SVE4.28

PFAS updated regulations

Draft Determination representations

28 August 2024

WONDERFUL ON TAP

SEVERN TRENT

Executive summary

This proposal sets out the evidence for £123m investment required to meet Severn Trent's expanded statutory obligations to reduce PFAS risk at two water treatment works that are classified as Tier 2 sites and to make preparations for 23 Tier 1 sites where it is likely they will become Tier 2 during AMP8. This is a requirement that has been placed on us since submitting our business plan in October 2023, including updated guidance issued by the DWI on 21 August 24.

What are PFAS

Per- and polyfluoroalkyl substances (PFAS), also known as 'forever chemicals', are used in waterproof clothing, plastics, firefighting foams, non-stick cookware, carpets and food packaging. They have been found to be widespread and persistent in the environment, and most people in the UK have been exposed to them. Although the scientific evidence for the impact PFAS on human health is limited and emerging, some (PFOA and PFOS) have known or suspected toxicity to humans.

Case for change

Public concern about PFAS has increased rapidly, following high-profile media coverage and interventions by scientific and government bodies (e.g. the Royal Society of Chemistry and the US Environmental Protection Agency). The Australian and US experience demonstrates the benefit of flexible funding mechanisms to deal with responding to a very rapidly moving area.

At the time of Severn Trent's PR24 submission in October 23, the DWI required water companies to reduce PFAS risk at Tier 3 sites only, not Tier 1 or 2 sites. Since then, the DWI set a Section 19 Undertaking (SVT-2023-00014), expanding our statutory obligations to include mitigation at our Tier 2 sites - Church Wilne WTW and Whitacre WTW. We have also included plans for 23 sites that are at high risk of becoming Tier 2 sites or have now become Tier 2 based on the DWI's revised guidance issued on 21st August. This guidance now sets Tiers based on the 'sum of' all PFAS compounds, whereas previously this was based on individual PFAS concentrations. We have included 6% development costs for the 23 sites and the remainder has been included in the large projects – gated process.

Table 0.1 overleaf sets out the key changes in the DWI requirements since our PR24 submission.

Table 0.1: DWI's PFAS tier system for adherence - pre and post PR24 submission.

Concentration of any PFAS[1]	Tier	Action required pre PR24 submission (July 2022)	Action required post PR24 submission (Nov/Dec 2023 & Feb 2024)[2]
<0.01 µg/l	Tier 1	Risk assessment and monitoring	"……..**design a mitigation plan**, which can be implemented should concentrations increase, or toxicological or other information change that requires mitigation be delivered."
<0.1 µg/l	Tier 2	Risk control and consultation	"….where there is a Tier 2 source or one that is seen to be approaching Tier 2 we expect that the company will consider the risk and **take the appropriate actions to mitigate the site to a consistent Tier1** or below".
≥0.1 µg/l	Tier 3	Risk reduction and notification	"……design, develop and **implement mitigation** to reduce PFAS concentrations in drinking water to at least tier 1 concentrations, with **a high priority**."

Solution

This case accelerates delivery of our PFAS Strategy, submitted to the DWI in June 2023.

Through the combination of extensive sampling[3], learning from our AMP7 green recovery PFAS pilot and comprehensive learning from others across the world through our innovation networks – we have considered and assessed a wide range of options. We have provided more evidence of this which responds to Ofwat's draft determination feedback on our original PR24 PFAS investment cases. This analysis has concluded that the best available solution for these sites is additional, second-stage granular activated carbon (GAC) treatment.

Catchment management is always our first line of defence for drinking water quality: removal at source eliminates the need for treatment, and also brings wider social and environmental benefits. We will continue to sample within the catchment. However, our assessment shows there are thousands of PFAS sources (live and historic) in larger catchments, so we must follow the twin-track approach of catchment management and water treatment processes to remove and destroy PFAS, as specified in the DWI's long-term planning guidance for water quality and water resources[4].

AMP8 proposal

The DWI has not set explicit timescales for PFAS mitigation at Tier 2 sites. We believe that action during AMP8 is critical – to not take risk reduction measures now would be irresponsible given:

- The possibility that further investigation will discover additional water sources with high PFAS concentrations, requiring us to take them out of supply and putting public water supplies at risk – we cannot afford to lose these sources of water as there is not enough headroom in our system.

[1] DWI decision letter for PFAS Strategy (SVT15) and draft Undertaking SVT-2023-00014
[2] DWI letters and clarification letter, and Water UK clarification from DWI
[3] analysing over 3,100 samples since 2020.
[4] Long-term-planning-guidance-for-drinking-water-quality-July-2022.pdf (dwi.gov.uk).

- The rapidly increasing public and media concern seen in the UK, US and Australia, that continues to influence regulation, similar to the water industry's programme on storm overflows.
- Our obligation (driven by the DWI and shared by Severn Trent) to take a precautionary approach to the unknown health impacts of PFAS.
- The cost efficiencies to be gained from implementing PFAS treatments alongside AMP8 water quality improvements already in flight at both of our Tier 2 sites; Church Wilne and Whitacre.

We recognise the importance of spreading the cost fairly across generations, as well as taking action quickly at the highest risk sites. We believe that mitigating PFAS risk at four sites in total (Tier 2 as well as Tier 3) out of Severn Trent's extensive asset base is proportionate for AMP8, and is in line with the expectation of our customers that tap water is safe to drink and free of contaminants. We also recognise that PFAS expectations could evolve very rapidly as per the experience in Australia and the US and so we have proposed development funding for a company wide PFAS risk reduction programme and separately a Notified Item/Uncertainty Mechanism for any further mitigation requirements to safeguard our supply.

Having evaluated 32 potential options and taken 10 through for cost benefit and cost benchmarking, our AMP8 proposal is for an investment of £123m (pre efficiency), to deliver the following benefits:

- **Protect public health.** Deliver priority PFAS mitigation activities at two sites (Church Wilne WTW and Whitacre WTW) to comply with our new Section 19 Undertaking (SVT-2023-00014) for PFAS.[5]
- **Protect public water supplies.** Deliver additional catchment sampling and investigation at 23 higher risk sites previously assessed as Tier 1 but now become, or are likely to become, Tier 2 based on revised DWI guidance.
- **Prepare for future legislation and growing public pressure.** This is a fast-moving area of concern, and the evolution of our programme is likely to be driven by public concern as much as by regulation – similar to how CSO spills is playing out in the industry right now. Our AMP8 proposal therefore includes development funding provision for a company-wide PFAS risk reduction programme, outlined in Table 0.2; we are also proposing an Uncertainty Mechanism/Notified Item which we are submitting alongside this case.

The proposed AMP8 activities are summarised in Table 0.2 below.

Table 0.2: Proposed activities in AMP8 (pre efficiency)

	AMP8 PFAS proposal	TOTEX estimate (£m)
Whitacre WTW	Catchment investigations and feasibility – Rivers Blythe and Bourne	1
	New treatment process – second-stage GAC with PFAS-selective media	32
Church Wilne WTW	Catchment investigations and feasibility – River Derwent	2

[5] In addition to PFAS mitigation at Witches Oak WTW and Cropston WTW, delivered as part of our original PR24 submission.

	New treatment process – second-stage GAC with PFAS-selective media	55
Company-wide PFAS risk reduction programme – development funding: • For 23 higher risk sites that are likely to move, or will move, from Tier 1 to Tier 2 – additional catchment sampling and investigation, increase GAC replacement, scheme feasibility & design, and planning permission		33
	Total	**123**

We have provided additional information compared to our original PR24 submission to demonstrate efficient costs, both through the use of Ofwat's enhancement cost models and through additional third-party benchmarking to demonstrate the proposed costs are both robust and efficient.

We have taken proactive steps to ensure we can deliver this investment and have proposed relevant price control deliverables in line with measures set out in the draft determination to track delivery with associated penalties to return money to customers in the event of non-delivery.

We are confident that this proposal represents the best option for customers. It will deliver best value in terms of costs, risks, affordability of customers' bills, and wider environmental and social benefits.

Contents

Note: Annexes referred to sit within separate PR24 documents whereas Appendices are contained within this document.

1. The need for investment

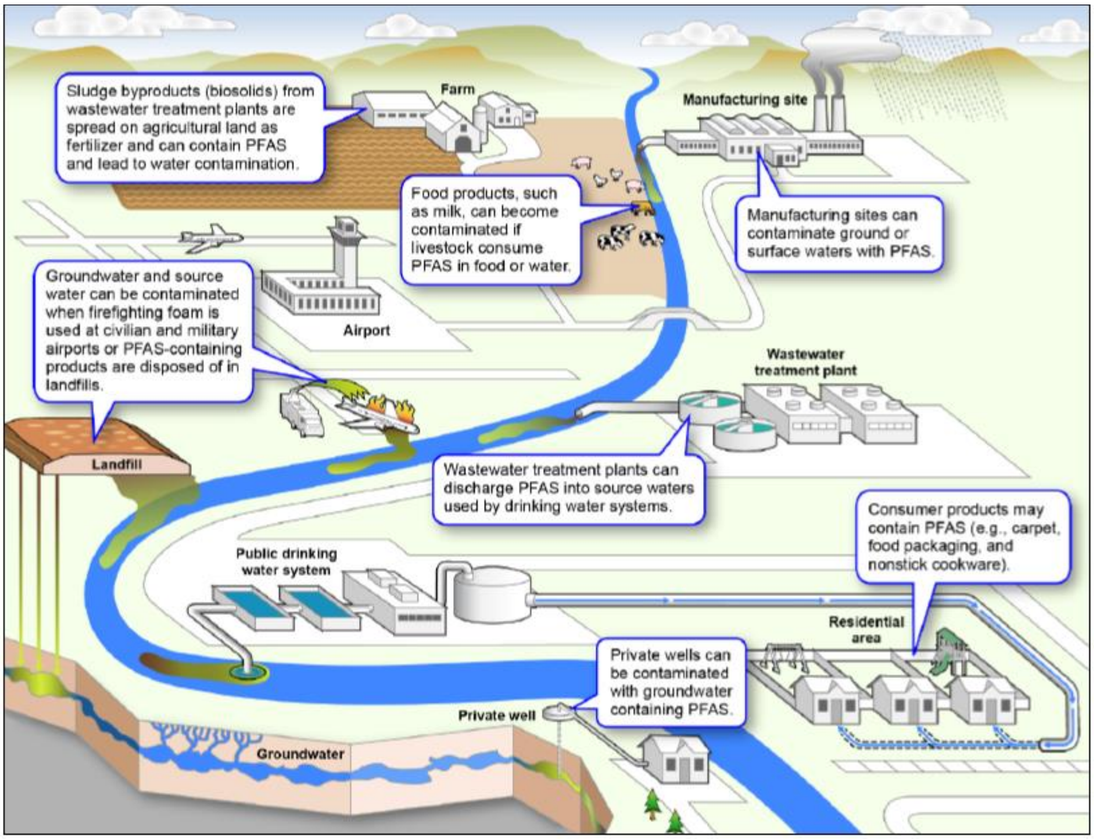
1.1 Responding to increasing risk

Per- and polyfluoroalkyl substances (PFAS) are a group of thousands of different man-made chemicals that have a wide variety of chemical structures made up chains of carbon atoms surrounded by fluorine atoms. They have been dubbed 'forever chemicals' because the carbon-fluorine bond in PFAS is one of the strongest bonds in organic chemistry, giving them an extremely long environmental half-life. PFAS have the ability to repel water and grease, and have been used in homes, businesses and industry since the 1940s, for a wide variety of products including waterproof clothing, plastics, firefighting foams, non-stick cookware, carpets and food packaging.

PFAS have been found to be widespread and persistent in the environment, food and drinking water[6] and most people in the UK have been exposed to them[7]. Although the scientific evidence for health impacts of PFAS is limited and emerging, some have known or suspected toxicity: studies suggest that exposure could be harmful to human health, including cancer, birth defects, liver disease, thyroid disease and other health problems[8]. Other PFAS are less well understood.

Along with food, chemical products and household dust, drinking water is one of the ways that people can ingest PFAS.

Figure 1: PFAS in the environment and water cycle (US EPA: Our Current Understanding of the Human Health and Environmental Risks of PFAS, 2024)



[6] US EPA presentation at the Royal Society of Chemistry (RSC) roundtable, October 2023.
[7] PFAS and Forever Chemicals - Drinking Water Inspectorate (dwi.gov.uk).
[8] Our Current Understanding of the Human Health and Environmental Risks of PFAS | US EPA, 2024.

1.2 Statutory requirements for PFAS have changed

The scientific evidence for the health impacts of PFAS is limited and uncertain, and better understanding is required before health-based limits for drinking water can be set. PFAS cannot be broken down by conventional drinking water treatment processes. Given this, the Drinking Water Inspectorate (DWI) is taking a precautionary approach to the problem, requiring water companies to treat drinking water for PFAS at specific, high-risk sites. Sites are designated Tier 1, 2 or 3, based on the concentration of PFAS measured through sampling (see Table 1 below for tier concentration boundaries).

Our PR24 business case (SVE 13 Raw Water Deterioration[9]), submitted in September 2023, was based on the DWI's requirement at the time for water companies to reduce PFAS risk at Tier 3 sites. For Severn Trent, this meant implementing PFAS treatment at one site (Witches Oak WTW). Separately, in July 2023, the DWI issued a legal instrument to include PFAS mitigation at a second site (Cropston WTW), when Severn Trent applied for use of a new source of water from Thornton Reservoir/Rothley Brook, which is at Tier 2.

Since our PR24 submission, the Drinking Water Inspectorate (DWI) required companies to offer a Section 19 Undertaking (SVT-2023-00014), which requires statutory activity for Tier 2 sites. For Severn Trent, this means implementing PFAS treatment at two sites (Whitacre WTW and Church Wilne WTW).

Between November 2023 and February 2024, the DWI issued company-specific and sector-wide clarification that confirmed this new requirement for Tier 2 sites. Table 1 below sets out the key changes in the DWI requirements since our PR24 submission.

Table 1: DWI's PFAS tier system for adherence - pre and post PR24 submission

Concentration of PFAS[10]	Tier	Action required pre PR24 submission (July 2022)	Action required post PR24 submission (Nov/Dec 2023 & Feb 2024)[11]
<0.01 µg/l	Tier 1	Risk assessment and monitoring	*"……..**design a mitigation plan**, which can be implemented should concentrations increase, or toxicological or other information change that requires mitigation be delivered."*
<0.1 µg/l	Tier 2	Risk control and consultation	*"….where there is a Tier 2 source or one that is seen to be approaching Tier 2 we expect that the company will consider the risk and take the appropriate **actions to mitigate the site to a consistent Tier1** or below".*
≥0.1 µg/l	Tier 3	Risk reduction and notification	*"……design, develop and **implement mitigation** to reduce PFAS concentrations in drinking water to at least tier 1 concentrations, with **a high priority**."*

[9] https://www.stwater.co.uk/content/dam/stw/about_us/pr24/sve29-13-raw-water-deterioration.pdf.

[10] Results of risk assessment for any PFAS in drinking water.

[11] DWI letters and clarification letter, and Water UK clarification from DWI.

PFAS regulation has rapidly evolved during PR24 and continues to do so in response to public concern, media coverage and the evolving scientific research and understanding in this new area. Appendix A provides a more detailed summary of those changes in regulation to highlight how they did not align with the PR24 timeline for business plan submissions.

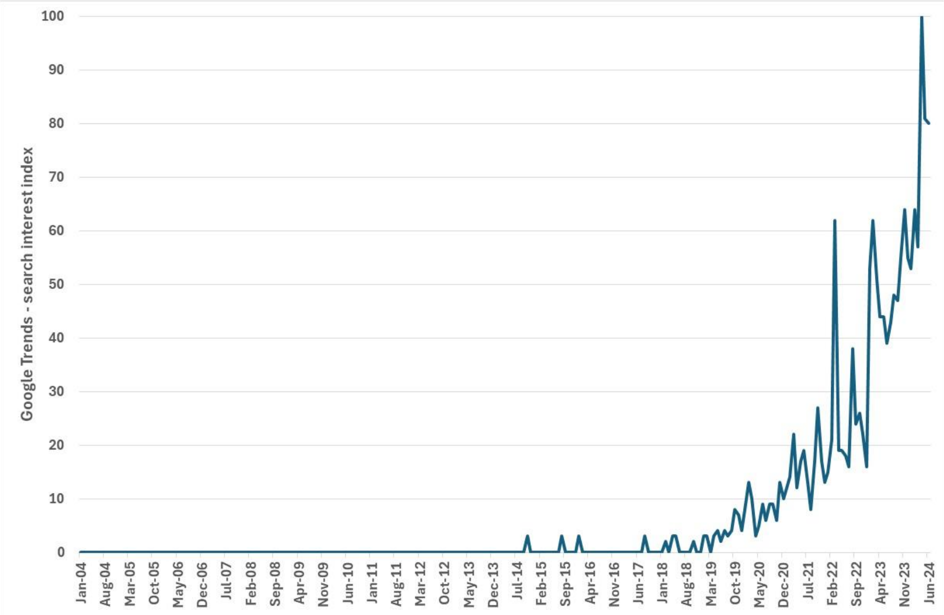
Very recently and in addition to the above, the DWI issued revised guidance on the 21st August 2024 (Information letter 03/2024) which now sets Tiers based on the 'sum of' all 48 listed PFAS compounds (6:2 FTAB included), whereas previously this was based on individual PFAS concentrations.

1.3 Responding to customer expectations

1.3.1 Public interest in PFAS is increasing

Figure 2 overleaf shows the rapid and recent increase in public interest in PFAS, as provided by Google Trends.

Figure 2: UK search interest in PFAS over time - Google Trends (June 2024)



This increase in interest has been driven by several factors, including media coverage[12] and interventions by scientific bodies (see Case Study 1 below for an example).

[12] Revealed: scale of 'forever chemical' pollution across UK and Europe | PFAS | The Guardian.

Case Study 1: The Royal Society of Chemistry's policy position on PFAS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PFAS

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Scientists call on ministers to cut limits for 'forever chemicals' in UK tap water

Permitted levels of PFAS should be lowered tenfold and national chemicals agency created, says Royal Society of Chemistry

Rachel Salvidge *and* Leana Hosea
Wed 18 Oct 2023 06.00 BST

In June 2023, the Royal Society of Chemistry (RSC) launched a policy position statement on PFAS, urging the UK Government to:

- Reduce the current cap per individual type of PFAS from 0.1 ug/L (Tier 3) to 0.01 ug/L (Tier 1).
- Introduce a limit of 0.1 ug/L for the total amount of PFAS combined.
- Make plans for a national chemicals regulator to provide better strategic coordination of monitoring and regulation of PFAS.
- Create a national inventory to report and capture the many hundreds of sources of PFAS.
- Introduce stricter emissions standards for PFAS in industrial emissions to water and landfill leachates.
- Within a reasonable timeframe, require water treatment plants to have technology in place that can adequately remediate water to the lowest levels defined by new statutory standards.

This policy position generated significant media attention and public interest. Alongside this, the RSC also produced an interactive map of PFAS concentrations, encouraging customers to write to their local MP to complain about water companies if the levels were higher than Tier 1. Given that the data used to create the map was environmental data from the EA, not drinking water quality data, customers were not given accurate information about their local water supplies – potentially causing unnecessary concern.

1.3.2 Customers want to see action now

Over many years, our customer research has shown that delivering safe drinking water is our customers' highest priority and a fundamental part of their expectations of us. Our PR24 research, outlined in our PR24 business case (SVE 13 Raw Water Deterioration[13]), showed that customers expect Severn Trent to be planning to meet current and future challenges, and that they trust us to choose the right technical solutions to meet these challenges.

Whilst the issue of PFAS/forever chemicals is not currently generating much spontaneous customer concern, when informed through deliberative research, customers accept the need for action. In response to the draft determination, we carried out further qualitative and quantitative customer research with over 1,750 customers. This is set out in full in Section SVE3.01.01 of our representations.

