. In addition, there is insufficient groundwater abstraction licence headroom available across the North West, to enable us to meet customer demand by switching to groundwater sources.

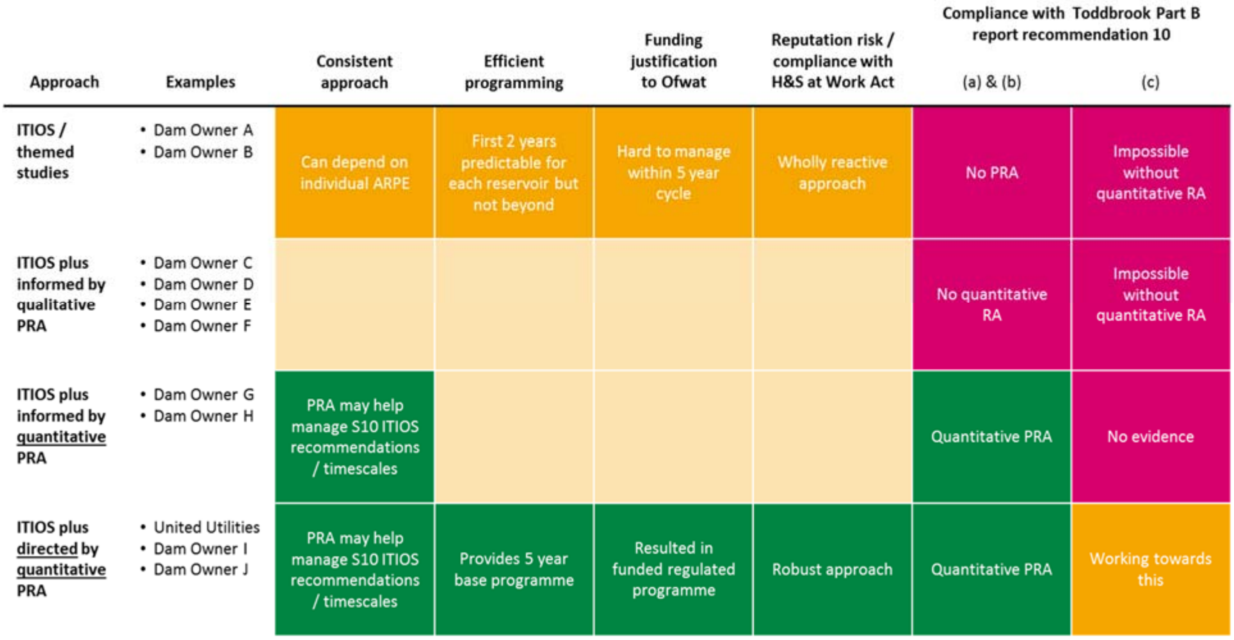
6.3.3 We have always carried out statutory actions issued under the Reservoir Act 1975 by independent Inspecting Engineers, to the timescale set by the Inspecting Engineer. We have previously been mindful of the cost impact to customers of our pro-active PRA risk reduction programme, and we planned to deliver that programme across multiple AMP periods in order to minimise those impacts. However, the 2020 Balmforth Report (Recommendation 5c) stated that "Inspecting Engineers should undertake or update, as necessary, a risk assessment for the reservoir. Where statutory actions are required as a result of a risk assessment, these should be specified so as to reduce risk to ALARP, and evidence should be provided to demonstrate that". This effectively places the responsibility for the timing of pro-active risk assessment and risk reduction (PRA activity) in the remit of the independent Inspecting Engineer.

6.3.4 Following the changes to dam safety regulation, (brought about as a result of the 2020 Balmforth Report), UUW sought independent assurance that our approach to dam safety management was still appropriate. In 2022 we commissioned Jacobs UK to carry out an exercise to benchmark our approach to dam safety against the revised regulations, along with the approaches taken by other water companies.

6.3.5 The benchmarking exercise found that the UUW approach was considered thus “the approach taken by UUW, using quantitative PRA to direct the capital works programme alongside statutory measures is considered current best practice and aligns with Recommendation 10 from the Toddbrook Part B Report” (2020 Balmforth Report).

6.3.6 Figure 26 shows the result of the Jacobs 2022 UK benchmarking exercise. The UUW approach was found to be meeting all of the requirements of the revised regulations. In the table below ITIOS refers to actions ‘In The Interests Of Safety’ (statutory actions issued to dam operators by the Inspecting Engineer) and ARPE refers to All Reservoirs Panel Engineers (the full title of Panel Engineers, the independent government appointed Inspecting Engineers).