[13] https://www.stwater.co.uk/content/dam/stw/about_us/pr24/sve29-13-raw-water-deterioration.pdf

In our deliberative research workshops, we found that customers accept the need to pay more now to tackle problems such as PFAS, which they consider to be important, rather than to leave them to be dealt with by future customers. In general, they feel the additional cost[14] of the PFAS package of investments presented in this business case is reasonable and worthwhile.

"70p [per year] is not worth worrying about. It sounds really good for that if it's going to help clean it up as well." HH customer, Leicester

In our representative customer survey, customers were given information about the seven key investments in Severn Trent's post-Draft Determination business plan. They were then asked to indicate how important or unimportant each one is to them. 93% of customers rated *Increasing tap water quality by removing emerging contaminants (PFAS)* as either *important* or *extremely important*.

In the survey, customers were also asked whether they consider each of the seven investments to be high, medium or low priority for Severn Trent. The majority of customers (62%) ranked *Increasing water quality by tightening standards on emerging contaminants (PFAS)* to be a high priority. One third felt it is a medium priority (32%) and only 4% felt it is a low priority.

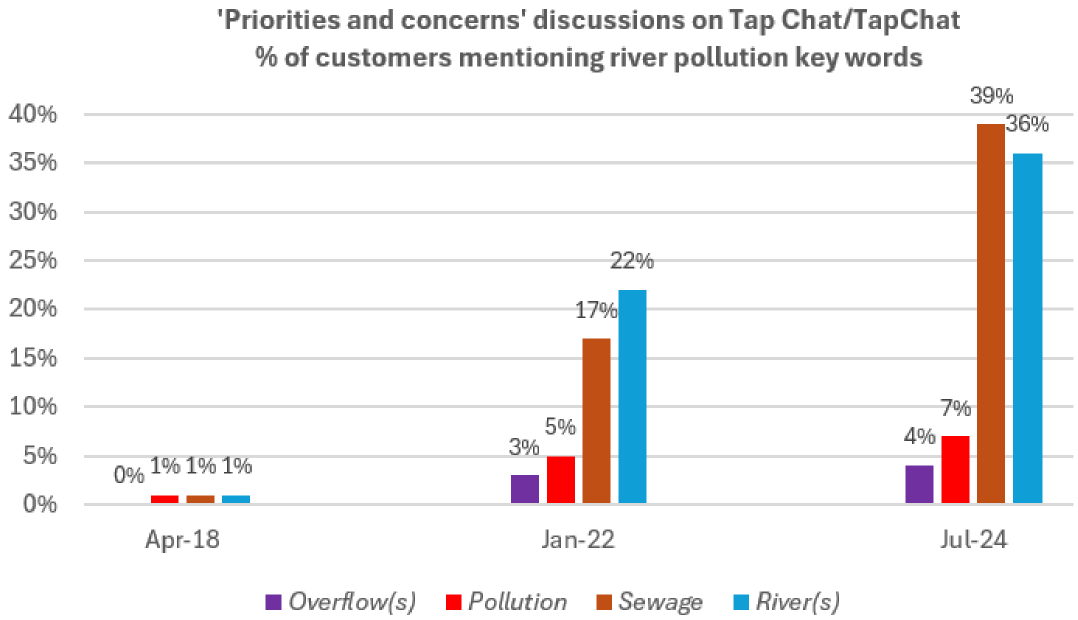
Feedback from customers on the DD response plan overall (with the bill impact including the costs of this investment) was extremely positive, with 81% of customers finding it acceptable. The main reasons for the plan being found acceptable are that customers support what Severn Trent is trying to do in the long term and the plan focuses on the right services. When informed about what the plan will deliver, as well as the personalised bill impact, 32% of customers find it affordable, with a further 37% saying it is neither affordable nor unaffordable.

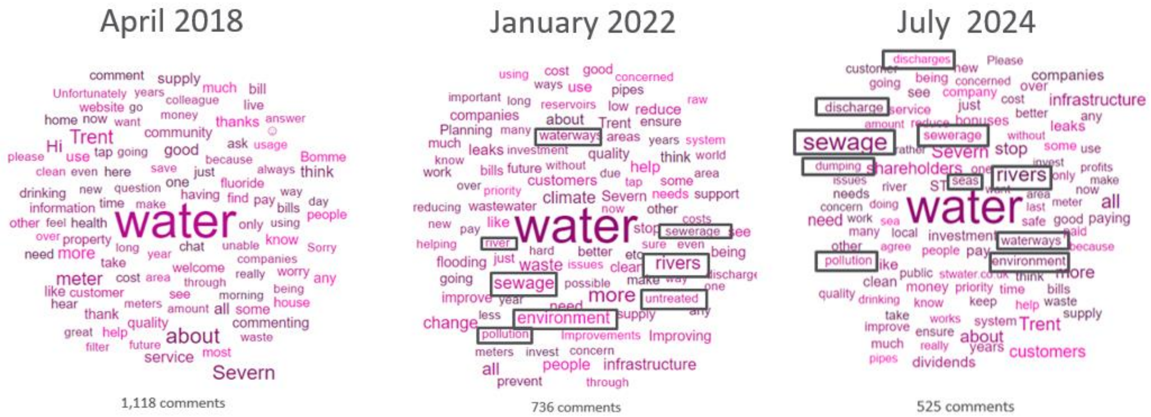
More broadly, since submitting our PR24 plan, the public interest in PFAS has continued to increase, a trend which is likely to continue and, as we have seen in other service areas, is likely to significantly influence the pace at which action is needed, irrespective of any legislative timeline. Learning on other policy areas shows that it is likely that our customers will not be satisfied to wait another six years (until AMP9) before they can see action being taken on PFAS.

Customer insight on storm overflows, an area of high customer concern, could demonstrate a potential future for the PFAS challenge. When we asked customers to tell us, in their own words, their priorities and concerns for Severn Trent in April 2018, no-one mentioned storm overflows or river pollution. By January 2022 and July 2024 it had become a key customer concern. In January 2022, 17% of customer comments mentioned *sewage* and 22% mentioned *river(s)*. In July 2024, 39% of comments mentioned *sewage* and 36% mentioned *river(s)*.

[14] The research was based on a figure of £115m – our estimate for this work at the time customer research was carried out – the bill impact of 70p stated in the workshop is unaffected by the figure now proposed of £119m.

Figure 3: Outputs from the latest Customer Insights session on TapChat.



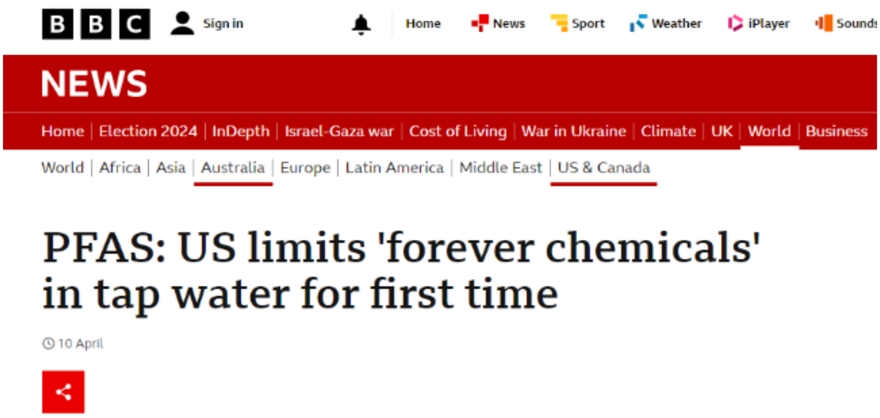


1.3.3 Drinking water legislation is increasingly shaped by public perception

Previously, the introduction of new or tighter drinking water standards has followed a well-established approach, often following a timeline lasting a minimum of 10 years with little or no public engagement. A different model can be observed in several policy areas in recent times, whereby public access to data, and the influence of well-organised stakeholder groups, drives policy in a more iterative way as the science evolves.

Case Study 2 below gives an example of drinking water policy in the US being shaped by public perception. The US Government's approach (identifying the PFAS of greatest concern, setting tight standards against them, and making available multiple funds to deliver improvements in the short term) will allow US water companies to make strong progress while growing the evidence base for harm and trialling innovations to tackle other PFAS.

Case Study 2: The recent US Government regulatory standard for PFAS



On 10 April 2024, the US issued the first-ever national, legally enforceable drinking water levels for PFAS. The US Environmental Protection Agency (EPA) says that between 6% to 10% of 66,000 public drinking water systems across the US may have harmful levels of PFAS.

This new US standard (Maximum Contaminant Level) covers five PFAS, including PFOS and PFOA. This compares to **47** PFAS which the DWI expect English and Welsh water companies to monitor, which includes the five US ones. For two of those five PFAS (PFOS and PFOA) the US level required is 0.004 ug/l, so well below DWI's Tier 1 threshold of 0.01 ug/l.

The new regulations give local municipalities three years to monitor for the chemicals in their water systems. If harmful levels are found, governments have five years to reduce the amount of PFAS in the water supply.

The US Government has allocated an extra $1bn to help states and territories implement PFAS testing and treatment at public water systems and to help owners of private wells address PFAS contamination.

This is part of a $9 billion investment through the Bipartisan Infrastructure Law to help communities with drinking water impacted by PFAS and other emerging contaminants – the largest-ever investment in tackling PFAS pollution. An additional $12 billion is available through the Bipartisan Infrastructure Law for general drinking water improvements, including addressing emerging contaminants like PFAS.

This announcement generated significant media coverage, including in the UK.

Case Study 3 below gives an example of drinking water policy in Australia being shaped rapidly by public concern and media attention, based on discussions with our colleagues from the Australian Water Services Association.

Case Study 3: The recent Australian experience of PFAS in the media

Between April and June 2024, PFAS and tap water concerns made it consistently in the headlines of papers, journals and local media including the Guardian, Sydney Morning Herald, The Age, WAToday, The Daily Telegraph, Sound Telegraph. This was following an investigative journalist who undertook a deep dive after the ‘Dark Waters’ movie and documentaries to investigate PFAS in drinking water. The work referred to a University of Queensland study from 2011 which indicated widespread detections; in reality, there are relatively few high risk sources known, and there are plans in place to remove PFAS.

During this time, health regulators were relatively quiet and the industry had to defend the safety of drinking water, including on national television (Sunrise, 7 News). There was significant pressure from media and some health experts on the federal health regulator (the National Health and Medical Research Council) to set standards at the same level as the US (see Case Study 2). The regulator’s review is anticipated to be completed in 2025. The Australian water industry is expecting guideline limits to be lowered to some extent, and is compiling a national database of data and available technologies to ensure the industry is prepared.

In a recent article[15], in an interview with the DWI Chief inspector, he set out the need to balance public sentiment for urgent and extreme action with the emerging science to understand the harm alongside the cost implication. The following quote summarises that the DWI understands it needs to take action before the science underpinning the harm is clear.

> *“To be sure that we are keeping the public safe, we need to take action to secure that water supply for future generations. That’s hugely important. And I think quite rightly, the public wouldn’t thank me if I wasn’t doing that.”*

1.4 We are clear on the need for action

1.4.1 Our sampling regime gives certainty of the need

The Section 19 Undertaking states that sites become Tier 2 where PFAS are detected at concentrations in Tier 2 or above in a single final water (or downstream treated water) sample, or

[15] The Water Report, June 2024, page 14-15

two or more raw water samples. The DWI's Information Letter 03/2022 states that where sample results fluctuate between different tier levels, the highest tier should be assumed. If results in the higher tier do not recur in subsequent sampling, the higher tier must continue to apply until at least one year of sampling and investigation proves otherwise.

Severn Trent's sampling regime meets the DWI requirements and also seeks to learn from other countries and past experience; a comprehensive and robust sample base is the key to understanding risks and ensuring we map solutions to the root cause. Our Green Recovery project at Witches Oak (our Tier 3 site) demonstrated that we need more frequent sampling in order to design the right solution – so we are undertaking additional sampling at our Tier 2 sites.

Table 2 below sets out the DWI's minimum requirements compared with our approach, and demonstrates that we have far greater certainty than the regulations require.

Table 2: Comparison between the minimum DWI requirement and Severn Trent's approach to PFAS

Sampling parameter	DWI requirement	Severn Trent approach
Compounds to be sampled	47 PFAS – as instructed in Information Letter 05/2021.	In addition to the 47 PFAS required, we have developed an accredited method to test for a 48th PFAS: 6:2 FTAB. The recent DWI Chief Inspectors report "Drinking Water 2023" confirmed that this PFAS will be added to the 47 required for analysis by all companies, from January 2025.
Robust method	Use of a UKAS-accredited laboratory for PFAS analysis.	Our laboratories have developed a UKAS-accredited method for PFAS analysis, allowing us to avoid sampling bottlenecks.
Location of sample points	Raw and final treated water samples.	Upstream catchment sampling was underway prior to Section 19 Undertaking requirements, including as part of our Witches Oak pilot plant trials.
Routine Sampling Frequency	No frequency specified, but sufficient to manage the risk.	Based on our current lab capability an original PF24 plans, our sampling frequency is: • Tier 1: 1-6 per year • Tier 2: 12 per year (monthly) • Tier 3: out of supply / investigational
Sampling start date	October 2021 – 47 PFAS.	July 2021 – already analysing 20 PFAS.
Total number of samples from 2020	Routine samples: 1,823	Routine, catchment and investigational samples: 3,173

1.4.2 We have a good understanding of our current position

In total, we have now taken just over 3,100 samples from across all our catchments and raw and treated waters for analysis of 47 PFAS (plus 6:2 FTAB as the 48th). Appendix B includes a full description of the sample results. Table 3 below shows that:

- All but four of our sites are in Tier 1, the lowest level of PFAS risk. Tier 1 sites represent 91% of our total peak week production capacity.
- Two sites, Witches Oak WTW and Cropston WTW, are implementing PFAS mitigation as part of our original PR24 enhancement business case (SVE13 Raw Water Deterioration).
- Two sites, Church Wilne and Whitacre, require additional PR24 planned investment for AMP8, due to a new statutory Section 19 Undertaking issued by the DWI.
- 23 sites are at high risk of becoming Tier 2 sites, or are soon to become Tier 2, based on elevated concentrations, catchment risk assessment or due to the DWI's revised guidance issued on 21st August which now sets Tiers based on the 'sum of' all PFAS compounds, rather than individual PFAS concentrations - Gated scheme development funding now required.

Table 3: Summary of our PFAS compliance, DWI Legal instruments and investment plans (July 2024)

Tier	No. of WTW sites	% of total PWPC[16]	Site name	Number and duration of sample data	PFAS data	DWI legal instrument	Investment for PR24 submission 2025-30 (Green = this case)
Tier 3	1	3%	Witches Oak WTW	300 samples since February 2020 (including GR investigation samples)	6:2 FTAB and 6:2 FTSA (Tier 2 for five other PFAS)	S19 Undertaking SVT-2023-00007 (PR24)	PR24 SVE13 Raw Water Deterioration - enhancement business case
Tier 2	3	6%	Cropston WTW (Thornton Reservoir)	15 samples since October 2022	6:2 FTAB	Reg 28 Notice SVT-2023-00002	
			Church Wilne WTW	63 samples since May 2021 (+ 120 river samples since February 2020)	6:2 FTAB	S19 Undertaking SVT-2023-00014 *for Tier 1: lists 31 sites with PFAS detections but need 2 years of data to remove from S19.*	New SVE4.28 "PFAS Tier 2 sites" business case as part of DD representations.
			Whitacre WTW	69 samples since December 2020 (+ 3 river samples since January 2020)	PFECHS, PFOS and PFBS		
Tier 1	23	28%	Multiple sites*	587 samples since June 2020	Sites with PFAS detections – high risk of moving to Tier 2 or will move to Tier 2.		"Gated scheme" development funding as part of new SVE4.28 "PFAS Tier 2 sites" business case - DD representations

[16] PWPC – Peak Week Production Capacity (forecast for2029/30).

	35	43%	Multiple sites	788 samples since January 2020	Sites with PFAS detections – lower risk of Tier 2.		*Proposed Notified Item for PFAS uncertainty.*
	62	20%	Multiple sites	836 samples since January 2020	No PFAS detections.	N/A	

**The 23 sites are Blacklake BPS, Boughton (Chester) WTW, Boughton (Notts) BPS, Bratch BPS, Campion Hills WTW, Chalford BPS, Chequer House BPS, Cosford BPS, Cropston WTW, Dimmingsdale BPS, Draycote WTW, Green Lane BPS, Green Street BPS, Hollies BPS, Little Eaton WTW, Lydbrook BPS, Mitcheldean WTW, Mount Nod BPS, Mythe WTW, Shelton WTW, Strensham WTW, Trimpley WTW and Wallgrange BPS. There are also another potential 4 sites: Bomere Heath BPS, Clipstone BPS, Ogston WTW and Sunnyside BPS that could become Tier 2 based on raw water samples but we need confirmation from the DWI whether one or two sample results are needed as this isn't clear in recent guidance.*

1.4.3 We are in a strong position to move quickly, but fairly

Our capital design and delivery teams are already mobilised at both our Section 19 Undertaking Tier 2 sites, allowing us to gain extra sample data to confirm the investment need:

- AMP7 Green Recovery project at Witches Oak WTW, adjacent to Church Wilne WTW.
- PR24/AMP8 Algae project (DWI PR24 supported) at Whitacre WTW, where the activity funded from AMP8 transitional expenditure is underway.

The DWI has not set explicit timescales for PFAS mitigation at Tier 2 sites. However, our plan for action needs to be created in the context of rapidly increasing public concern that could lead to changes in regulation in the short term. We recognise the importance of spreading the cost fairly across generations, as well as taking action quickly at the highest risk sites.

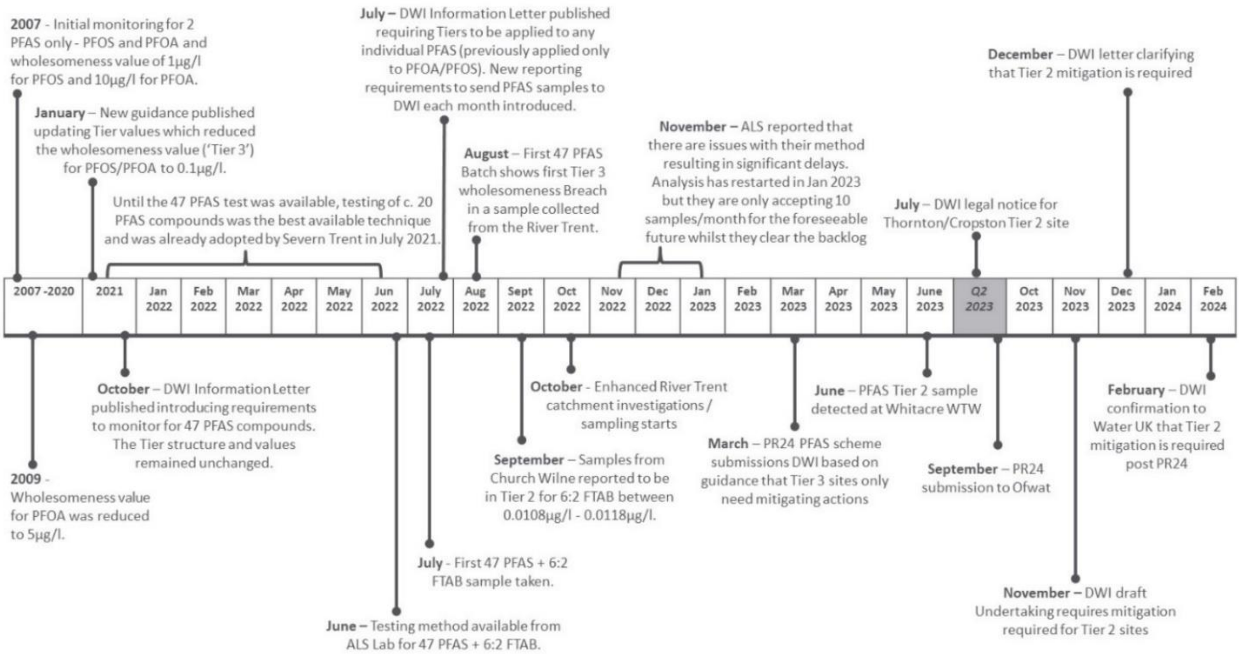
Because we are already undertaking water quality improvements at both the Tier 2 sites listed in S19 Undertaking, it will be most cost-efficient for Severn Trent to implement PFAS risk reduction at Church Wilne and Whitacre within AMP8. We believe that mitigating PFAS risk at four sites (in total) out of Severn Trent's extensive asset base is proportionate for AMP8 – and is in line with expectation of our customers that tap water is safe to drink and free of contaminants (see Section 1.3.2).