Figure 26 - Overview of the different approaches to reservoir safety taken across the industry



Approach	Examples	Consistent approach	Efficient programming	Funding justification to Ofwat	Reputation risk / compliance with H&S at Work Act	Compliance with Toddbrook Part B report recommendation 10	
						(a) & (b)	(c)
ITIOS / themed studies	• Dam Owner A • Dam Owner B	Can depend on individual ARPE	First 2 years predictable for each reservoir but not beyond	Hard to manage within 5 year cycle	Wholly reactive approach	No PRA	Impossible without quantitative RA
ITIOS plus informed by qualitative PRA	• Dam Owner C • Dam Owner D • Dam Owner E • Dam Owner F					No quantitative RA	Impossible without quantitative RA
ITIOS plus informed by quantitative PRA	• Dam Owner G • Dam Owner H	PRA may help manage S10 ITIOS recommendations / timescales				Quantitative PRA	No evidence
ITIOS plus directed by quantitative PRA	• United Utilities • Dam Owner I • Dam Owner J	PRA may help manage S10 ITIOS recommendations / timescales	Provides 5 year base programme	Resulted in funded regulated programme	Robust approach	Quantitative PRA	Working towards this

Source: Jacobs (2023) Internal Benchmarking Report

6.4 Customer support for investment timing

6.4.1 UUW also sought customer views on our approach to the timing and phasing of investment to ensure the operability of our dams. UUW commissioned Price Waterhouse Coopers LLC (PwC) to carry out research into customer priorities. UUW reservoir safety activity is undertaken to ensure that assets can continue to safely provide good service for customers, for generations to come. The ongoing safe operation of critical physical assets is a key activity for UUW across a number of service areas. In order to facilitate easier dialogue with customers, the safe operation of critical assets was given the shorthand description of “Pipes and Pumps” in the PwC facilitated customer research. In the research it was made clear that this topic covered all critical assets, not just pipes and pumps.

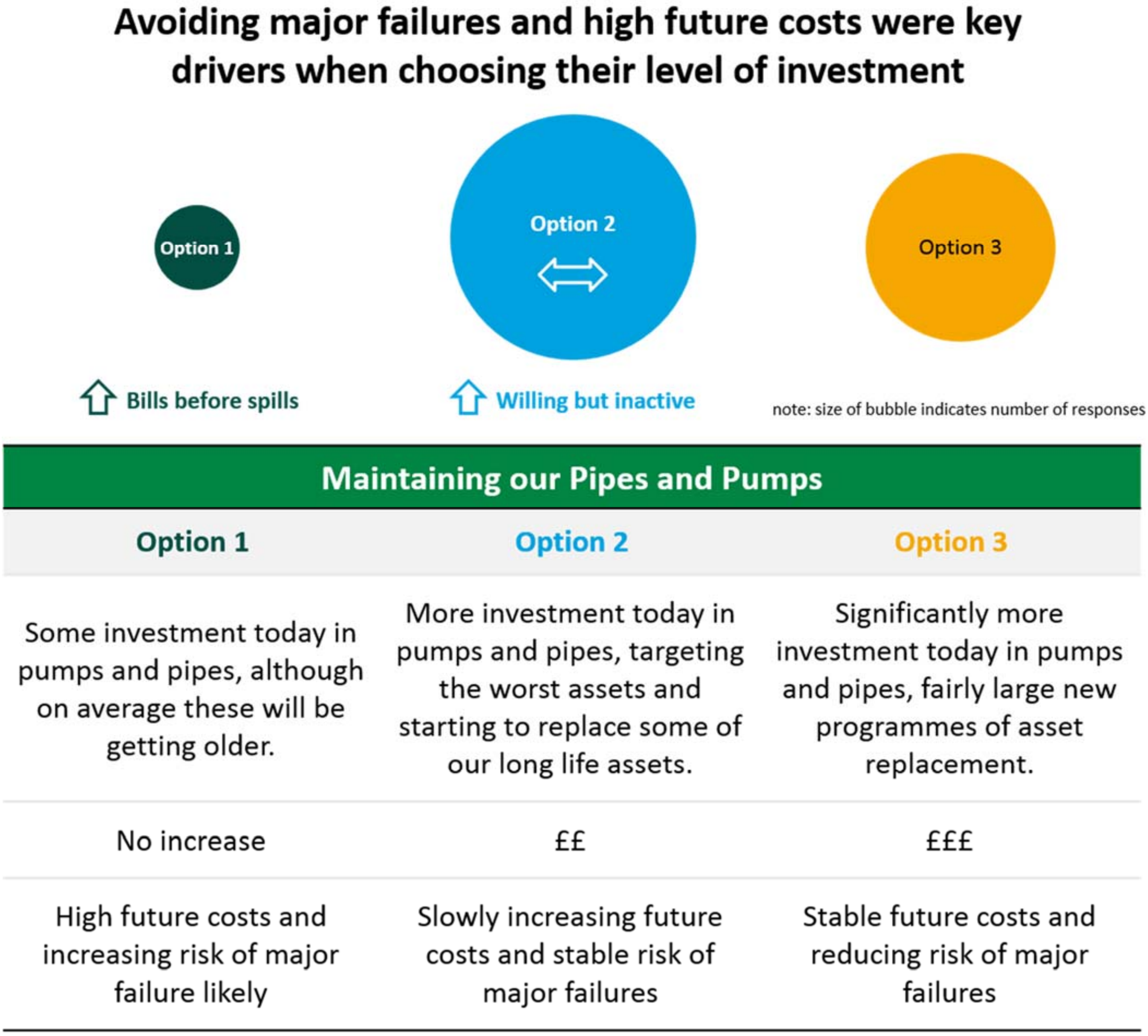
6.4.2 In the PwC facilitated research, customers were shown UUW plans in different thematic areas, and were then asked to comment on those plans, and were given a range of spend and delivery profiles to choose from.