1.5 Outside management control

1.5.1 The fast-moving regulatory landscape

The PFAS regulatory timeline in Figure 4 below shows that we tested for the original PFAS listed in regulatory guidance and all our sites were at low risk. We have aimed to gain the best possible insights to inform our investment plan and understanding of the risk, including the development of a method for PFAS analysis, resulting in UKAS accreditation. Based on regulatory guidance at the time, we included investment in PFAS mitigation at Tier 3 sites in our PR24 submission. The need to include our Tier 2 sites, Church Wilne and Whitacre, in our PFAS mitigation programme is due to a new Section 19 Undertaking that the DWI required us to submit.

Figure 4: PFAS sampling, monitoring and regulatory timeline



1.5.2 Managing uncertainty

All our existing sites currently in Tier 1 (i.e. those not having full mitigation covered by our original and new PR24 enhancement business cases) have some risk of becoming Tier 2 or 3 and triggering a need to respond. This represents around 90% of our water supply. If this happened, the DWI would enforce statutory action at these sites, either through an updated Section 19 Undertaking for PFAS, or a Regulation 28 Notice.

PFAS is a developing area, and with growing public interest, as well as the potential for statutory action to be required for any sites moving into Tiers 2 or 3, it is important (and the DWI requires) that we are able to respond. For those 23 Tier 1 sites which are higher risk of requiring mitigation in AMP8 (explained in scenario 1 below), we have put forward a Gated scheme and included the feasibility and design of treatment mitigation as part of this case to progress in AMP8. A Notified Item/Uncertainty Mechanism for the remaining 35 Tier 1 sites with detections (which we have proposed alongside our draft determination representations) would ensure that there is sufficient flexibility within AMP8 to protect consumers if the following scenarios arise:

- **Scenario 1: Tier 1 sites move to Tier 2 or 3.** Of our 120 sites currently classed as Tier 1, 58 have had positive detections of PFAS. So far, our data is still relatively limited, and is not showing any trajectory that we can use for forecasting. However, on the basis that PFAS is certainly present, these sites have the potential to change tiers with very little or no warning (i.e. there is a source and pathway for PFAS at these sites). Of these 58 sites, we have identified 23 that are at a higher risk of moving to Tier 2. This is based on elevated concentrations (close to Tier 2 threshold); catchment risk assessment identifying potential sources of PFAS; and/or where the total sum of all PFAS detected (as opposed to the levels of individual PFAS) brings these into Tier 2 i.e. the measure that the DWI have now confirmed in their Information Letter 03/2024 on 21st August 2024. As part of this business case, we propose investment to carry out feasibility and design in AMP8 at these 23 higher-risk sites (see Section 2.3 for details).

- **Scenario 2: We are required to work to more stringent PFAS limits.** The DWI may reduce the tier concentration boundaries due to the precedent set by the US EPA, growing public pressure, increasing evidence of health impacts, and/or improved understanding of PFAS toxicology and treatment technologies. Anecdotally, we heard in June 2024 (at a conference of global water sector insurers and insurance brokers) that PFAS is now the top concern for water industry insurers, overtaking climate change and flooding. It could be argued that the conditions for this scenario are already in place: the Royal Society of Chemistry's policy and position statement (June 2023) is a good example of putting public pressure on the DWI to tighten PFAS regulation in water industry. *Note – costs for this scenario are not covered by this business case but are set out in our Notified Item/Uncertainty Mechanism for PFAS.*
- **Scenario 3: We are required to mitigate new PFAS compounds.** We may be required to monitor and risk assess new PFAS beyond the 47 PFAS currently required by the DWI. This already happened to us in AMP7/PR24 with 6:2 FTAB, which was not one of the original 47; both our original PR24 scheme obligations are all based on detections of 6:2 FTAB. The DWI have now confirmed in their Information Letter 03/2024 on 21st August 2024 that all companies will be required to test for 6:2 FTAB, from January 2025. *Note – costs for this scenario are not covered by this business case but are set out in our Notified Item/Uncertainty Mechanism for PFAS.*

To manage these uncertainties, and to monitor appropriate triggers, our internal PFAS working group of technical experts covers all business functions affected by PFAS: Rural and Urban Catchments, Water Treatment/Networks, Wastewater Treatment/Networks, Bioresources (inc. biosolids to land) and our Strategic Resource Options (SRO) team. This group is co-chaired by two of our senior professionals (one water, one wastewater), sponsored by senior management, and attended by our representative at Water UK's sub-group on PFAS.

The purpose of the PFAS working group is to develop, co-ordinate and implement a response to the PFAS challenge at the operational, tactical and strategic level. Its key outputs will include:

- Quantifying the size of the problem across catchment, water, waste and bioresources.
- Defining and tracking PFAS metrics and trigger points so we can adapt our AMP plans if necessary (e.g. uncertainty mechanism, LTDS).
- Identifying solutions to reduce risk.
- Providing communications, policy and strategy recommendations to our executive team.
- Producing a single PFAS strategy document for the company, building on our submission to the DWI in June 2023.

1.5.3 PFAS source control

In the long term, reducing PFAS levels in raw water will require Government intervention, i.e. regulatory restrictions on PFAS use and manufacturing. A similar approach has been used successfully to reduce concentrations of the pesticide metaldehyde in recent AMPs. We are yet to see the Government's Chemical Strategy, and how this deals with PFAS – it was originally promised in 2018, and was expected in 2024.

We recognise that our wastewater systems are one of many pathways through which PFAS can enter the environment and water sources. The industry Chemical Investigation Programme (CIP3) identified that domestic input is one of the main sources of PFAS in wastewater treatment works final effluent. Our wastewater and sludge treatment processes are not designed to remove PFAS – they cannot be broken down by conventional treatment processes. Our understanding is that the Environment Agency (EA) are not currently pursuing final effluent permitting for PFAS, as there is no Environmental Quality Standard (EQS) for PFAS compounds, except PFOS. The national Chemical Investigations Programme next AMP (CIP4) will help the EA, Defra and the industry better understand this emerging industry risk. In particular, targeted investigations into sources of PFOS will be undertaken in 22 of our larger sewerage catchments.

In the meantime, to ensure statutory drinking water compliance in AMP8, end-of-pipe treatment solutions are required to remove these compounds which have already contaminated, and continue to contaminate, our water sources.

1.5.4 We are engaging at the most senior level and with the board

We have / are engaging at the most senior level and the board to ensure PFAS risk is understood and that sufficient controls are in place. An internal audit is currency underway which will report to our Board in September 2024. Its scope is to:

- review our company approach to managing the impact of PFAS on drinking water quality and wastewater discharges.
- assess how the company is responding to the changing regulatory landscape, PFAS industry expectations and regulatory requirements.
- review how PFAS removal is being considered as part of short- and long-term business planning.

This audit will assess controls against the following Principal Risks:

- Risk 2 - We do not provide a safe and secure supply of drinking water to our customers.
- Risk 7 - Changing societal expectations, resulting in stricter legal and environmental obligations, commitments and/or enforcements, increase the risk of non-compliance.

1.5.5 We have sought to learn from others and equip employees at all levels

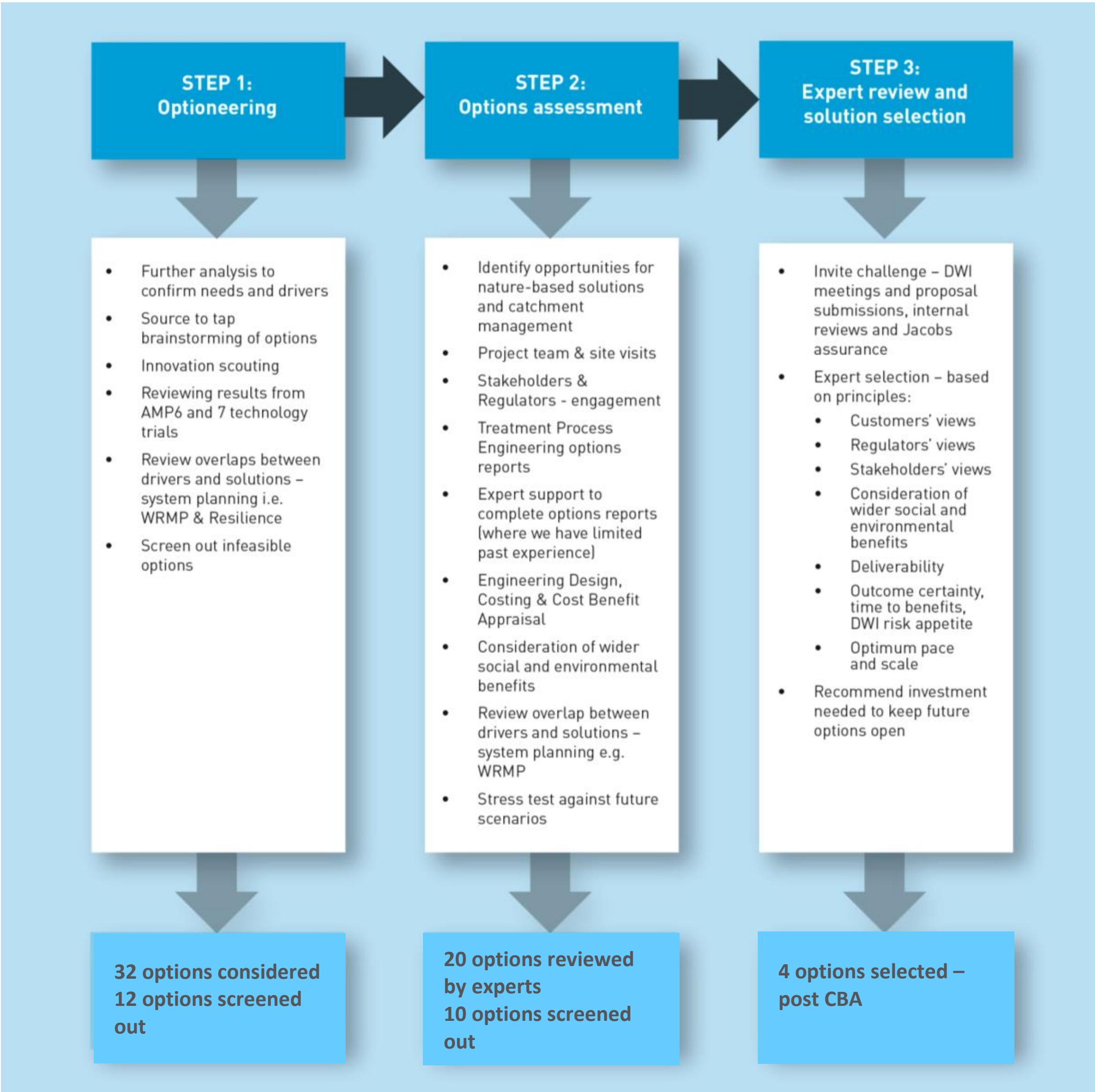
Please also refer to section 2.1.4 explaining our industry leading position on PFAS trials and projects. At the highest level of our organisation right through to our process scientists, engineering, strategy and frontline teams we have upskilled ourselves in understanding the challenges, global best practise and treatment/mitigation options for PFAS. We have had delegations at international conferences who have shared education sessions to feedback their learning and we have a PFAS working group meeting quarterly that is sponsored by senior management to share updates insights and developments. For our current and planned PFAS treatment projects, we have held frequent meetings to share lessons learned in this fast moving area as these project solutions develop.

2. Best option for customers and the environment

There is no dedicated technology available for large-scale removal of PFAS from drinking water in the UK (or elsewhere). That means we need to follow a twin-track approach to this challenge: controlling PFAS at source as much as possible, and utilising treatment processes to maximise the certainty of outcome.

In our PR24 business case (SVE 13 Raw Water Deterioration), we set out our process for identifying options to manage raw water deterioration. We have used the same comprehensive process for this business case, outlined in Figure 5 below.

Figure 5: Process for identifying options for PFAS mitigation



2.1 Step 1: Optioneering

2.1.1 Source to tap brainstorming

To consider and then develop potential solutions, we have a utilised a broad range of expertise, including our 400-strong design team and partners working on AMP8 transitional PFAS removal schemes at Witches Oak and Cropston, and our technical experts. The 36 possible solution options, from source to tap, are summarised in Table 4 below including our consideration and rationale for screening out options for further assessment.

Table 4: 36 solution options considered for PFAS – source to tap

Number and type of solution options		Consideration	Screened out? Y/N
2	Site abandonment / relocation – replacing with another source of water or a new WTW using options identified in our Water Resources Management Plan WRMP24	We have overlaid and checked our WRMP24 solution options for synergies. Church Wilne WTW and Whitacre WTW are critical baseline sources for achieving our WRMP24. For Whitacre, we had considered the option of abandonment by looking at two of our WRMP24 solution options (non-preferred) to backfill the water: Minworth effluent re-use schemes which ranged from [✂]Ml/d (c.£205m) and [✂]Ml/d (c.£472m). These were considerably more expensive than treatment options for our AMP8 DWI-supported Algae scheme (£67.3m) coupled with the new PFAS proposal below (£119.2m), and a draft WRMP24 solution option to expand Whitacre WTW. There was also a non-preferred WRMP24 option for Ogston WTW expansion by [✂]Ml/d at c.£83m, but this is further north in our strategic grid and it was deemed to be very difficult to move water to the areas currently supplied by Whitacre.	Y
2	Bankside storage / abstraction management – traditionally used to avoid "peak" pollution events on rivers	Not relevant for PFAS mitigation. Unlike ammonia or turbidity, continuous real-time monitoring does not exist for PFAS to allow abstraction management. Unlike turbidity or crypto, PFAS cannot be removed or reduced by settlement.	Y
2	Alternative raw water intakes – PFAS-free source of water	Our sampling shows that any nearby alternative sources of raw water at these sites have PFAS present – this is a widespread issue, for a large catchment area.	Y
2	Catchment management – a scheme for each site aimed at source control	Catchment management is always our first line of defence for drinking water quality and brings wider social and environmental benefits – removing at source, to eliminate the need for treatment. We have strong, industry-leading catchment management plans	N

		in place and much of it is delivered through our WINEP under Drinking Water Protected areas. We fully acknowledge the DWI's long-term planning guidance that companies will be required to adopt a twin-track approach that includes treatment and/or other operational control measures in addition to catchment management actions to mitigate the risks to consumers from raw water deterioration. PFAS catchment investigations and investigative sampling in the River Trent has already started, related to our Green Recovery project at Witches Oak. Investigative PFAS sampling has also started at Whitacre as part of our transitional AMP8 spend for the DWI statutory scheme there for Algae. Given that there are thousands of PFAS sources (live and historic) in these large river catchments, a catch-all end of pipe treatment approach is the most likely short- to medium-term option for these statutory obligations (more detail in Section 2.2 below).	
2	Nature-based solutions – removing PFAS at each site without the need for chemical- and energy-intensive traditional engineering solutions	Learning from AMP7 Green Recovery at Witches Oak, we have considered the use of floating wetlands. However, PFAS is likely to bioaccumulate in the plant material and then be re-released as plants die off – so it is not likely to be effective for PFAS mitigation.	Y
18	Conventional treatment options for each site	As part of AMP8 transitional spend, carbon adsorption (GAC) trials are fully up and running for our original PR24 projects for PFAS: Witches Oak and Cropston (more detail in Section 2.1.2 below).	N
2	New technologies – effective, more guaranteed PFAS removal and destruction	Much has gone on in this space since our PR24 submission in September 2023, and we have learned from academia, regulators, other water companies and other sectors from around the world, as well as from our own Green Recovery pilot plant and SRO pilot plant at Minworth (more detail in Section 2.1.2 to 2.1.4 below).	Y
2	Distribution network solutions – reducing levels by diluting with other sources of lower concentrations	Taking the learning from the DWI's legal response to Thorton (Tier 1) to Cropston (Tier 2) under its 'no deterioration' principle, we cannot rely on blending as a risk mitigation solution.	Y

After this initial step, we chose to pursue further optioneering for catchment management and treatment but being aware of the following considerations.

Catchment management considerations

In the long term, catchment management and prevention at source are the best options for PFAS, and we have already started investigations into their feasibility for the River Trent as part of our Green Recovery project and AMP8 transitional activity for the Witches Oak PFAS scheme we submitted for PR24. We now need to extend this catchment investigation approach to the River Derwent (Church Wilne WTW) and Rivers Blythe and Bourne (Whitacre WTW) due to the new requirements for these Tier 2 sites (see Section 2.2 below).

Our desktop assessment shows there are thousands of PFAS sources (live and historic) in these large catchments, so catchment management alone will not solve the problem. A water treatment approach, running in parallel with catchment management, is the most likely option for our new Tier 2 statutory obligations.

PFAS treatment considerations – removal and destruction

There are currently no dedicated PFAS removal and destruction technologies available for effective PFAS treatment in UK drinking water. Advanced technologies such as electrochemical oxidation look promising, but their effectiveness for PFAS removal or destruction is unknown because they have not yet been trialled and tested at a large enough scale. It could be at least five to 10 years before these solutions are commercially available at the scale required, and we are actively working with new technology providers to support this development (see Section 2.1.4).

In the meantime, Powdered Activated Carbon (PAC) and Granular Activated Carbon (GAC) have been identified as technologies capable of removing PFAS. Even though these technologies are usually installed for pesticide removal, evidence suggests that GAC and PAC are effective in removing PFAS, particularly longer-chain PFAS compounds, because the PFAS adsorbs to the pores of the activated carbon. However, due to competition for adsorption sites with other organic molecules (TOC) a good level of pretreatment is required. Therefore, raw water dosing of PAC is not likely to be an effective PFAS control measure.

Whatever the selected option for PFAS removal, we need to avoid putting PFAS back into the water cycle or the wider environment as it persists and bio-accumulates. This means either separating the PFAS from any treatment waste stream by concentrating it into a solid form, or chemically separating it. For PAC, the PFAS-laden media is filtered or floated out of the water and disposed of via a sludge route to a wastewater treatment works. Our approach is that no PFAS waste should enter our wastewater treatment works, as they are not designed to remove PFAS either. PFAS would pass through them and so contribute to river pollution and risk non-compliance with any future EQS/permits that the EA may impose in future AMPs, pending the findings of CIP4.

For GAC, used media is sent to suppliers for regeneration. However, from the literature it is not clear if GAC can be regenerated without the risk of releasing PFAS breakdown products into water or air via the exhaust gases during thermal destruction. Suppliers claim that the PFAS is volatilised at high temperature in their regeneration process, and so the carbon chain is broken down through thermal oxidation and the C-F bonds are destroyed. Validation of PFAS destruction relies on a fluorine mass balance and currently the accuracy of this method is not reliable.

The alternative to regeneration of spent PFAS-laden GAC media is to dispose of it and replace it with virgin media. However, this is a more expensive option and does not align with our long-term carbon strategy. We are aware that this is the option that Anglian Water put forward in their original PR24 enhancement business case for 20 Tier 2 sites, at a cost of £41.7m. However, we cannot see any assumptions around media replacement frequency during the AMP.

Incineration has been highlighted as a way of destroying PFAS laden waste but there are concerns that it may not fully destroy PFAS compounds, and hence release them into the atmosphere. We are planning laboratory scale studies to explore this process further to deem whether this option is acceptable.

Commercial availability of destruction technologies will open a greater range of treatment options. Destruction technologies include but are not limited to:

- Electrochemical oxidation
- Supercritical water oxidation (SCWO)
- Plasma
- Thermal
- Hydrothermal alkaline treatment
- Sonolysis

2.1.2 Learning from Green Recovery – Witches Oak

Our Green Recovery project (Decarbonising Water Resources) at Witches Oak is employing a wide range of innovation that we are learning from to inform AMP8 options, including:

- Catchment management
- A pilot plant that is able to test new and emerging technologies for PFAS removal and destruction.
- New ceramic membrane treatment.
- Use of wetlands (i.e. floating wetlands) as a pre-treatment process for nitrate, ammonia, phosphorus, organics and solids.
- Use of Witches Oak as bankside storage, for protection from raw water quality incidents
- UV as part of the disinfection process, replacing the need for a contact tank.
- Installing in-line coagulation units at half the height to reduce the lift required by the abstraction pumps.

To prepare for the specific PFAS design challenge at Witches Oak and Church Wilne, we already have a pilot plant that has been operating for 12 months. The pilot plant is enabling us to test the following:

- Performance of the in-line coagulation and CeraMac membrane.
- Organics removal by ion exchange.
- Organics and PFAS removal by Actiflo®Carb (PAC with sand ballasted lamellas).
- GAC trials for pesticides, organics and PFAS removal.
- PFAS destruction technologies e.g. electrochemical oxidation.

Figure 6: Witches Oak Pilot plant

The plant has two process streams that are operated concurrently on:

- River Trent raw water, which will predominantly feed our new Witches Oak WTW.
- River Derwent raw water, which feeds Church Wilne.
- We actually have multiple pilot plants which means we can also test a blend of River Trent and River Derwent raw water.

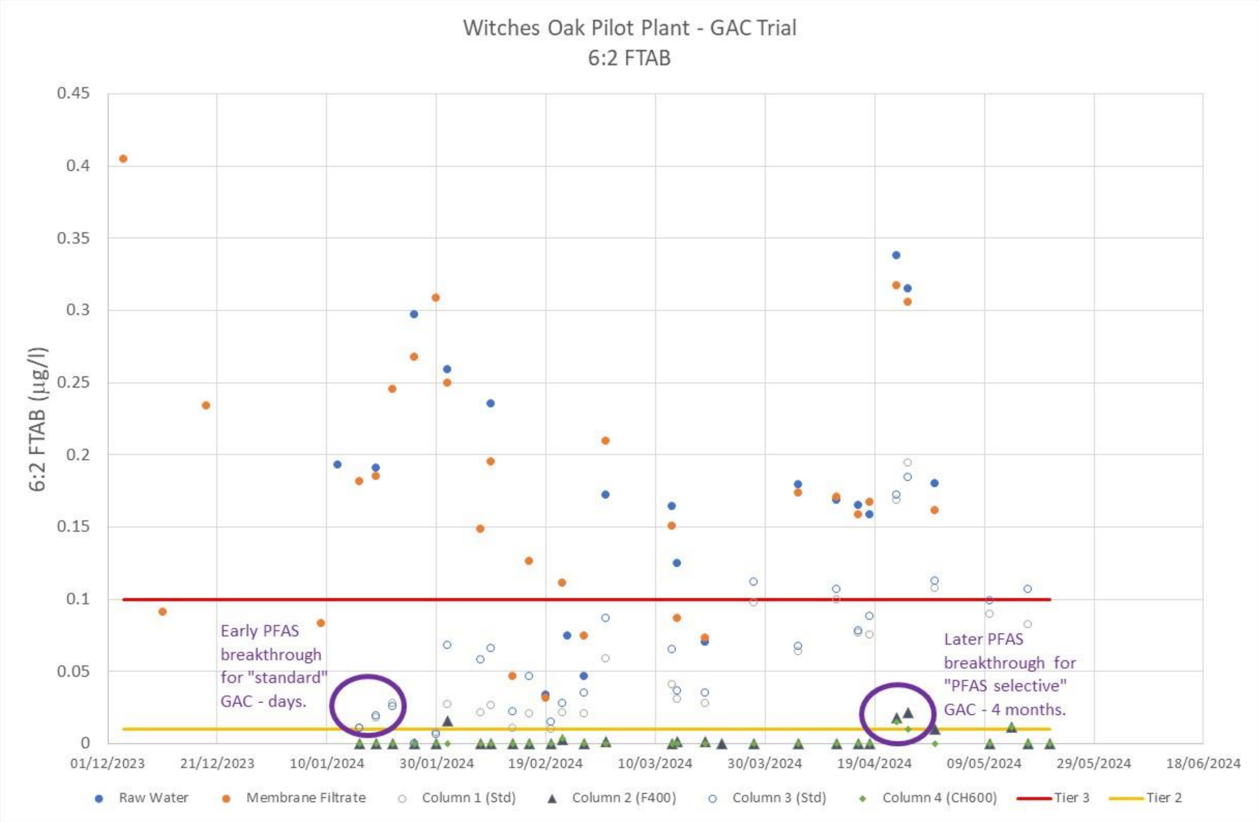
The pilot plants allow us to trial new technologies for PFAS removal and destruction, determining effectiveness, size, dose rates, and likely costs; and they also provide us with additional monitoring and data to better quantify risk and inform future plans. Determining the effect of background organic matter is also important as it could influence the efficiency of any PFAS removal process.

A significant challenge with operating the pilot plant for PFAS is the lag time between weekly sampling and results, due to the complexity of PFAS analysis. This has been five weeks, but with our DWI-supported PR24 investment for laboratory PFAS capacity/capability as part of SVE13 Raw Water Deterioration, we can see this dropping to two weeks.

Appendix C provides a summary of our PFAS pilot plant trials programme, initially focussed on GAC. For River Trent water, we started in December 2023, and for River Derwent in May 2024. We will need at least 12 months of data, to represent seasonal loading, before we can draw any conclusions or sign-off on a solution for construction. For the River Trent (Witches Oak), this will be December 2024, and for the River Derwent (Church Wilne) this will be June 2025.

Figure 7 below presents some of our latest results from the GAC pilot trial. In summary, the first-stage columns containing standard media (circles) showed PFAS breakthrough very early on – within days or weeks. The second stage columns (triangles and green dots) which contained more PFAS-selective media lasted about four months before PFAS breakthrough led to Tier 2 concentrations.

Figure 7: Early results from Witches Oak GAC pilot plant



2.1.3 Learning from our PFAS trials for our Strategic Resource Options (SRO)

The treatment process investigations for the Minworth and Netheridge SRO projects included rapid scale small column testing (RSSCT) for PFAS removal with GAC media and FLUORO-SORB® media. The specific PFAS compounds evaluated differ from the 48 compounds being monitored by the DWI, as the EA EQS limits are different from the tier system employed by the DWI. Given the difference in the water matrices (final effluent undergoing enhanced treatment vs. partially treated drinking water) results comparison is not helpful at this stage, but we are paying close attention to the results.

2.1.4 Innovation scouting and trials

We are well developed in a thinking as a result of the PFAS trials and projects, not least because of our Green Recovery pilot plant at Witches Oak and our successful Ofwat Innovation Fund bid for PFAS, which are outlined below in Table 5. In the short to medium term, GAC appears to be the most practical PFAS removal option. Since our PR24 submission, we have learned a lot from academia, regulators, other water companies and other sectors about future technologies for PFAS removal and destruction. A summary is provided below in Table 5.

Table 5: Severn Trent's PFAS innovation portfolio

<table>
<tr><th>Innovation</th><th colspan="2">Project summary</th></tr>
<tr><td>PFAS removal in drinking water</td><td>DWI/UKWIR project to determine the best technologies to remove PFAS from drinking water (Cranfield University)</td><td>Via UKWIR, we are participating in the steering group. The technologies tested to date include removal by:
Membranes: Nanofiltration and Reverse Osmosis.
Adsorbents: GAC and an adapted Bentonite media (FLUORO-SORB®).
Ion-exchange: Four ion-exchange media.
Redox processes: UV/sulphite, UV/TiO2.
Foam floatation.
Coagulation.</td></tr>
<tr><td rowspan="5">PFAS waste destruction</td><td>Ofwat Innovation Fund – investigating options for the destruction of PFAS containing wastes</td><td>In conjunction with Cranfield University, we developed a project proposal to address this, which has now successfully secured £1.98m of funding and will run from September 2024 to March 2026. The project will use the output from the DWI/UKWIR project on PFAS removal technologies to generate a matrix of likely waste streams/volumes to guide the selection of waste destruction technologies for trials.</td></tr>
<tr><td colspan="2">We have undertaken extensive research on existing and emerging technologies for both PFAS removal and destruction – where appropriate, we will invite them to be tested at our Witches Oak pilot plant. This includes:</td></tr>
<tr><td>Electrochemical destruction</td><td>ZEO pilot plant (not on site yet)
Boron doped diamond electrodes.
Actiflo® Twin carb PAC waste slurry.
University of Warwick bench top investigations.
Boron doped diamond electrodes & mixed metal electrodes
SUIKI bench top trials (TDK spin off company).
Composite titanium dioxide and ceramic electrodes.</td></tr>
<tr><td>Incineration</td><td>Incineration trials for PFAS destruction – Watstech.</td></tr>
<tr><td>Integrated solution - removal and destruction</td><td>Zimpro wet air oxidation (WAO) integrated solution: PAC-WAO-ZEO
PAC Technology – enhanced activated sludge process with PAC & membrane filtration.
Wet Air Regeneration – capable of breaking down organics to recover spent PAC with <10% loss per cycle. Increases the capacity to adsorb PFAS. best suited for high flows and water with high COD.
Zimpro electrochemical oxidation – PFAS destruction using BDD electrodes.</td></tr>
<tr><td>PFAS in wastewater and biosolids</td><td colspan="2">We are also actively investigating solutions for:
Wastewater – exploring the use of biological treatment (Daphnia) on tertiary treatment to remove both PFAS and microplastics from final effluent.
Biosolids – an alternative option for the treatment of biosolids that removes the risk of releasing PFAS to the soil. advanced thermal conversion of biosolids into biochar.</td></tr>
</table>

In addition to our links to Cranfield University, we are also a steering group member of UKWIR's Substances of Emerging Concern Advisory Group (SECAG). This forum includes experts from five universities, NERC and water/wastewater quality regulators from the UK nations. This forum enables us to learn from the most recent academic research, and highlight challenges where further research is required.

To ensure we are able to find novel technologies and learn from the experience of others, we are active members of knowledge exchange forums. These include the global tech scouting via Isle Utilities Technology Approval Group (TAG), the Isle Utilities European PFAS Working Group, and the WRc PFAS & Emerging Contaminants Expert Forum.

2.2 Step 2: Options assessment

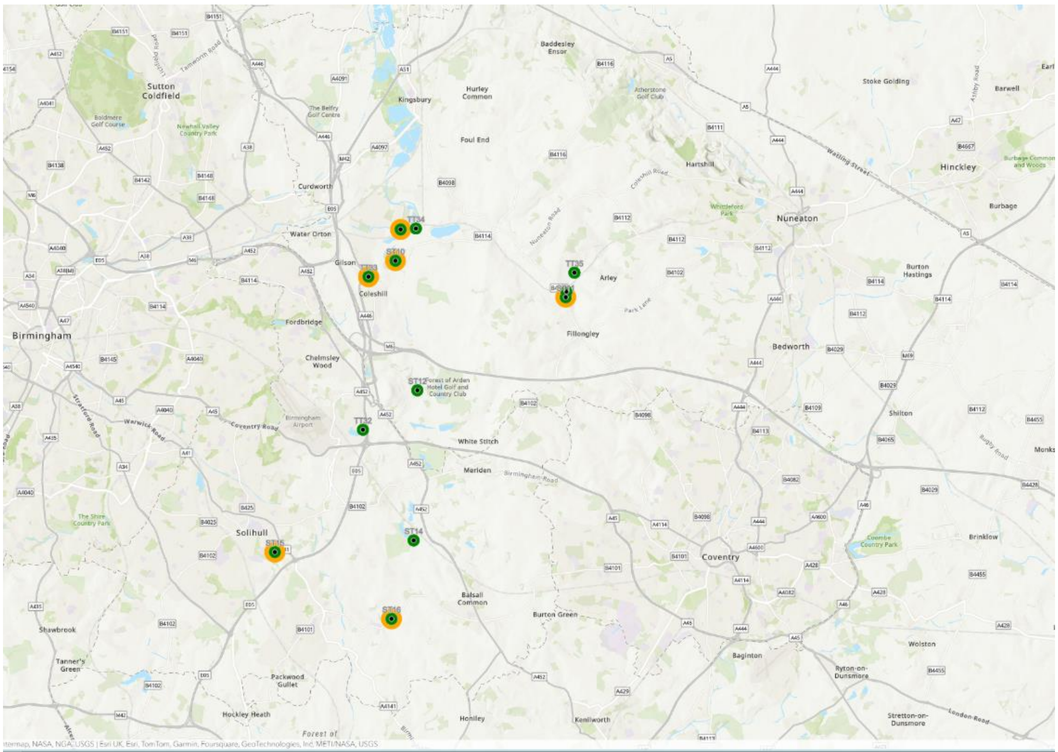
2.2.1 Identifying opportunities for nature-based solutions and catchment management

There are potentially thousands of PFAS sources (live and historic) within the large catchments of Church Wilne WTW (River Derwent) and Whitacre WTW (Rivers Blythe and Bourne). Through our catchment risk assessment, sampling, modelling and stakeholder engagement we are trying to identify sources within each catchment. Currently there is no clear conclusion what catchment interventions would be, or whether they would be feasible – these will come from the information and data discovery part of investigations we need to implement.

Whitacre

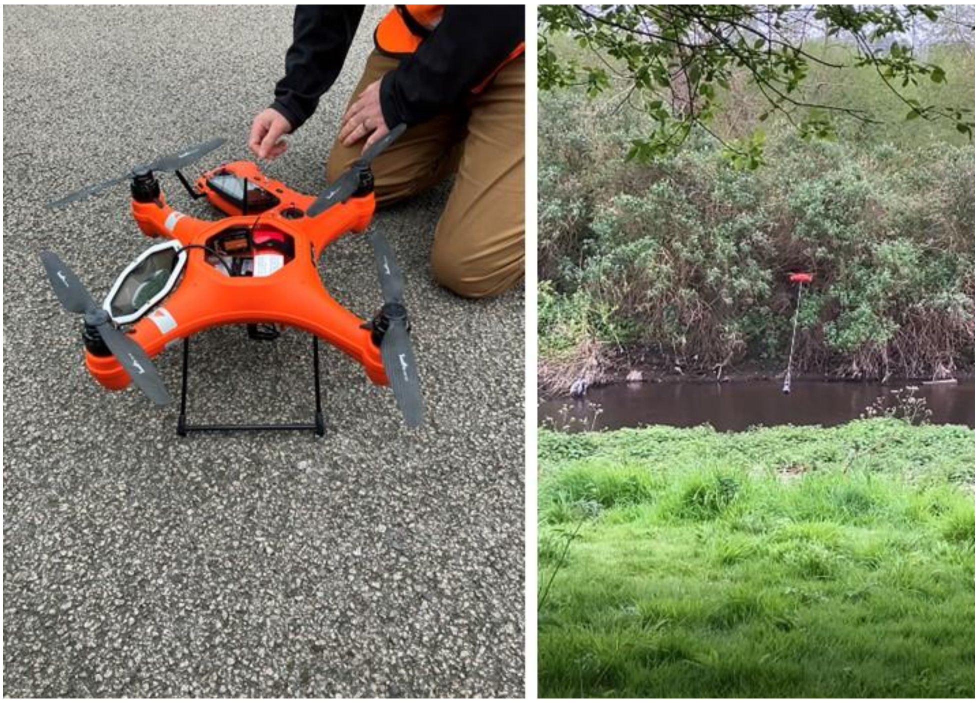
For Whitacre, elevated samples in June 2023 at the WTW prompted us to undertake high level desk-based investigation. This focused on industrial inputs and the presence of Birmingham International Airport which borders the catchment. A further review was undertaken in January 2024 following the detection of Tier 2 concentrations for PFOS and Perfluoro(2-ethoxyethoxyethanol) (PFEECHs) during 2023. Through subsequent collaboration with our AMP8 DWI Whitacre algae project, and following our experience implementing intensive PFAS sampling in the Trent catchment, a programme of intensive PFAS (and nutrient) sampling was explored for the Whitacre catchment. 15 locations have been identified capturing inputs from Birmingham Airport, fire stations, wastewater treatment works, and biosolids applications. Results from the first 4 weeks of sampling have shown 9 PFAS above the tier 2 threshold. Total PFOS reported highest levels with tier 2 concentrations observed at 6 locations across the catchments (Figure 8). As such, our Drinking Water Safety Plan (DWSP) catchment risk assessment (CRA) work has identified this catchment as 'red risk', noting 231 potential point PFAS risks with the Blythe having a higher PFAS risk than the Bourne which aligns with differences in predominant land uses.

Figure 8: Total PFOS results from Bourne and Blythe catchment sampling[17]



Following a similar approach to our work in the Trent catchment, results from our intensive sampling will be reviewed to identify hotspot sub catchment. Sample locations will be rationalised and relocated to gain more insight into possible PFAS sources within these hot spot areas. Where locations are hard to reach, we are utilising drone technology to collect samples (Figure 9).

Figure 9: Example of Severn Trent drone in action taking sample remotely



[17] Green dots = Tier 1; amber dots = Tier 2

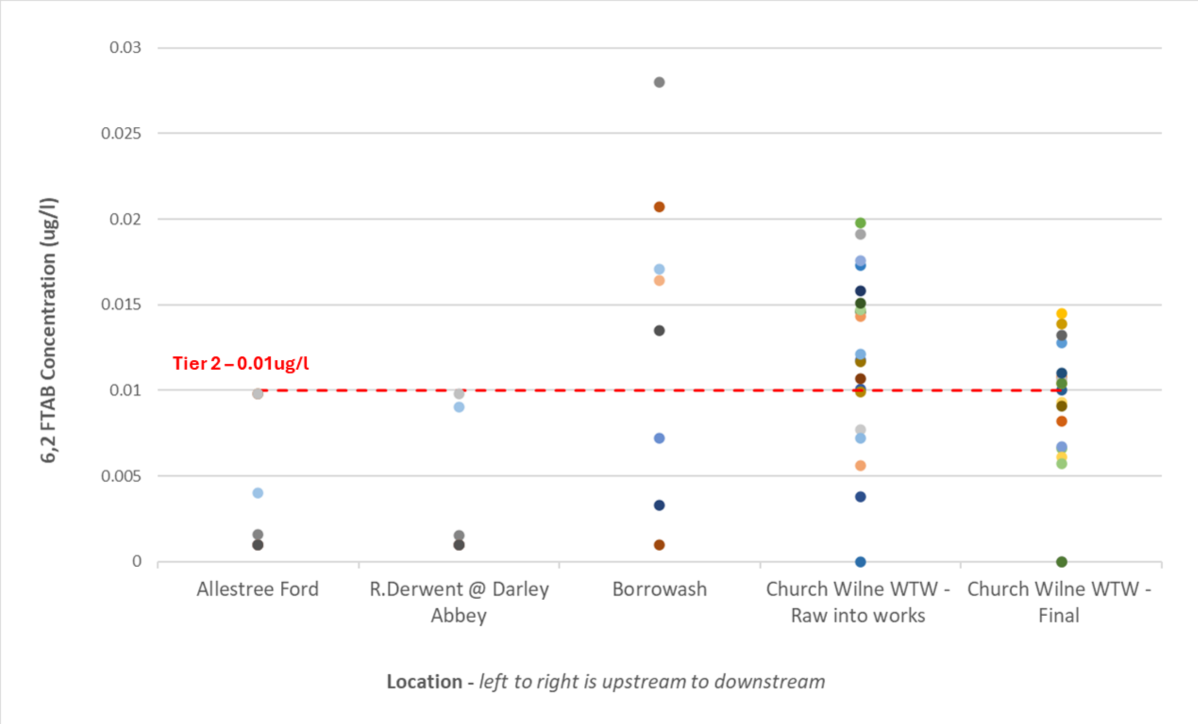
As part of the process in identifying the appropriate catchment solutions, we have commissioned AECOM to undertake the following activities at catchments of the Trent and Rothley Brook (PR24 submission), of Whitacre WTW, and potentially the Derwent catchment if sampling data shows it to be worthwhile, including;

- **Data forensics** to gain a better understanding of the origin of detected PFAS. AECOM will employ chemometric data fingerprinting utilising the observed distribution of the PFAS substances. The representative chemical patterns (i.e. fingerprints) can be compared against literature-established source patterns, enabling mapping of existing PFAS samples to different types of sources across the catchment.
- **Desk-based reviews** of water quality data, UKWIR CIP (Chemical Investigation Programme), NRFA surface water flow monitoring data, and Environment Agency/Defra groundwater level data and rainfall data to investigate the relationships between water quality and hydrology, particularly around PFAS fate and transport with the aim of developing an understanding of high-risk sub catchments.
- **Mass balance and source apportionment modelling** by combining flow and concentration data to help identify the potentially most significant sources. A simple Excel-based model will be built to quantify and simulate PFAS transport in each catchment, linking likely sources to measured concentrations and ultimately to abstraction points.