6.4.3 The plans related to critical asset maintenance were described as; “Help maintain their efficiency and condition. Reduce costly and disruptive failures. Maintain consistent supply to household and businesses.”

6.4.4 Customers consistently identified critical asset maintenance as a core, high priority. The maintenance of a broad range of critical assets also had the potential to help with other ambitions too (i.e. water quality, lead pipe removal, leaks etc.) and was therefore important to invest in.

6.4.5 Customers were offered three spend profile options, from deferred investment resulting in ageing assets, to moderate investment focussing on long life asset replacement / maintenance, to accelerated investment. Customers indicated a preference for moderate investment, with interventions on some long life assets. This is shown in Figure 27.

Figure 27 – Internal UUW customer research relating to investment priorities



Maintaining our Pipes and Pumps		
Option 1	**Option 2**	**Option 3**
Some investment today in pumps and pipes, although on average these will be getting older.	More investment today in pumps and pipes, targeting the worst assets and starting to replace some of our long life assets.	Significantly more investment today in pumps and pipes, fairly large new programmes of asset replacement.
No increase	££	£££
High future costs and increasing risk of major failure likely	Slowly increasing future costs and stable risk of major failures	Stable future costs and reducing risk of major failures

Source: UUW (2023) Internal customer research data

6.4.6 The proposed UUW reservoir safety programme matches the option favoured by customers for critical asset maintenance. The proposed programme would see only modest bill impacts, would be focussed on the worst performing assets, and would involve interventions on long life reservoir assets, to secure their safe operation for the future.

7. Customer protection

7.1 We will submit a Price Control Deliverable as part of our wider business plan submission

7.1.1 UUW recognise the vital importance of protecting customers when large programmes of investment are planned. UUW proposes that this cost adjustment case will be complemented by a Price Control Deliverable mechanism.

7.1.2 We will propose a mechanism by which investment is linked to performance (output and timescale performance), with a process through which UUW will return money to customers if we fail to achieve planned outcomes to time, or if the anticipated actions are not required following inspection.

7.1.3 This Price Control Deliverable mechanism is likely to focus upon the delivery of quantified risk reduction, and the delivery of statutory ITIOS actions to an agreed timescale.

7.1.4 UUW recognises that Price Control Deliverable mechanisms are mainly intended for use in protecting customers as part of our enhancement expenditure business cases.

7.1.5 At the time of writing this cost adjustment business case (June 2023), dialogue with Ofwat is ongoing regarding the shape and scope of Price Control Deliverable mechanisms. This ongoing dialogue is helping to develop the understanding of what can be achieved through the Price Control Deliverable framework. On that basis, we commit to including a Price Control Deliverable mechanism as part of this cost adjustment, but we propose to submit a full suite of Price Control Deliverable mechanisms, covering cost adjustment and enhancement business cases, in October 2023 as part of our final business plan submission. The details of this Price Control Deliverable mechanism specifically relating to this cost adjustment business case will be submitted to Ofwat alongside the other suite of Price Control Deliverables.

Appendix A Evolving dam construction over time

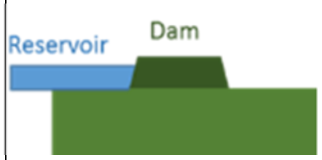
A.1.1.1 Construction on our oldest dam began in 1775, at the height of the Georgian era, before industrialisation and mechanical construction methods were available. Our youngest dam was completed in 1971, using highly technical design processes and the full range of modern construction techniques.

A.1.1.2 While all earth embankment dams look superficially similar, their internal construction will vary very considerably depending upon the era in which the dam was built. The nature of the internal construction will have a significant effect upon the resilience of the dam, the level of risk it poses, and the costs that we will incur to bring the dam within HSE tolerable risk limits.

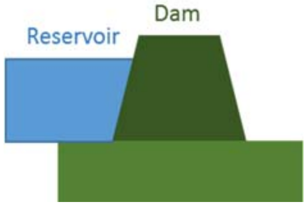
A.1.1.3 Figure 28 shows (over a number of pages) how dam construction has evolved over time, and how this will influence our risk management activity.

Figure 28 Dam construction over time

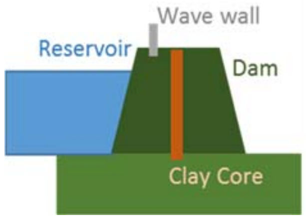
(Over 200 years old)

Cross section	Construction technique	Purpose of structure	Events that influence the construction	Construction / legal standards	Maintenance costs
	Embankment material gathered from the immediate location. Hand construction. Homogenous embankments, no core, no foundation cut off trench, no wave wall. Typically <2m high. Often no formal spillway, no facility to empty the reservoir in an emergency.	Dams of this era are typically built to form ornamental lakes, on country estates or large urban parks.	During this period most public water supply was drawn from local wells, very little institutional water supply infrastructure. Very few structures of this age are operated by water companies.	No construction standards apply.	Extreme. Facilities of this age will require very extensive modification to bring them up to modern safety standards, (would require wavewall, draw down facility, spillway). Reservoirs of this age are usually taken 'off line' from a water course to reduce the risk of flood overtopping (filled by piped supply)

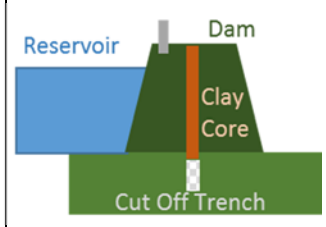
(150 to 200 years old)

Cross section	Construction technique	Purpose of structure	Events that influence the construction	Construction / legal standards	Maintenance costs
	Embankment material gathered from the immediate location. Hand construction. Homogenous embankments, no core, no foundation cut off trench, no wave wall. Dams of this era can be up to 5m high, impounding large reservoirs. Drawdown and wavewall usually present, but do not meet modern standards.	Dams are constructed to feed the developing canal network (some of these reservoirs are now used by water companies)	The beginning of industrialisation. Earliest large commercial water supply reservoirs.	No construction standards apply.	High. Facilities of this age will require very extensive modification to bring them up to modern safety standards, (improved wavewall, draw down facility, spillway). As these reservoirs are 'homogenous' (no core) they are often found to have very high risk of leak induced failure (internal erosion).

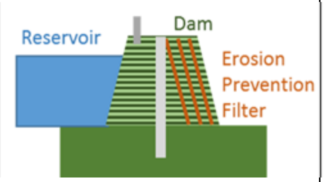
(100 to 150 years old)