Church Wilne

Catchment sampling upstream of Church Wilne WTW began in August 2022, focusing on three locations with safe access. Of the 48 PFAS tested for, 6:2 FTAB has consistently returned the highest results. This is in line with results from Church Wilne WTW, where 6:2 FTAB levels have been frequently at Tier 2 concentrations. In February 2024, Perfluorobutanesulfonic acid (PFBS) was also detected and shows an increasing trend. As such, this catchment has now been identified as ‘red risk’ in DWSP, noting 980 potential point PFAS risks in the Church Wilne catchment. Figure 10 below shows 6:2 FTAB results from the three catchment locations relative to Church Wilne raw and final results. Levels of 6:2 FTAB increase with closer proximity to Church Wilne WTW, with a notable increase downstream of Derby city centre, with Borrowash catchment sample location and Church Wilne results at Tier 2 concentrations.

Figure 10: 6:2 FTAB concentration in the Church Wilne catchment (upstream to downstream.[18]



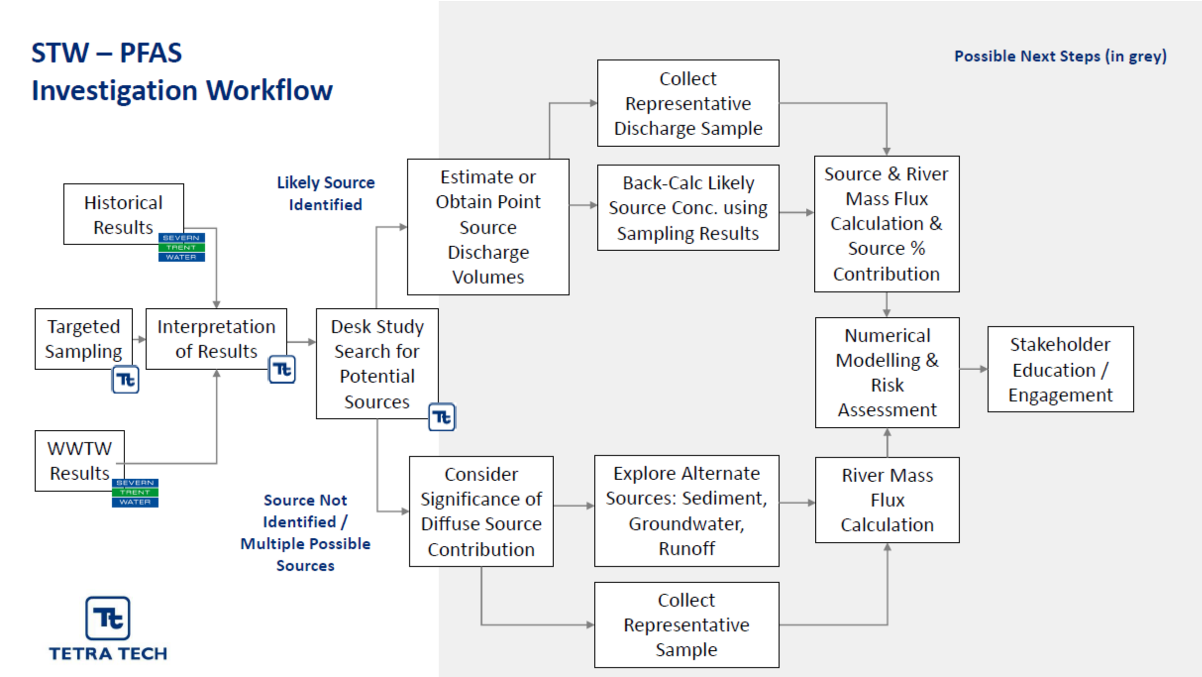
Sub-catchment sampling, similar to that being done for Whitacre is being scaled up, with assessment currently being done to assess the capacity and capability of our laboratories and River Ranger team to undertake this in-house. PFAS data from Church Wilne WTW is being compared to that of upstream WTW on the River Derwent to determine how far upgradient our sampling should extend.

Obtaining more detailed catchment PFAS data will provide greater insight into hotspot sub-catchments and possible sources in the catchment. However, more detailed catchment assessment will be required to provide robust evidence of individual sources and to facilitate engagement with associated stakeholders. It is likely that the Church Wilne catchment would also benefit from those activities being undertaken for Whitacre.

Working with consultants, we have been provided with the following schematic to suggest one way that our investigations could develop and how we can make best use of iterative sampling – ultimately allowing us to identify catchment solutions. Figure 11 below highlights the complexity and depth which investigations could require to build a strong evidence base to approach stakeholders and source users. Due to the currently unknown nature of significant PFAS sources and stakeholders involved, it is not yet possible to say what kind of interventions would be required to manage these risks.

[18] Each data series represents a different sampling date.

Figure 11: PFAS catchment investigations workflow



Catchment options

We are putting forward an option for detailed catchment assessments at each of these two sites, which counts as two of our 20 options considered. These are likely to involve:

- A more detailed programme of catchment sampling and data interpretation, e.g. reviewing ratios of PFAS compounds to help identify potential sources.
- Better site-specific identification of PFAS risks.
- Stakeholder engagement to both help identify risks and create options that target risk reduction that are suitable in scale given the risk and surrounding circumstances.
- Engagement, alongside other stakeholders, with landowners and businesses on a local level to raise awareness of PFAS (see Table 7 below for details of stakeholder groups).

These activities are set out in more detail in Table 6 below along with a cost estimate breakdown that we are including as part of this business case. We propose a two-year investigation, which involves a greater level of stakeholder engagement compared to our standard catchment investigations to date.

Table 6: One catchment management option x 2 sites: cost estimate breakdown of proposed PFAS catchment investigations for Whitacre and Church Wilne (£000)

Activity	Description	Church Wilne (Derwent)	Whitacre (Bourne and Blythe)
Desk-based investigation	• Desk-based catchment investigation reviewing PFAS sources and transport in catchment. • Catchment mass balance / modelling with analysis of weather, surface and groundwater flows.	440	440

	• Forensic analysis of sampling data to identify likely sources of PFAS. • Development of conceptual understanding of catchment and compilation of robust evidence base to share with stakeholders.		
Investigative sampling (two-year)	• Initial 8 weeks intensive sampling across catchment to identify higher contributing sub-catchments. • Focussed sampling in sub-catchments with highest PFAS concentrations. Sampling aims to monitor levels up and downstream of specific sources to help identify highest contributing PFAs sources and levels of PFAs contributed from these sources. • Sampling of WWTW and trade effluents and other point sources to offer more insight into sources feeding directly into river system. • Monitoring of diffuse sources such as groundwater sediment and runoff.	779	779
Stakeholder engagement	• Extensive plan for stakeholder engagement of industry, regulators and other users / source producers as detailed in Table 8 below. This encompasses a broader level of stakeholder engagement to that of our standard catchment investigations which have been more rural / agriculture focussed. • Engagement to both help identify risks (through acquisition of more detailed and site-specific data – see Table 8 below) and to develop options that target risk reduction that are suitable in scale given the risk and surrounding circumstances. • Engagement, alongside other stakeholders, with landowners and businesses on a local level to raise awareness of PFAS.	100	100
	Total	**1,319**	**1,319**

Table 7: List of our key stakeholders for PFAS as part of proposed activities

Stakeholder	Key topics for engagement
Environment Agency and Natural Resources Wales	River flow and dilution More detailed information about pollution events
Wastewater Teams	Volume of discharges Storm overflow spill frequency
Trade Effluent	Further detail about specific companies and their discharge consents
Fire Services	Location of training centres
Airports, Airfields, Airstrips (including military)	Run-off locations Information about waste disposal
Landfill Operators	Discharge conditions Discharge quality

	Type of landfill
Local Authorities	Confirmation of information held Discussion regarding possible effects on private supply boreholes Exchange of risk assessments and data Regular collaboration Landfill site location and type
UK Health Security Agency (UKHSA)	Consideration of any health-based restrictions

2.2.2 Project teams and site visits

Having clearly established the need for interventions with our planning and operational teams, we started early feasibility and high-level design on solution options with our innovation, process design, engineering, and commercial teams and our supply chain. Our process closely follows our capital design and delivery process for feasibility and high-level design.

Site visits and engagement with teams across the asset management cycle and outside our organisation have been carried out to identify these solutions, along with key stakeholders and regulators (see Table 8 below).

Table 8: Activities and engagement undertaken during options assessment stage

Need	Site visits and activity	Teams involved	Engagement with stakeholders and regulators
PFAS Tier 2- Church Wilne	We currently have a pilot plant and live project delivery team on site for our Green Recovery scheme at Witches Oak. The same team has been working on PFAS solution options for AMP8.	Severn Trent: Catchment team, Customer Operations (site team) – water/wastewater/biosolids/trade effluent, Engineering Design and Delivery, Treatment Process Engineering design team, Innovation team. External supplier: Veolia.	EA local teams – water and wastewater, fire service, East Midlands Airport, landfill operators, local authorities, UKHSA.
PFAS Tier 2 Whitacre	Engineering design team already mobilised on site as part of DWI supported AMP8 Algae project (transitional spend). WRc sampling & column testing.	Severn Trent: As above, plus the Whitacre algae project team. External supplier: AECOM, Tetra Tech.	As above – planning approach with Birmingham airport.

2.2.3 Treatment process options

As per our SVE13 Raw Water Deterioration business case, our in-house treatment process engineering team undertook Process Options Reports for this case - our standard approach for all our live capital projects. We have self-funded these knowing that several options would not proceed but needed high calibre work for this business case.

These technical reports considered feasible options and outlined advantages, disadvantages, risks, and certainty of outcome. These are summarised in Table 9 below, and highlight which ones we screened out, and those we put forward for preliminary design, costing and benefits assessment using our standard tools (see Section 5 for our approach to costs).

Table 9: 18 options - summary of our treatment Process Options Reports for PFAS

9 options x 2 sites (18 options)	Overview of option – benefits and disbenefits	Certainty of outcome	Viability	Put forward for CBA?
Option A: GAC - Replace media in existing single stage GAC beds with PFAS-selective GAC media.	**Treatment:** This option would make use of the existing single stage GAC vessels/beds at Whitacre and Church Wilne (used for pesticides) by replacing the media with a PFAS-selective higher adsorbency carbon. However, we have limited trial results for this option: the PFAS breakthrough time, which indicates when GAC needs to be regenerated or replaced, is not known. It could be as low as four to five months[19] per filter or a maximum of 10-12 months compared to our current programme which is once every 60 months. This higher frequency would pose significant physical and logistical challenges. Therefore, this option is very dependent on specific breakthrough patterns in the water/type of PFAS being treated and, with the current lack of data, carries significantly higher risk than providing a second stage of carbon adsorption for compliance and customer protection (Options C and D below). In addition to this risk, even with our increased laboratory PFAS capacity/capability planned for AMP8, it would take two weeks before sampling can show whether PFAS breakthrough has occurred. This means two weeks of compliance risk per filter which would have to be managed by a blind and overly conservative and expensive approach to GAC regeneration/replacement frequency i.e. higher than necessary. The expected higher regeneration/replacement frequencies for this option potentially means not a having enough beds/vessels left in service to maintain WTW supply. GAC filter re-commissioning after regeneration/replacement currently ranges from 15 days at Whitacre to 43 days at Church Wilne. **Waste disposal and destruction**: The global water industry and academia does not know enough yet about the effectiveness of PFAS destruction during the regeneration process that exists for used GAC i.e. whether PFAS compounds are fully destroyed and not returned to the environment. So at this stage, this option	Med (based on literature)	Low	No

[19] Short chain PFAS have been found to have breakthrough after as low as 5,000 bed volumes in GAC with an iodine number of 1260 mg/g (high adsorbency), with a range of 5,000-19,000 Bed volumes. See Riegel et. Al, page 7 Fig 5, page 10 table 8. Sorptive removal of short-chain perfluoroalkyl substances (PFAS) during drinking water treatment using activated carbon and anion exchanger | Environmental Sciences Europe | Full Text (springeropen.com)

9 options x 2 sites (18 options)	Overview of option – benefits and disbenefits	Certainty of outcome	Viability	Put forward for CBA?
	can only consider replacement of used GAC with new virgin GAC media each time.			
Option B: GAC - Replace media in existing single stage GAC beds with PFAS selective media and provide additional filters to enable more frequent replacement of carbon.	**Treatment:** This is the same as Option A, but provides additional filter capacity so that more filters can be offline for the required increase rate of regeneration/re-commissioning, without WTW output being impacted. We estimate that around 50% additional capacity is required at each site given that carbon replacement would be required on 1-2 filters per month at Church Wilne and 2-4 vessels per month at Whitacre. The required replacement frequencies will be confirmed by our planned bench-top and pilot trials outlined in Appendix C. **Waste disposal and destruction**: As per Option A, replacement of used GAC with new virgin media each time, not regenerated media.	Med (based on literature)	High	Yes
Option C: Install second stage GAC filters - with new PFAS-selective media.	**Treatment:** A two-stage GAC filtration process, using higher adsorbency carbon (PFAS-selective), is being trialled at Witches Oak WTW pilot plant and showing promising results with respect to time before breakthrough of PFAS on the second stage of GAC. Bench-top and pilot trials with partially treated water (pre- and post-GAC) from Church Wilne and Whitacre WTW would be required to determine PFAS breakthrough curves and indicative reactivation or replacement frequency of GAC media. **Waste disposal and destruction**: As per Option A, replacement of used GAC with new virgin media each time, not regenerated media.	High	High	Yes
Option D: Install second stage GAC filters - with PFAS selective media - and lead-lag configuration.	**Treatment:** As per Option C, but designed for a 'lead-lag' configuration – as being tested by our pilot plant trials. This means having the facility to switch first-stage GAC filters, after they experience PFAS breakthrough, to become second-stage filters for "polishing", and vice versa, to maximise PFAS removal and optimise replacement/ regeneration frequencies. However, retro-fitting this lead-lag arrangement into the existing single stage GAC at Church Wilne and Whitacre has prohibitive hydraulic, spatial and control challenges – not pursued for CBA. **Waste disposal and destruction**: As per Option A, replacement of used GAC with new virgin media each time, not regenerated media.	High	Low	No
Option E: PAC dosing	**Treatment:** It is likely that a high PAC dose will be required for efficient PFAS removal (>20 mg/l). There is no viable dosing location at Whitacre as the works has	High	Low	No

9 options x 2 sites (18 options)	Overview of option – benefits and disbenefits	Certainty of outcome	Viability	Put forward for CBA?
	intakes from two rivers with neither having a suitable arrangement to achieve the required contact time with the activated carbon. If PAC is dosed at the Church Wilne raw water river intake, it would have enough contact time in the raw water main before reaching the site of the reservoir and treatment works. **Waste disposal and destruction:** At Church Wilne, PAC would need to be settled prior to coagulation, and cannot be allowed to settle in the reservoir as PFAS could desorb from it and then accumulate in the reservoir. A separation stage would be required upstream of the reservoir to prevent this. Any PFAS-laden waste would need to be segregated from other process waste streams on the WTWs. Due to these challenges with waste segregation and ensuring low turbidity for the downstream process at Church Wilne, PAC dosing is not deemed a viable solution for Church Wilne.			
Option F: Install an Actiflo®Carb process	**Treatment:** This technology utilises PAC to remove PFAS, but unlike Option E is able to segregate the PAC waste stream. Actiflo®Carb is equipped with a contact tank that utilizes PAC for the adsorption of floc-resistant organic matter, taste and odour compounds, pesticides and emerging micro-pollutants including PFAS. The operating characteristics of Actiflo®Carb are identical to Actiflo® which we have installed at our Frankley WTWs as part of our Birmingham Resilience scheme. This option was our preferred solution put forward in our PR24 submission for Witches Oak PFAS (Tier 3 site). Unfortunately, early data from our pilot plant trials to date have not shown much promise for this solution – the originally intended dose of 10mg/l of PAC has been increased to 80mg/l to establish if effectiveness will improve. In addition to sand and PAC, the Actiflo®Carb process requires coagulant dosing and a significant amount of flocculation aid (polymer). **Waste disposal and destruction:** The segregated waste stream from the Actiflo®Carb process itself must be segregated from other WTW waste streams on site, i.e. PFAS-laden PAC still needs to be disposed of. As part of our Green Recovery pilot plant trials, we are assessing disposal options which include electrochemical destruction of PFAS in a PAC-slurry (ref trials section). Dewatering of the PAC for incineration or landfill is not considered acceptable as neither option removes PFAS from the environment.	High	Med	Yes
Option G: FLUORO-SORB®	**Treatment:** FLUORO-SORB® is a PFAS-selective sorbent product. It does not currently have Regulation 31 approval from DWI and may not receive it in time for our requirements. The media cannot be regenerated and	High	Low	No

9 options x 2 sites (18 options)	Overview of option – benefits and disbenefits	Certainty of outcome	Viability	Put forward for CBA?
	would need to be disposed of via incineration or landfill (the current disposal method in the USA). Of benefit, the empty bed contact times for the media is low (~2 minutes) and appears to be quite effective in removing the entire spectrum of PFAS compounds. Due to the lack of Regulation 31 approval and challenges with spent media disposal, FLUORO-SORB® is not deemed a viable solution.			
	Waste disposal and destruction: No disposal route for spent media.			
Option H: Ion Exchange	**Treatment:** PFAS-selective ion exchange resins are available but they do not have Regulation 31 approval and most of them are for single use, i.e. cannot be regenerated like our nitrate ion exchange plants. The empty bed contact times for these resins are low (~2 minutes) and they appear to be quite effective in removing shorter-chain PFAS compounds that typically have more rapid breakthrough when using GAC media.	High	Low	No
	Waste disposal and destruction: PFAS-laden resin or regeneration waste will need to be disposed of. The waste disposal route is a concern; it seems that incineration and landfill are the only options. Also, for Church Wilne, the predominant type of PFAS present (6:2 FTAB) is not suitable for ion exchange as it is positively charged. There is no disposal route for spent media and there are foreseen issues with disposing of solvents used for media regeneration e.g. methanol.			
Option I: Nanofiltration (membranes)	**Treatment:** Nanofiltration (NF) and reverse osmosis (RO) are effective in removing PFAS from water. NF is preferred to RO as the energy requirements tend to be lower. PFAS levels at Church Wilne and Whitacre would require 60% of flow to treatment for a NF solution.	High	Med	Yes
	Waste disposal and destruction: The PFAS-laden reject stream (brine) will require further treatment for PFAS destruction, electrochemical destruction being the most likely method. We would expect the cost of treatment and waste disposal to be prohibitive for this solution. At present we do not have a PFAS destruction method that we can reliably put forward to accompany this option However, brine lends itself well for waste destruction process such as plasma or Super Critical Wet Oxidation, unlike other treatment waste streams described above.			