Cross section	Construction technique	Purpose of structure	Events that influence the construction	Construction / legal standards	Maintenance costs
	Canal network allows importation of material from elsewhere. First use of clay cores to improve water retention. Some examples now have shallow foundation cut off trenches to improve prevention of leakage between dam and ground interface. Dams still typically hand built without construction machinery, resulting in poor material compaction and high risk of leakage.	Rapid expansion of industrial towns in the North West. First widespread construction of water supply reservoirs.	1848 the Bold Venture dam in Darwen fails (12 dead), during flood. First detailed study of flood overtopping related dam failure. 1864 Dale Dyke fails due to internal erosion leakage (244 dead). Second deadliest flood in British history.	1838 Sir Thomas Telford publishes first design standards for clay cores, specifying a 3:1 hydraulic gradient across the core. In response to the Dale Dyke disaster, 1866 Waterworks Act introduces dam design requiring oversight by a civil engineer approved by a panel of experts (Panel Engineers).	Medium. Earth embankment dams of this age have typically experienced some settlement, and due to poor compaction will have established leakage pathways (high internal erosion risk). Draw down and spillway capacities, and wavewall heights are usually not up to modern standards, and require improvement following regulatory inspections.

(50 to 100 years old)

Cross section	Construction technique	Purpose of structure	Events that influence the construction	Construction / legal standards	Maintenance costs
	Introduction of rail transport and powered machinery allows concrete to be used in the foundation cut off trench. Experience from the mining industry applied to make far more deep and effective cut off trenches. However embankments still hand built.	Establishment of town 'Water Boards'. Large cities such as Liverpool and Manchester begin very large dam projects (Vyrnwy and Thirlmere).	1860 Ainsworth Mill Reservoir fails flooding neighbouring Rylands mine workings (0 dead). 1925 Egiau and Dolgarrog dams fail in chain (16 dead). Construction paused during WW2 and 1950s austerity period. First use of wholly concrete dams, which have very good (low) leakage performance.	Landmark 'Rylands versus Fletcher' legal case setting 'liability' into British Law. Dam operators now legally strictly liable for the effects of dam failure, regardless of cause or blame. Reservoirs (Safety Provisions) Act 1930, introduced in response to the Dolgarrog disaster. Dams must be safety inspected every ten years by independent Inspecting Engineers.	Medium. Draw down and spillway capacities, and wavewall heights are usually not up to modern standards, and require improvement following regulatory inspections. Risks of internal erosion still high due to poor core and embankment compaction.

(0 to 50 years old)

Cross section	Construction technique	Purpose of structure	Events that influence the construction	Construction / legal standards	Maintenance costs
	Widespread use of roller compacted concrete and other technical innovations to significantly improve water retention. Soil mechanics applied in detail, with embankment filter media to prevent internal erosion.	Some large reservoirs constructed in the late twentieth century for mixed use, to feed water supply, industry and hydro-power (e.g. Dovestone).	1970 Warmwithens dam near Oswaldtwistle fails during maintenance. Disaster narrowly averted (0 deaths) as a reservoir immediately downstream was drawn down and held the flood waters.	In response to Warmwithens, the Reservoir Act 1975 introduced. All significant dam maintenance requires Panel Engineer oversight. Floods and Reservoir Safety guidance introduced 1978.	Low. Typically good leakage (internal erosion) performance, due to advanced construction techniques. Auxiliary dam structures (spillways, draw down, wave walls etc.) usually up to modern standards, little further upgrade needed.

Appendix B Examples of a more stringent inspection regime since the 2020 Balmforth Report

Table 17 - The inspection regime has become more exacting since the publication of the 2020 Balmforth Report

Reservoir Name	Statutory actions arising from independent inspection under Section 10 of the Reservoir Act 1975 (pre-2020 Balmforth Report)	Cost of actions	Statutory actions arising from independent inspection under Section 10 of the Reservoir Act 1975 (post-2020 Balmforth Report)	Cost of actions
[✂]	[✂]	[✂]	[✂]	[✂]

Reservoir Name	**Statutory actions arising from independent inspection under Section 10 of the Reservoir Act 1975 (pre-2020 Balmforth Report)**	**Cost of actions**	**Statutory actions arising from independent inspection under Section 10 of the Reservoir Act 1975 (post-2020 Balmforth Report)**	**Cost of actions**
[✄]	[✄]	[✄]	[✄]	[✄]
[✄]	[✄]	[✄]	[✄]	[✄]

Reservoir Name	Statutory actions arising from independent inspection under Section 10 of the Reservoir Act 1975 (pre-2020 Balmforth Report)	Cost of actions	Statutory actions arising from independent inspection under Section 10 of the Reservoir Act 1975 (post-2020 Balmforth Report)	Cost of actions
[✄]	[✄]	[✄]	[✄]	[✄]

Reservoir Name	**Statutory actions arising from independent inspection under Section 10 of the Reservoir Act 1975 (pre-2020 Balmforth Report)**	**Cost of actions**	**Statutory actions arising from independent inspection under Section 10 of the Reservoir Act 1975 (post-2020 Balmforth Report)**	**Cost of actions**
[✂]	[✂]	[✂]	[✂]	[✂]

Reservoir Name	Statutory actions arising from independent inspection under Section 10 of the Reservoir Act 1975 (pre-2020 Balmforth Report)	Cost of actions	Statutory actions arising from independent inspection under Section 10 of the Reservoir Act 1975 (post-2020 Balmforth Report)	Cost of actions

Appendix C Our expectations of ITIOS expenditure in AMP8

C.1.1.1 While we have based our cost of compliance on the observed unit rate of statutory schemes and statutory actions received since the 2020 Balmforth Report, we also have expectations on the statutory actions we are likely to receive during AMP8 and the cost of these actions. This expectation is set out in Table 18 and explained in further detail below, split across the different programmes of work. This reveals that there is a gap between our expectations and the amount we are seeking as part of this cost adjustment claim. However, we consider that this is appropriate as it will provide additional incentives for us to deliver risk reductions as efficiently as possible.

Table 18 - UUW expectations of statutory compliance in AMP8

Cost Driver Block	Total value (million)
[✂]	[✂]
[✂]	[✂]
[✂]	[✂]
[✂]	[✂]
[✂]	[✂]
[✂]	[✂]
[✂]	[✂]
ITIOS Total	[✂]

C.1.1.2 There are eighty statutory ten yearly inspections due to be undertaken within the last two years of AMP7 (from January 2023) and the first three years of AMP8 (by 31st March 2028), which may require statutory work to be undertaken during AMP8. Additionally statutory inspections undertaken in 2022, which required further investigation works may lead to the requirement for capital works to be delivered in AMP8.

C.1.1.3 The statutory requirements cost build up represented in Table 18 is the best assessment of likely project drivers from current updates to guidance in relation to reservoir safety and the future ten yearly Statutory Inspection requirements.

C.1.1.4 We note that if any requirements under the H&SWA 1974 are not carried out as part of our PRA programme, then they will be picked up as part of a statutory reservoir inspection and will become a statutory requirement. Therefore, if Ofwat does not allow the PRA element of this cost adjustment claim in full, our expenditure on statutory actions under the Reservoirs Act 1975 will necessarily increase without an appropriate upwards adjustment to our allowances.

C.2 Wavewall block

C.2.1.1 Works required to increase in height and/or strengthen reservoir wavewalls that sit on top of the dam in order to contain flood surcharges and waves. This is as they have a water level rise above the top of the dam by more than 100mm and significant wave surcharge on the wavewall, during a Probable Maximum Flood (PMF) – the maximum flood that modelling techniques indicate is possible at this location. This is as a result of the Cumbria floods in 2016, which led to the Flood and Water Management Act 2010 accompanying guidance increasing the PMF, taking into account climate change.

C.2.1.2 Since the updated guidance UUW have undertaken investigations and works, as required, on the majority of wavewalls affected. Studies and investigations have removed the need to undertake capital works at nine sites in AMP8 as they have proven the reservoirs can hold the PMF.

C.2.1.3 [✄].

Table 19 - Review of potential Wavewall requirements based on existing freeboard

Reservoir	Reservoir Top Water Level (mAOD)	Crest Level (Top of Dam) (mAOD)	Flood Surcharge Level (mAOD) – water level the reservoir would rise too in a PMF based on inflows/outflows	Freeboard (m) – space between top of crest and top of flood surcharge level? (100mm space required. Negative number means there is not enough room to hold the PMF)
[✄]	[✄]	[✄]	[✄]	[✄]
[✄]	[✄]	[✄]	[✄]	[✄]
[✄]	[✄]	[✄]	[✄]	[✄]
[✄]	[✄]	[✄]	[✄]	[✄]

C.3 Drawdown block

C.3.1.1 Works likely required for emergency drawdown (lowering of water levels) improvements following on from the publication of the *"Guide to drawdown capacity for reservoir safety and emergency planning"*[19] published by the EA in 2017, which requires the ability to drawdown (reduce the water level) a reservoir by 1 metre a day (subject to size).