For the options put forward for CBA, we have established cost estimates based on the following, which have been assessed through our CBA tool:

- **GAC filtration** (single stage or two stage) estimates based largely on our cost curves – see section 5 for further details for two stage GAC along with benchmarking comparisons; we have used the same approach for single stage. Additional single stage GAC, however, does not require additional interstage pumping or backwash waste infrastructure as the existing can be used.
- **Actiflo Carb** estimates are based on quotations received as part of our Witches Oak PFAS mitigation scheme and pro-rata the costs based on the respective flows for Church Wilne and Whitacre, based on advice from our expert delivery teams and cost estimators.
- **Nanofiltration** estimates are based on a third party consultant's cost curve for the Nanofiltration plant, with supporting infrastructure (connecting pipe work, interstage pumping, and chemical dosing) based on our 'STUCA' cost curves – described more in section 5.
- **Operational and carbon costs** are based on standard unit rates for power and chemicals, with tonnes of CO2e derived from our carbon calculator for infrastructure assets

These costs and impacts have then been run through our benefits assessment tool (BAT) for CBA and monetisation of carbon to establish a 25 year financial cost benefit. (see further details in our LTDS document: sve06-long-term-delivery-strategy.pdf (stwater.co.uk) where section 4.3.3 has an explanation of the Benefits Assessment Tool (BAT) and how it meets Ofwat requirements for CBA).

Table 10 below shows the outputs from our CBA on the most credible options – currently four options for each site. Actiflo®Carb and Nanofiltation options include no costs for waste disposal and destruction (these would make them less cost beneficial), and we know from pilot plant trials that Option B is not going to be effective enough for sustained PFAS removal given how quickly PFAS is shown to break through a single stage of GAC filters.

The option in which we have most confidence, based on trials undertaken to date, is C: installing a second stage of GAC treatment and using PFAS-selective GAC media.

Destruction of PFAS as part of the GAC options would be carried out through the GAC regeneration process. GAC media suppliers are claiming their reactivation processes completely destroy PFAS that has adsorbed in the media. However, we are still in the process of verifying this, as well as trialling their reactivated media to confirm its suitability and performance. We have therefore assumed in our whole life cost assessment, that virgin GAC is required upon each media replacement. The actual costs of media replacement may therefore be lower than those assumed. This does not affect the AMP8 TOTEX as the initial media fills will be virgin media anyway but could be an opportunity for AMP9.

Table 10: Summary of outputs from Cost-Benefit Analysis for shortlisted options considered

Site	8 x solution options	AMP8 TOTEX (£m)	Financial cost and risks – 25yr Ofwat compliant (£m)[20]	Total carbon costs (£m)
Whitacre	**Option C: Install second stage GAC with PFAS selective media[21] PREFERRED**	**31**	**52**	**30**
	Option B: Additional single stage GAC with PFAS-selective media[22]	25	56.3	33
	Option F: Actiflo®Carb (PAC)[22]	24	56.2 +waste disposal costs	58
	Option I: Nanofiltration[23]	45	55.5 +waste disposal costs	11
Church Wilne	**Option C: Install second stage GAC with PFAS selective media[21] PREFERRED**	**53**	**91**	**50**
	Option B: Additional single stage GAC with PFAS-selective media[22]	36	94	55
	Option F: Actiflo®Carb (PAC) [23]	48	157 +waste disposal costs	196
	Option I: Nanofiltration[23]	75	108 +waste disposal costs	32

2.3 Step 3: Expert review and solution selection

2.3.1 Inviting challenge, review and assurance

Regulatory challenge and collaboration

In June 2023, we submitted our PFAS Strategy to the DWI. In this document, we recognised that PFAS is a serious, complex and emerging challenge for us and the industry, and committed Severn Trent to working with regulators to find out more about this problem so we can best protect our customers.

We set out our approach which consists of the following key components:

- Analytical Capability – sufficient for current and future watchlist parameters.

[20] Our TOTEX assessment assumes replacement of GAC media with virgin GAC each time (i.e. not regenerated media). Our pilot plant trials will establish the actual required GAC replacement frequencies. Further trials are also assessing whether reactivation of media is suitable for these applications GAC.
[21] This media has greater pore sizes to adsorb more contaminants. We have not shown costs for replacing existing 'non-PFAS' media more frequently, as early indications show that PFAS breaks through this media too rapidly.
[22] Options F and I do not include the costs for waste disposal and destruction, as the solutions for these are unknown, and dependent on trials and innovation described in Section 2.1.4.

- Monitoring – risk-based and going beyond minimum regulatory requirements.
- Risk Characterisation – benchmarking sites against international or potential new standards.
- Catchment Management - risk assessments and investigations to determine potential control measures in high-risk areas, collaborating with stakeholders and regulators.
- Research, Development and Innovation – into monitoring, treatment and waste streams.
- Operational Measures – optimising our existing assets in readiness.
- Identifying Investment Needs & Solutions – Our PR24 proposals and the Long Term.

The document provided more explanation behind these key components and we hope that it satisfied the requirements of regulators and ultimately provided reassurance for our customers. The strategies submitted to DWI resulted in the Section 19 Undertaking that lists our Tier 2 sites as requiring mitigating action.

We have considered a wide range of solution options. These consider whole-life costs and risks and benefits, and align with our longer-term system plans for meeting future water demand[23] and the customer-supported need to be more resilient at times when our system is under the most pressure[24].

2.3.2 Managing uncertainty and stress testing future scenarios

In Section 1.5.2, we described the scenarios that we are considering for the future of PFAS, and our proposed Gated scheme as well as uncertainty mechanism/Notified Item. This is a fast-moving area of concern, and the evolution of our programme may be driven by public interest and stakeholder pressure as much as by regulation. Because of this, our AMP8 proposal includes provision for a Gated scheme which incorporates a company-wide PFAS risk reduction programme, set out in Table 11 below.

This includes interim risk mitigation and feasibility studies for permanent treatment at up to 23 of our higher risk sites. Subsequent permanent treatment solutions would be based on a contingent allowance under the Large scheme gated process.

The options selection for this company wide PFAS risk reduction programme, and its inclusion as a development funding for a Large gated scheme, is based on the rationale set out in section 2.2 above, applied as follows:

- **Additional catchment sampling** at our 23 higher risk sites: Required to understand the types and potential sources of PFAS at these sites to inform options selection and potential catchment management activities.
- **Increased GAC replacement** at sites that have GAC (one year allowance): As per option A in Table 9, for the 11 higher risk sites that already have GAC filters, this is not likely to be a permanent solution to mitigate PFAS, but instead is proposed as a risk-reduction for customers that we can readily deploy without infrastructure upgrades, using a GAC media that has higher adsorbency of PFAS compounds. The longevity of this media is highly

[23] Refer to our SVE 08 (Meeting our Future Water Needs) PR24 business case.
[24] Refer to our SVE 01 (Resilient Water Networks') PR24 business case.

dependent on the characteristics of the water source and the PFAS present, but reduction of levels of PFAS will be achieved as interim mitigation.

- **Feasibility and design of new schemes**: For these higher risk sites we will progress feasibility and design of treatment/mitigation solutions. This is based on 2% of the projected CAPEX for solutions at 17 sites that we know are about to become Tier 2 due to new DWI guidance, and we will factor in the options presented in section 2.2 and build on the learning and insights from the schemes and trials we already have underway.

Table 11: Company-wide PFAS risk reduction programme – development funding

Activity	Capex estimates (£m)
Additional catchment sampling and investigations - 8 surface water catchments and 9 ground water catchments	6
Increased GAC replacement at sites that have GAC (for one year)	15
Feasibility & design for new schemes	9
Land acquisition and Planning for sites which require additional GAC filters or other new treatment plant	2
Total	**32**

2.3.3 Option selection

Our three-step process for identifying, assessing and selecting options results in four options out of our original 36 considered:

- The opportunity for a catchment approach at our two Tier 2 sites – two options.
- The need for extra GAC treatment processes at our two Tier 2 sites (along with some uncertainty around its effectiveness and sustainability) – two options.

There is also a need for a company-wide PFAS risk reduction programme going beyond current statutory requirements for sampling and activity, in anticipation of the evolution of this topic.

Given this, our final selected programme of work is estimated at £123m (pre efficiency), broken down in Table 12 below.

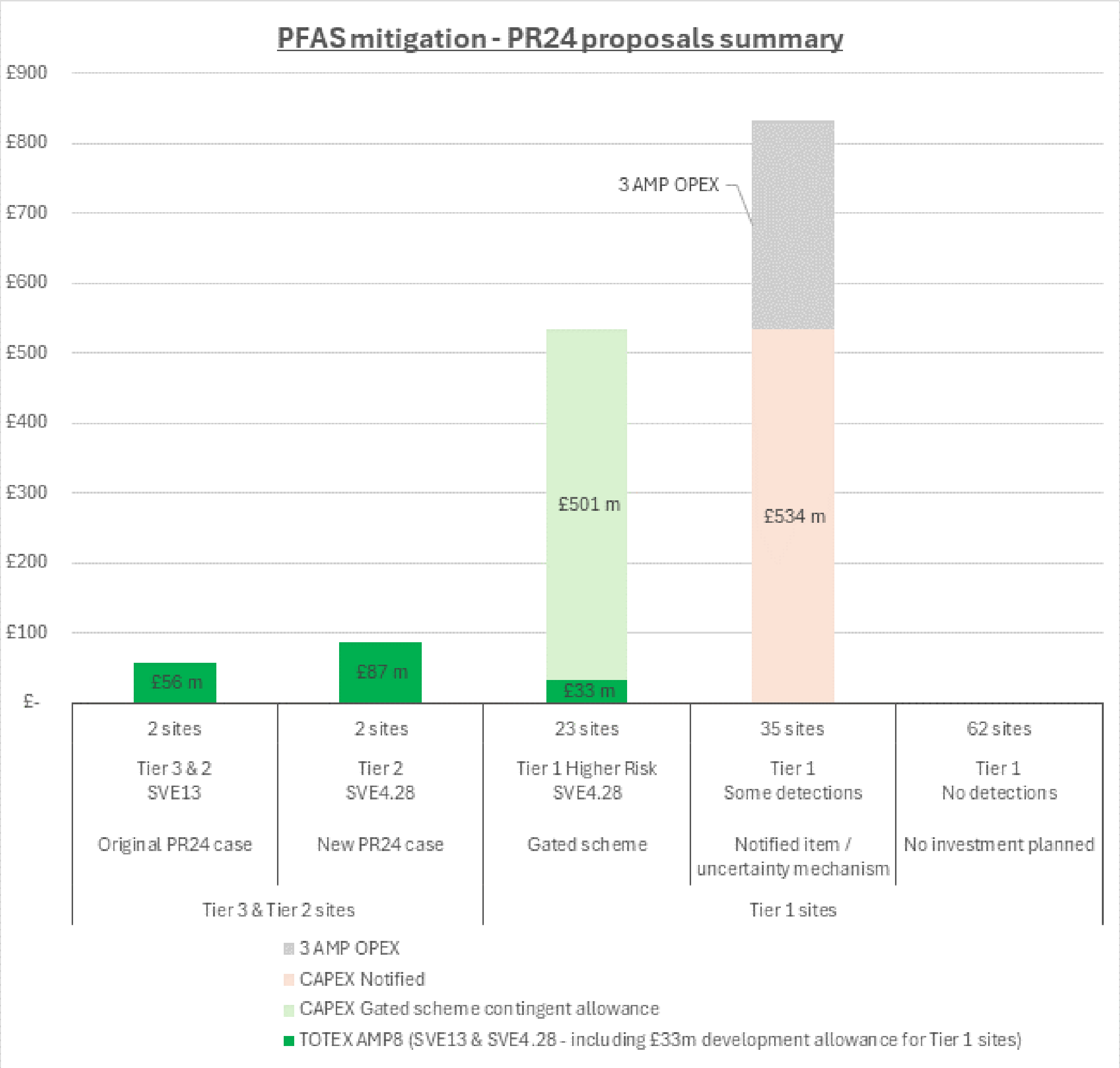
Table 12: Our selected options - summary of additional AMP8 PFAS proposals - TOTEX estimates

	AMP8 PFAS proposal	TOTEX estimate (£m)
Whitacre	Catchment investigations and feasibility – Rivers Blythe and Bourne	1
	New treatment process – second-stage GAC with PFAS-selective media	32
	Catchment investigations and feasibility – River Derwent	2

Church Wilne	New treatment process – second-stage GAC with PFAS-selective media	55
Company-wide PFAS risk reduction programme – development funding (see Table 11)		33
	Total	**123**

To clarify how this and other components of our PFAS mitigation in AMP8 piece together, the following graph summarises the different risk levels at our sites and how we are addressing these in our plans.

Figure 12: Graphic representation of the cost of addressing each level of risk in AMP8



3. A ‘no- and/or low-regrets’ strategy for the long term

In our business case SVE 13 Raw Water Deterioration, we provided the specific evidence to show how we applied the adaptive planning principles described in our Long-Term Delivery Strategy (LTDS)[25] to the investment case, and how it met the definition of ‘no-regrets’ investment choices against a wide range of plausible futures.

The additional PFAS investment proposed here is statutory driven and required by 2030, and therefore meets the definition of ‘no regrets’. Likewise, our analysis shows the investment is not sensitive to the Ofwat common reference scenarios, which means our proposed investments remain the best value across all eight.

3.1 Alternative adaptive pathways

For our three alternative pathways, which are explained in LTDS Annex 2, Table 13 below shows our assumptions for this investment related to raw water deterioration or change in standards.

Table 13: Alternative adaptive pathways considered

Alternative adaptive pathway	*By 2030*	*By 2035*	*By 2040*	*By 2045*	*By 2050*
Adverse climate triggered change	No change	Legislation change for emerging contaminants	Better WTW construction materials		
Societal shifts	No change				Better WTW construction materials
Government-led legislative future	No change	Legislation change for emerging contaminants		Better WTW construction materials	

For ‘Legislation change for emerging contaminants’, we assumed treatment would be needed at around 30 sites that could face non-compliance with potential new legislation for emerging contaminants. As a proxy, this is based on the 30 sites we have currently identified that would not be compliant with existing USEPA and Danish PFAS standards, which are much stricter than current DWI PFAS guidance for England and Wales (see Section 1.3.3). Based on carbon adsorption technology, a high-level estimate put this at c.£530m, which would need to be phased across AMP9 and AMP10 to reflect supply chain deliverability and time for implementation of any legislation. This gave a sense of the cost and deliverability challenge we may be facing with emerging contaminants such as PFAS.

Since our LTDS, public concern around the world has rocketed and legislation has already changed i.e. in the form of the PFAS Section 19 Undertaking. We can now see that since our LTDS, there is a real chance of significant changes before 2030 rather than 2035.

[25] https://www.stwater.co.uk/content/dam/stw/about_us/pr24/sve06-long-term-delivery-strategy.pdf.

3.2 Mitigating risk from other emerging contaminants

In our SVE13 Raw Water Deterioration business case, we highlighted other emerging contaminants that could lead to new statutory requirements. Our proposed solution for second-stage GAC at Church Wilne and Whitacre is likely to reduce the risk for all those parameters listed, to some extent, depending on trials and design. See Table 14 below for details.

Table 14: Summary of other emerging contaminants that are likely to become new standards in the future, as adapted from Table 2 of our SVE13 Raw Water Deterioration business case

Substance	Explanation
Other emerging contaminants	Since leaving the EU, the EU Drinking Water Directive (DWD) no longer drives the UK water quality regulations. The 2021 revision of the DWD has left UK regulations behind in some areas. In response to this, the DWI is establishing a standards board in 2023 to help inform future changes to UK regulations, and this is likely to lead to the inclusion of new standards for emerging risk parameters such as: • PFAS – currently has guidance in place; • Haloacetic acids (HAAs) – toxic disinfection by products, five of these have an EU DWD PCV of 60µg/l; • Endocrine disruptors – Bisphenol A has a DWD PCV of 2.5µg/l; • Pharmaceuticals and personal care products; and • Persistent mobile toxic substances (PMTs). The first three are likely but the latter two will be further in the future as they are not as well understood and are on the DWD watchlist until further research is undertaken.

4. Summary of AMP8 investment

Table 15 presents our preferred solutions, costs and benefits for the schemes needed for our DWI Section 19 Undertaking (SVT-2023-00014), to address PFAS. We have presented this alongside our original PR24 submission so the potential AMP8 PFAS programme can be seen in its entirety.

Table 15: Summary of outputs from CBA for selected solutions (totex stated post efficiency)

Raw water driver	Preferred solution & DWI scheme/notice Reference	Benefit: Water resource protected * (Ml/d)	Benefit: CRI impact avoided	Whole-life carbon emissions (ktCO2e)	AMP8 opex (£m)	AMP8 capex (£m)	AMP8 totex (£m)
	Original PR24 submission in SVE 13 Raw Water Deterioration						
	SVT-2023-00002 – Cropston – treatment and removal verification.	[✂]	-0.175	Not known at time	1.030	17.9	**18.9**
	SVT-2023-00007 – Witches Oak WTW (River Trent) – catchment management, treatment and removal verification.	[✂]	-0.977	Not known at time	3.650	31.3	**34.9**
	SVT-2023-00007 – Laboratory capability and future monitoring.		N/A	Not known at time	0.000	2.4	**2.4**
				Total	4.68	51.6	**56.2**
	New additional PR24 submission – this enhancement business case						
	Section 19 Undertaking (SVT-2023-00014) – Tier 2 site – Whitacre WTW						
PFAS and future emerging contaminants	- Second-stage GAC treatment, built by end of AMP8 (OPEX to provide PFAS-selective media in existing vessels as interim solution). - Catchment management investigations and feasibility.	[✂]	-0.342	125.6	1.7	30.9	**32.6**
	Section 19 Undertaking (SVT-2023-00014) – Tier 2 site – Church Wilne WTW						
	- Second-stage GAC treatment, built by end of AMP8 (OPEX to provide PFAS-selective media in existing vessels as interim solution). - Catchment management investigations and feasibility.	[✂]	-0.977	214.0	3.3	51.3	**54.6**
	Company-wide PFAS risk reduction programme – development funding						
	Sampling, catchment investigation, GAC replacement, feasibility & design, planning permission.			TBC		32.0	**32.0**
				Total	5.0	114.2	**119.2**

***Average licence or WRMP24 capacity.**

5. Robust and efficient costs

We have reflected on the feedback given in the PR24 draft determination regarding cost robustness and efficiency, which resulted in Ofwat's view of costs being set 40% lower than our plan. Half of this adjustment was due to insufficient evidence on optioneering and cost benefit which we have addressed in section 4 above and the other half of the adjustment was due to lack of evidence of efficiency benchmarking. The feedback states that we **did** provide a description of the costing approach which is based on both top down and bottom up methods and no issues were identified with this approach. We have retained this approach and section 5.1 provides the specific evidence for the build up of costs for this case. To ensure this new case incorporates sufficient and compelling evidence on cost efficiency we have provided three sets of analysis:

- Benchmarking through the use of relevant Ofwat enhancement models;
- Third party benchmarking and assurance; and
- Comparison with other company PR24 submissions and draft determinations.

5.1 Cost robustness

As per our original PR24 submission, SVE 13 Raw Water Deterioration, our estimates are based on a large and relevant bank of data comprising our own completed projects over the last twenty years and projects completed by the sector since 2020/21. These have been used and combined with market testing, where historic data is not available, to challenge ourselves to be the most efficient deliverer of DWI-supported drinking water quality schemes and statutory obligations. This section sets out the key evidence to demonstrate this. Full details of our costing methodology and overall efficiency can be found in Annex 4a 'Costs, efficiency and stretch' of our PR24 submission.

5.1.1 Design basis for cost estimates

Our design, capital delivery and commercial teams are currently mobilised at both Church Wilne and Whitacre WTWs. The following summarises the design and scope on which we have based our costs. Given the current presence of Engineering teams on these sites we have confidence in the proposed new plant locations and integration with the existing sites and assets:

<u>Church Wilne</u>

At Church Wilne, we have established a proposed location for the new plant based on the following:

- **Area required:** Location is based on accommodating a replica of the existing GAC filters. The existing filters were built in phases – original GAC vessels built in AMP1, an extension to the GAC treatment built in AMP3, and a replacement of the AMP1 filters built in AMP6. The total size of the AMP3 and AMP6 filters therefore represents the total size of the second stage GAC treatment that we are proposing for AMP8 PFAS removal.
- **Suitable location:** See Figure 13 below. The existing Church Wilne site is constrained (site circled in blue). Our Witches Oak WTW (circled in green) is being built on land adjacent to Church Wilne and from this we have established the following considerations:
    - Planning permission is more likely to be forthcoming in a location adjacent to the new Witches Oak treatment plant as the only location on the Church Wilne site is not immediately adjacent to existing buildings and therefore more of a standout/unsightly location based on experience with the local authority during the Witches Oak scheme. This

has led to the preferred location (2) in the plan below. Location (3) is further away from Church Wilne on the other side of a railway and would therefore require further pipe lengths.

- The only location available on the Church Wilne site is adjacent to the Reservoir embankment and excavations would risk compromising this.
- There is a large amount of congestion for pipe work routes in the area of land between the Church Wilne site and the new Witches Oak WTW – for this portion of the route of new pipe work we have therefore applied a slightly higher unit cost based on standard costs for pipe laying in a more congested urban setting.

Figure 13: Church Wilne and Witches Oak sites – showing optional locations for new GAC treatment – preferred option (2).
Top: Severn Trent Land ownership is indicated by pink shading, whilst red cross hatch indicates land on which Severn Trent has a tenant. Below: Work underway in construction of the Witches Oak WTW, showing the preferred location of new Church Wilne GAC filters (purple)

The integration of the second stage GAC into the process at Church Wilne WTW will require additional pumping due to the distances involved at any of the proposed locations and associated pressure losses in the pipes. A new pumping station can be accommodated on site at Church Wilne adjacent to the existing GAC, as this will require a much smaller foot-print than the GAC itself. This is included in the proposed scope, which is shown in process flow diagram format below in Figure 14.

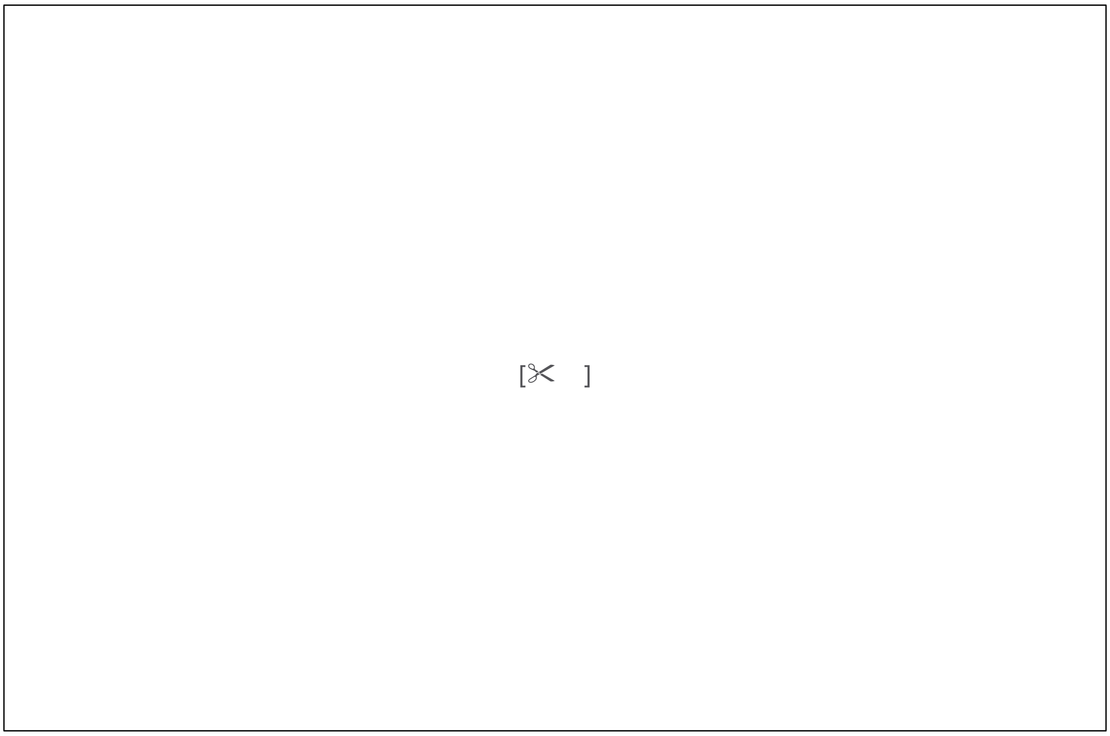
Figure 14: Process flow diagram showing the scope of the new Church Wilne second Stage GAC with associated Interstage (IS) pumping stations, pipe work, buildings and backwash system

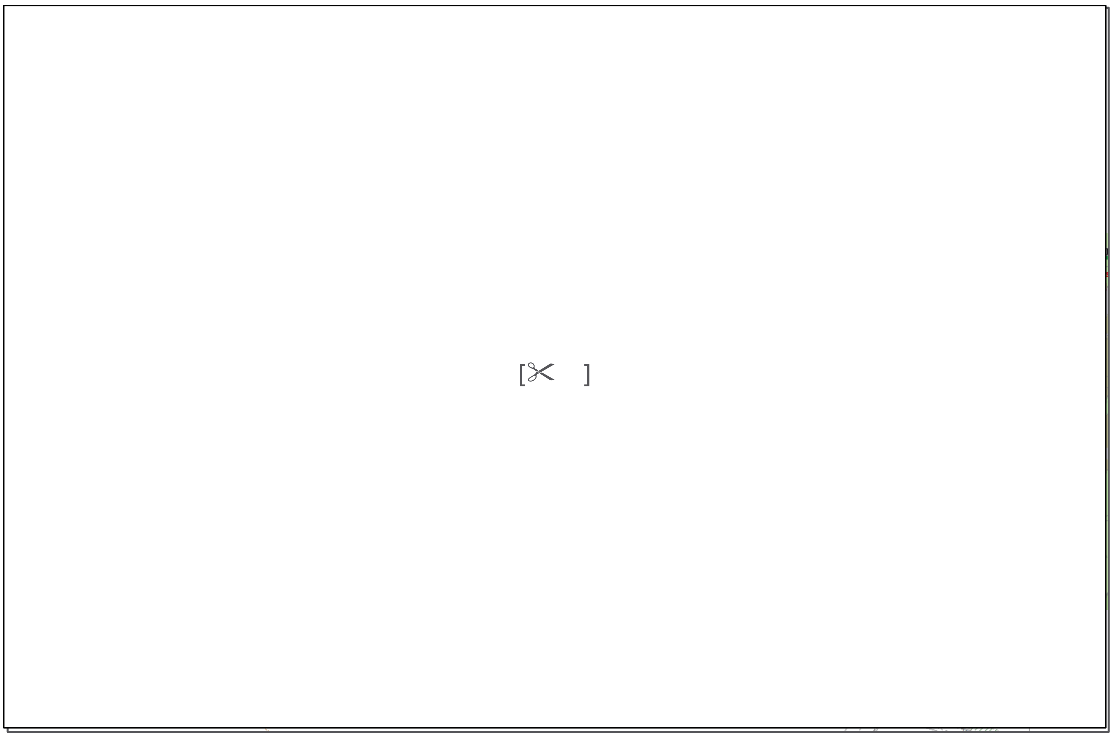
Whitacre

At Whitacre, we have established a proposed location of a new second stage GAC plant based on the following:

- **Area required and suitable location:** Whitacre WTW is constrained within the area of land owned by Severn Trent (see Figure 15, top). Our proposed location is based on accommodating a replica of the existing GAC filters, which cannot be accommodated within the curtilage of the existing site; and we are proposing to purchase land on the other side of the road to Whitacre. This is to be located alongside the new treatment plant proposed as part of our PR24 AMP8 algae removal project for which we have commenced more detailed feasibility and have commenced land referencing needed to purchase the land.

Figure 15: Top: Land ownership of Whitacre WTW – Severn Trent ownership shown in pink, hatched areas are leased to tenants. Bottom: Overlaid with proposed land purchase area to accommodate the second stage GAC for PFAS removal (purple). Pipe route connections are shown (green). Red outlines also show the proposed location of our new DAF plat (for algae removal) on the same plot of new land





The integration of the second stage GAC into the process at Whitacre WTW will require additional pumping to and from the new GAC plant due to the distances involved and associated pressure losses in the pipes. This is included in the proposed scope, which is shown in process flow diagram format in the below Figure 16.

Figure 16: Process flow diagram showing the scope required for the integration of the new Whitacre second Stage GAC with associated Interstage (IS) pumping stations, pipe work, buildings and backwash system

5.1.2 Cost derivation

We have a well-established cost estimating approach from completed DWI statutory and supported programmes over the last 20 years. Our main capital projects/programmes of work have all been costed using the same estimating approach.

Regarding GAC, the option we have put forward in this business case, Table 16 below shows our history with designing, building and operating major installations of GAC for pesticide removal since privatisation; in that time, it has played a substantial part of our DWI statutory water quality programme. As such, we have a dataset of GAC scheme costs for standard items in our STUCA tool (Severn Trent unit cost assessment) based on schemes delivered in AMPs3-6, to develop estimates for this solution. Given the age of some of the data points used in our curves we have also sought benchmarking of these costs (see Standard cost items section below, and section 5.2.2) which show that our costs are in line with industry benchmarks. At Church Wilne specifically, it was our first site to receive GAC filtration vessels in the 1970s, with additional vessels installed in the 1990s to expand capacity. These were respectively replaced in 2002 and 2019 with new GAC beds – the most recent installation has directly informed our thinking on the requirements and cost estimation for the proposed additional GAC beds in this case.

For non-standard items, this experience of GAC scheme delivery as well other major treatment works installations and expansion in recent AMPs provides us with a comprehensive library of costs to draw upon, giving us a very good understanding of the typical level of cost estimating risk we should apply to these sorts of projects.

Table 16: Our track record of GAC installations and major replacements

AMP	Outputs and outcomes
AMP1-3	• 6 GAC bed installations at 5 WTW sites (Melbourne, Mitcheldean, Strensham, Mythe, Trimpley) and 1 GW site (Green Lane). • 8 GAC vessel installations at 8 WTW sites (Shelton, Whitacre, Church Wilne, Draycote, Little Eaton, Ogston, Cropston, Campion Hills). • 1 GAC significant replacement scheme at Church Wilne.
AMP4	• 1 DWI lead and pesticides solution; GAC vessel installation at Sunnyside. • 1 GAC vessel installation at Frankley.
AMP5	• 1 DWI pesticides solution; GAC bed installation at Clipstone.
AMP6	• GAC beds at Church Wilne to replace half of the original vessels.

Table 17 provides an overview of the cost derivation for this case. 81% of the cost has been built up as standard, using STUCA.

Table 17: Cost derivation for AMP8 PFAS additional DWI supported/statutory schemes

Scheme/programme	STUCA (outturn past projects) – % of value derived	Non-standard bottom-up build – % of value derived	AMP8 CAPEX (£m)
Whitacre second-stage GAC treatment	78	22	29.6
Church Wilne second-stage GAC treatment	84	16	50.0
Total	82	18	79.6

Table 18 provides a cost breakdown and description of the basis for cost derivation.

Table 18: Breakdown of scheme cost components for Whitacre and Church Wilne (post efficiency)

Cost Component	Whitacre	Church Wilne
Standard	£13.6m	£25.0m
Non-standard	£3.9m	£4.7m
On cost	£4.7m	£8.0m
Subtotal	£22.3m	£37.6m
Optimism bias	£5.6m	£9.4m
Burden	£1.7m	£2.9m
Total	**£29.6m**	**£50m**

Standard cost items

The highest proportion of standard cost estimates for these schemes comes from the GAC treatment process itself. The GAC volume required at each site is 1600m^3 for Church Wilne and 623m^3 at Whitacre. Costs are based on a standard cost curve for GAC filtration which has a total of seven data points from previously delivered schemes (see Figure 17 below). This curve has also recently been benchmarked by our cost estimating team against TR61 (WRC) cost curves and a Jacobs bottom up estimate, as part of SRO projects. Our cost curve was found to be between 8-9% lower (more efficient) than the benchmarks.

Figure 17: GAC standard cost curve

Other standard items include:

- Pipe work connections to the new GAC locations (541 data points on our cost curve from previously delivered schemes):

  - Church Wilne's new GAC plant will be located 380m away from the existing GAC plant, on land adjacent to the WTW owned by Severn Trent, due to physical site constraints.
  - Whitacre's new GAC plant will be located on land on the other side of the access road to the WTW, which is being currently purchased as part of our AMP8 DWI statutory scheme for Algae (transitional spend). This is circa 310m away from the existing GAC plant.
- Interstage pumping stations to pump water through the new GACs and return them to the main site contact tank for disinfection, including pump sumps to buffer the flow (62 data points on our cost curves):
  - 537kW and 358kW pump capacity respectively and 2 x 1200m^3 tanks at Church Wilne.
  - 165kW and 165kW pump capacity respectively and 2 x 512m^3 tanks at Whitacre.
- Backwash tanks and pumps for both sites' new GAC plants.

Non-standard cost items

Table 19 below outlines non-standard cost items for this business case.

Table 19: Non-standard items

Item	Description
GAC building	A unit rate for two storey process buildings has been used for the building to house the GAC process units (for Church Wilne as it has filter beds which need to be housed in a building) and interstage pumps (Church Wilne and Whitacre). The rate of £2,500/m^2 has been applied to a size of 50x25m for Church Wilne (the same as the size of the existing GAC plant), and 70x15m for Whitacre (replicating the existing GAC pumphouse building).
Demolition of existing unused process plant at Church Wilne	In order to accommodate a new Interstage pumping station adjacent to the existing GACs at Church Wilne, we have allowed a cost of £320,000 to remove items from an area of 15x20m. This is the only viable location for a new interstage pump building to facilitate flows to the new second stage GAC plant.

GAC media replacement

Regarding the OPEX component of these schemes, we have well-established relationships with suppliers for the provision of activated carbon at our sites. At two of our sites, we are already using the higher-absorbency, PFAS-selective carbon that we are proposing for Whitacre and Church Wilne. We have based our estimates on the cost per volume for this carbon, which our suppliers have confirmed (from 2022-23 for correct PBD) and included the supplier's standard GAC delivery costs.

5.1.3 Assurance and independent challenge

As per our PR24 SVE 13 Raw Water Deterioration business case, we have sought challenge and reviewed the costs throughout the development of these solutions, along with formal assurance. Within the shorter timescale of this case compared to our full PR24 submission, this activity is key to ensure accuracy of assumptions and robustness of cost estimates. The key inputs include:

- STUCA (unit cost database) – since it was built in 2006, process and data assurance has been carried out by PWC (PR09), Atkins (PR14), and our Group Compliance and Assurance team

(PR24). Benchmarking of outputs has been carried out by EC Harris/Arcadis (AMP5 and AMP6), Mott MacDonald (PR19), Aqua Consultants (AMP7), and Jacobs for PR24.

- Arup review of costs and methodology in 2021.
- Turner and Townsend review of approach against published best practice.
- Jacobs, as part of our formal three lines of assurance;
- Internal review and challenge – senior management and director level review of the business case, the Cost Reliability and Maturity (CRAM) process, technical governance through our Water Service Area Board, Water Quality Strategy Group, and input from personnel across our operational and engineering functions to give a broader view.
- Input from the design and delivery teams managing our live PFAS treatment pilot trials at Witches Oak WTW.
- Input from the design and delivery team managing our DWI statutory AMP8 project at Whitacre, for Algae (promoted as part of transitional spend).
- Our internal PFAS Working Group dedicated to understanding the PFAS challenge facing the industry and the associated developments and current thinking in effectiveness of treatment technologies.

Internal challenge and review

As described in Annex 4a 'Costs, efficiency and stretch' of our PR24 submission, as part of our commitment to continuous improvement we commissioned cost consultants, Turner and Townsend, to assess our approach against best practice[26]. We mapped our approach to the eight steps described through the Cabinet Office best practice and found it aligned well in most places. The key improvement we made was to formalise the cost estimating reporting and to track the change in the estimate and corresponding improvement in the estimate maturity as we developed both the costs and the solution over time (using a Cost Reliability and Maturity (CRAM) tool).

Figure 18 below is an output from CRAM showing that our PFAS solutions for Church Wilne and Whitacre have greater cost reliability and maturity than the PFAS solution we submitted for Witches Oak WTW, in our original PR24 submission at the time.

This reflects the following:

- The amount of work that we have been undertaking to develop our understanding of the requirements for PFAS treatment in the current regulatory landscape.
- The additional learning from our Green Recovery pilot plant and trials (see Section xx), and from the project we have already promoted at Whitacre as part of transitional spend.

This level of maturity is well in excess of that typically expected at the strategic planning phase, especially as confirmation of the statutory need for this activity at Tier 2 sites was confirmed in February 2024, five months after our original PR24 submission.

Some of the key changes during our cost estimating process that came about by internal reviews and challenges included:

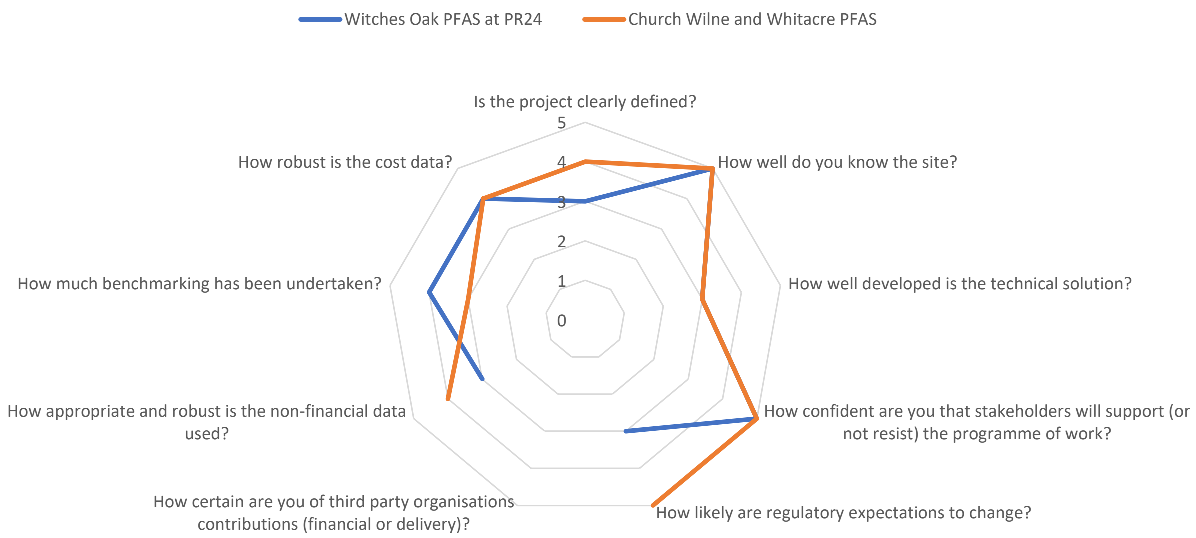
- Scope certainty

[26] Cabinet Office & HM Treasury Cost Estimating Guidance: https://www.gov.uk/government/publications/cost-estimating-guidance.