C.3.1.2 [✄].

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[19] Environment Agency (2017) *Guide to drawdown capacity for reservoir safety and emergency planning*. Available here.

Table 20 Preliminary assessment of drawdown capacity

Reservoir	Installed drawdown depth per day (metre)	Drawdown capability required as per guidance (cumec)	Sufficient drawdown capability	Shortfall in installed drawdown capability (cumec)
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]

C.3.1.3 At reservoirs where the required drawdown cannot be achieved using installed assets the shortfall is currently accommodated utilising temporary pumps.

C.3.1.4 From an initial assessment it is likely that temporary pumps could continue to be utilised at the majority of sites, with investigations planned to confirm this.

C.3.1.5 [✂].

C.3.1.6 [✂].

C.4 Spillways block

C.4.1.1 Works required to increase the capacity and integrity of spillways (channel allowing the safe passage of water out of a reservoir when it is full) in order to allow a reservoir to safely pass flood surcharges during a PMF. This is as a result of the Cumbria floods in 2016, which led to the Flood and Water Management Act 2010 guidance increasing the PMF thresholds associated with climate change.

C.4.1.2 Flood studies and other site investigations will need to be undertaken to understand which sites require spillway works.

C.4.1.3 [✂].

C.5 Valve tower refurbishment

C.5.1.1 This block is for the refurbishment of valve towers and associated assets. Valve towers house the pipes and valves required for taking water out of the reservoir. Valve towers go down into the dam and in some cases also traverse through the dam. Therefore Valve towers have ladders and landings that go down the tower to allow personnel to inspect, maintain and operate assets.

C.5.1.2 As stated in section 3.3.3 we have an aging fleet of reservoirs with an average age of one hundred and forty one years. In many cases the pipework, valves, ladders and landings are all original and were built before health and safety was a key priority. Therefore the assets may require maintenance, replacement and upgrading to current safety standards.

C.5.1.3 [✂].

C.6 Statutory Very Small Projects (VSPs) (<£250,000)

C.6.1.1 There is potential for low cost actions of statutory works capturing replacement of valves, installation of new values, lining of pipes and other smaller repairs to the dams and associated assets. These actions will not be known until we have received the statutory inspection reports.

C.6.1.2 [✂].

C.7 Statutory Major Capital Projects (MCPs) (>£250,000)

C.7.1.1 There is also the potential for high cost actions of statutory works being requested from statutory inspections. These actions could include things like installation / improvements to embankment drainage, installation of debris barriers, installation of monitoring equipment etc. These actions will not be known until we have received the statutory inspection reports.

C.7.1.2 [✂].

C.8 Studies and investigations

C.8.1.1 In order to support and optimise planned works for delivery in AMP8 and AMP9 studies are required at sites where they have not yet been undertaken, details and costs of which are summarised in Table 21 (for AMP8) and Table 22 (for AMP9). Costs are based on outturn costs for studies in previous AMPs.

C.8.1.2 [✂ **].**

Table 21 - Estimated cost of studies to inform AMP8 delivery

Reservoir	Ground investigation cost (on-site intrusive investigation techniques)	[✂ [redacted]]	Toolbox costs (£) (a full risk assessment based on site investigation findings)
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	**[✂]**	**[✂]**	**[✂]**
[✂]	**[✂]**		

Table 22- Estimated cost of studies in AMP8 to inform AMP9 delivery

Reservoir	Ground investigation cost (on-site intrusive investigation techniques)	[✂ [redacted]]	Toolbox costs (£) (a full PRA assessment based on site investigation findings)
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	**[✂]**	**[✂]**	**[✂]**
[✂]	**[✂]**		

Appendix D UUW Reservoirs individual HSE defined risk categories pre and post EA flood risk map changes in 2022

Table 23 - Reservoirs in the HSE Unacceptable / Unacceptable Societal category prior to EA flood risk map changes (26 reservoirs total)

Reservoir Name	[✂[redacted]]	[✂[redacted]]	[✂[redacted]]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]

Source: UUW (2023) Internal Data

*Table 24 - Reservoirs in the HSE unacceptable / unacceptable societal category after EA flood risk map changes (37 reservoirs total)**

Reservoir Name	[✂ [redacted]]	[✂ [redacted]]	[✂ [redacted]]	[✂ [redacted]]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
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[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
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[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]

*[✂]

**[✂

]

Source: UUW internal data

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