  - Based on the results we are seeing from our in-house trials, and third-party pilot plants for treatment of PFAS, we have more certainty in the solution being put forward.
  - Process Options Reports (PORs) were finalised by our process engineering design teams following more technical data gathering.
  - More information and dialogue with suppliers of GAC media, as well as more ongoing reviews of literature regarding treatment effectiveness for different types of PFAS.
  - More clarity on the wider regulatory landscape for PFAS and its impact on the environment, confirming that taking PFAS-laden waste to wastewater treatment works or landfill is unviable.

- Cost certainty
  - Reviews were carried out by our expert in-house cost estimating team who have generated non-standard costs for common key ancillary items such as buildings and Motor Control Centres (MCCs) etc based on: i) use of best practice methods; and ii) regular contact with the supply chain about estimates, iii) use of a standardised rates book.
  - Detailed scope item-based bottom-up benchmarking as outlined in Section 5.2.2 below.

Figure 18: Cost Reliability and Maturity (CRAM) assessment – comparing Witches Oak PFAS solution at PR24 submission (Blue Line) with Church Wilne and Whitacre PFAS solutions, Tier 2 business case (Brown Line)[27]



Given the level of maturity of our cost estimates, we have concluded that these projects are at a similar level of scope development to those in our original SVE 13 Raw Water Deterioration business case. We have therefore applied the same level of optimism bias. In our original PR24 submission, we reduced initial optimism bias (which was based on Green Book supplementary guidance[28]) from 66% down to 25%, which we and our third-party consultants considered to be more reflective of both the cost maturity and the level of complexity of these projects.

[27] NB. Third-party contributions are not relevant for this business case.
[28] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/191507/Optimism_bias.pdf.

5.2 Demonstrably efficient costs

To ensure this new case incorporates sufficient and compelling evidence on cost efficiency, addressing the concerns raised in the draft determination for our Witches Oak and Cropston PFAS schemes, we have provided the following sets of analysis:

- Benchmarking through the use of relevant Ofwat enhancement models;
- Third party benchmarking and assurance; and

We did attempt to compare our costs with other company PR24 submissions and draft determinations. The only other companies with PFAS scheme investments were Anglian and Affinity. However, there was not enough detail in their cases to make a like for like comparison with our GAC solutions – from what we could see, it appeared that most solutions assumed single stage GAC or GAC media replacement at existing works. However, an estimation of assumed replacement frequency was not given to make a comparison, and also, through our pilot plant work described in section 2 above, we know that single stage GAC is not effective enough – it needs to be two stage GAC.

5.2.1 Efficient using Ofwat enhancement models

Our business plan included two PFAS schemes: Witches Oak WTW and Cropston WTW, both of which were assessed by Ofwat through deep dives at draft determinations. Ofwat made an adjustment of 40% to our scheme costs following this assessment and said that we had not provided sufficient and convincing evidence that our costs are efficient. Since the submission, two new PFAS schemes have been to our AMP8 RWD scheme portfolio: Whitacre WTW and Church Wilne WTW.

Our business plan also included one algae removal scheme at Whitacre WTW. Algae removal and PFAS are two separate treatment interventions (construction of a Granular activated carbon plant for PFAS, and the construction of a Dissolved Air Flotation (DAF) plan for Algae removal). However, we consider that it is appropriate to consider them together here given that we are benchmarking against a holistic water treatment works upgrade which would require interventions at multiple treatment stages[29].

These schemes are summarised below.

Table 20: Summary of our proposed AMP8 PFAS mitigation schemes

PFAS scheme	Totex	Benefit	Treatment process
Witches Oak WTW	£34.9m	[✂] Ml/d	Granular activated carbon
Cropston WTW	£18.9m	[✂] Ml/d	Granular activated carbon
Whitacre WTW	£31.8m	[✂] Ml/d	Granular activated carbon
Church Wilne WTW	£53.8m	[✂] Ml/d	Granular activated carbon
Total	£139.4m		

Table 21: Summary of our proposed AMP8 algae removal schemes

Algae removal scheme	Totex	Benefit	Treatment process

[29] A typical WTW flow will includes: Pre treatment processing, Clarification, Filtration, Chlorination, and additional processes as required to manage specific raw water risks (e.g. GAC, UV, Ion exchange)

Whitacre WTW	£67.31m	[✂] Ml/d	Dissolved air flotation (DAF)

We then compared the costs of our PFAS and algae removal schemes against the unit cost benchmarks from Ofwat's supply (excluding interconnectors) models. The results are set out in the table below.

Table 22: Results from cost benchmarking our PFAS and algae removal schemes against Ofwat's supply models

PFAS and Algae scheme	Totex	Category for Ofwat's supply scheme model	Applicable unit cost benchmark	Modelled cost	Implied efficiency score
Witches Oak PFAS	£34.9m	Base activity scheme	£5.71m per Ml/d	£371.28m	0.09
Cropston PFAS	£18.9m	Base activity scheme	£5.71m per Ml/d	£148.51m	0.13
Whitacre PFAS + Algae	£99.11m	Base activity scheme	£5.71m per Ml/d	£289.60m	0.34
Church Wilne PFAS	£53.8m	Base activity scheme	£5.71m per Ml/d	£936.76m	0.06
Total	£206.71m			£1,746.14m	

These results suggest that our PFAS and Algae removal schemes are very efficient compared to other treatment work upgrade schemes included within Ofwat's supply enhancement models.

To provide a further layer of assurance, we also compared our single process PFAS scheme costs against the unit cost benchmark for the "other" schemes category that Ofwat used in its supply enhancement model covering minor works (other than treatment works upgrades). This comparison also shows that our scheme costs are relatively efficient.

Table 23: Results from cost benchmarking our PFAS removal schemes against Ofwat's "other" schemes category used in its supply enhancement model

PFAS and Algae scheme	Totex	Category for Ofwat's supply scheme model	Applicable unit cost benchmark	Modelled cost	Implied efficiency score
Witches Oak PFAS	£34.9m	Other	£0.71m per Ml/d	£46.15m	0.76
Cropston PFAS	£18.9m	Other	£0.71m per Ml/d	£18.46m	1.02
Church Wilne PFAS	£53.8m	Other	£0.71m per Ml/d	£116.44m	0.46

5.2.2 Third party benchmarking and assurance

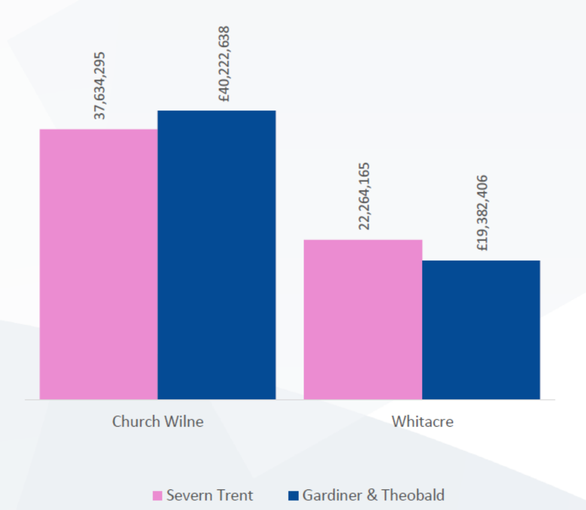
To help us identify any areas of inefficiency and improve the robustness of our cost estimates, we engaged Gardiner & Theobald to test all our proposed scheme costs, down to scope item level. The objective was to assess/benchmark the accuracy and reliability of our cost estimates.

Gardiner & Theobald's assessment included the following:

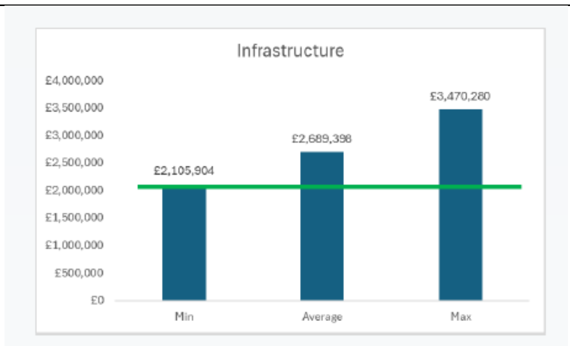
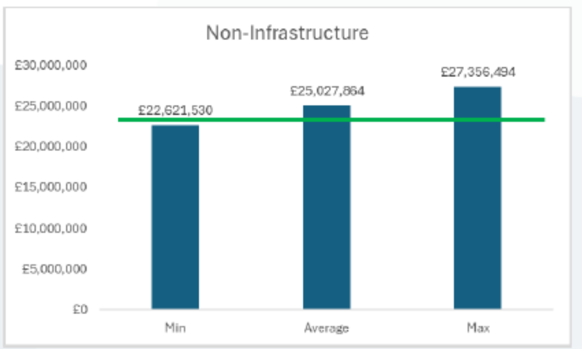
- A review of the priced items - direct and indirect costs within the projects.
- The costs provided did not include corporate overhead or Optimism Bias.

Overall costs were within a tolerance expected with the maturity of the projects assessed. As a total the combined project estimates are **within 0.5% of the benchmarks** developed by G&T as shown in Figure 19 below.

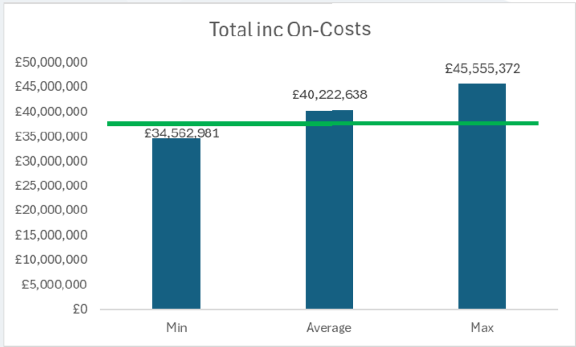
Figure 19: Graphical representation of benchmarked costs between Severn Trent (pink) and G&T (blue)



Church Wilne – detail behind cost benchmarking:

<u>Infrastructure costs:</u> G&T assessed costs which included: • 380m of 1200mm diameter pipe through fields • 380m of 1200mm diameter pipe through urban highway • 380m of 350mm diameter pipe through suburban highway Severn Trent's estimate (green line) was in line with the benchmark developed by G&T at 23% below the average including a contract adjustment to increase pipework rates.	
<u>Non Infrastructure costs:</u> G&T assessed costs which included: • GAC Filters (RGF type) • Pumping Stations • Service Reservoirs Although Severn Trent (green line) sat below the average cost for non-infrastructure they were above the benchmark for pumping stations and below for GAC.	

<u>Overall</u>
The costs of the scheme (green line) sat within the three point benchmark produced by G&T.

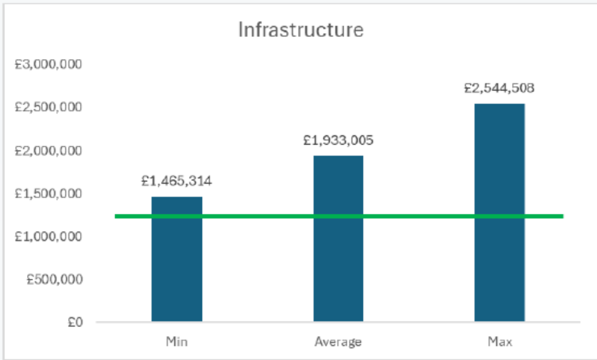


Whitacre – detail behind cost benchmarking:

<u>Infrastructure costs:</u>
G&T assessed costs which included:

- 310m of 900mm diameter pipe through fields
- 310m of 900mm diameter pipe through urban highway
- 310m of 250mm diameter pipe through suburban highway

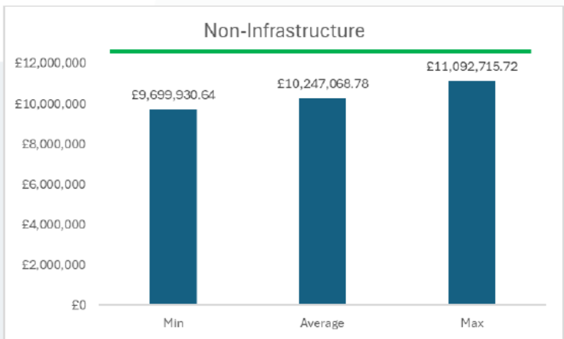
Severn Trent's estimate (green line) was in line with the benchmark developed by G&T at %30 below the average including a contract adjustment to increase pipework rates.



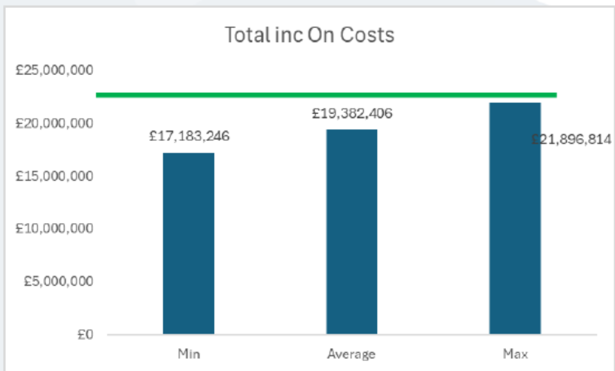
<u>Non Infrastructure costs:</u>
G&T assessed costs which included:

- GAC Filters (RGF type)
- Pumping Stations
- Service Reservoirs

Although Severn Trent (green line) sat above the average cost for non-infrastructure they were above the benchmark for pumping stations and below for GAC.



<u>Overall</u>
The cost of the Whitacre scheme (green line) sat above the three point benchmark produced by G&T. When taken in the context of the Church Wilne estimate being below the benchmark, the combined position is within 0.5% of the benchmarks and assessed as efficient for a project at this stage.



6. Customer protection – being accountable for delivery

In our SVE13 Raw Water Detection business case, we said that we have been careful to protect customers from paying twice, paying without experiencing the intended benefits, and paying for an unfair share compared to future customers.

The bill impact of this investment is an average 70p per year over AMP8, which customers have said they are willing to pay for the peace of mind of dealing with this emerging issue. Our aim is to ensure customers are protected from under or late delivery through deliverables that are easy to measure, track and verify. We took into account existing regulatory reporting mechanisms, and aligned our deliverables with these mechanisms where appropriate.

6.1 Our proposed Price Control Deliverable

We acknowledge that our proposed PCD in our SVE13 Raw Water Deterioration business case will be replaced by a common non-delivery PCD that was set out in the Draft Determination, based on combined number of DWI legal instruments and any accepted acknowledged actions across raw water deterioration. In our DD representation document SVE5.07 PCDW13 Raw Water Deterioration, we propose to include Church Wilne and Whitacre as two additional PCD outputs for PFAS legal instruments, with delivery in 2031-32 to align with the other PCD scheme outputs.

6.2 Impact on our common Performance Commitments

In our SVE 13 Raw Water Deterioration business case, we presented Table 20 below, identifying water quality-related performance commitments and why we consider that there is no overlap and therefore no adjustment required to the PC target as a result. This remains true for the projects related to this business case.

Table 24: Evidence of no overlap with the AMP8 Performance Commitments (PCs)

Performance Commitment	Impact (L/M/H)	Rationale for no PC adjustment
Compliance Risk Index	Low	No adjustment has been made to this PC in relation to this business case. Impact is low as the investment will have no impact on the target. The proposed schemes may reduce risk of CRI failures in future AMPs if PCVs for PFAS are set by law for England and Wales – offsetting future pressure.
Supply Interruptions	Low	Benefit of raw water deterioration schemes is reduced risk of interruptions beyond AMP8.
Unplanned outage	Low	We note that the new Ofwat definition of this asset health PC for AMP8 no longer has an exclusion for the impact of raw water quality. Consequently, the schemes put forward in this case may contribute to maintaining this PC after AMP8 investment.

6.3 Deliverability

We are confident with our PFAS delivery and have engaged with key suppliers to deliver. Our schemes are allocated to incumbent suppliers who have confirmed their capability, resource and availability to deliver. Not only have we developed positive relationships and secured commitments from our tier 1 supply chain, we have recognised the importance of the technology providers and the role that they play in this emerging issue. Their engagement in these programmes is key, and following our engagement to date, confirmation of their ability to deliver has been communicated. This is on the basis of a smooth transition into the AMP, and with the majority of the commitments phased across this period.

We have made an early start by accelerating activity through the transition programme. In October 2023, we announced an acceleration of our AMP8 plans, pulling forward planned AMP8 delivery into 2023-24 to 2024-25, including £30.2m of the DWI-supported programme. This was made possible by our low gearing and excellent financeability, and will mean we will be investing at a run rate beyond the expected run rate throughout AMP8.

Whilst we acknowledge the addition of more schemes into our AMP8 programme is challenging, the good news is that both Whitacre and Church Wilne, the sites related to this business case, already have design and delivery teams mobilised on-site and we are mitigating deliverability risks through efficient use of existing resource and securing supply chain involvement early:

- At Whitacre, as part of AMP8 transitional activity for the AMP8 DWI supported programme for Algae removal we have a design and delivery team set up with Early contractor involvement of MWHT to ensure deliverability, and this team are already incorporating the PFAS challenge into their approach.
- For Church Wilne, our team that have been working on the Church Wilne/Witches Oak Green recover scheme are already on-site working up a delivery plan for PFAS removal for our DWI supported scheme at Witches Oak and are now also incorporating Church Wilne PFAS removal into their plans. Having also delivered a major GAC treatment replacement at Church Wilne in AMP6 we have experience to draw on with respect to most suitable and efficient construction and commissioning methodologies.

Appendix A: Evolving PFAS requirements

Table A: Evolution of regulatory PFAS requirements vs PR24 timeline

Date	PFAS requirements
October 2021	A **DWI Information Letter (05/2021**) was issued to companies to request additional analysis and **monitoring for 47 PFAS**, moving from 20. The intention was that data provided would be used to inform the introduction of science-based PFAS drinking and environmental water quality standards into water quality regulations.
July 2022	A second **DWI Information Letter (03/2022)** required monthly submission of raw and final water samples, and adherence to their new PFAS tier system. This was to implement solutions for **Tier 3 sites**, which we followed during the development of our PR24 submission.
March 2023	We **submitted** to the DWI our **PR24 proposals** for PFAS: PFAS catchment management and treatment scheme for our new Witches Oak WTW (our only Tier 3 site), and specialist laboratory equipment to validate PFAS removal.
June 2023	We submitted to the DWI our **AMP8 strategy** for investigating PFAS risks and identifying actions – a requirement for all water companies in England and Wales.
	The **Royal Society of Chemistry** released a high-profile policy statement, with media interest, asking Government to make Tier 1 the standard to enforce remedial action. This was followed by roundtable discussions with industry and regulators in October 2023, which we participated in.
July 2023	The DWI issued a **legal instrument (Reg 28 notice *SVT-2023-00002*)** to include PFAS mitigation at Cropston WTW (a Tier 1 source), upon us applying for use of a **new source** of water from Thornton Reservoir/Rothley Brook (a Tier 2 source). This was an unexpected requirement, based on the 'no deterioration' principle, that came late to our PR24 planning and outside of the DWI PR24 process. The requirement was included in our business case SVE 13 Raw Water Deterioration.
August 2023	The DWI issued a PR24 **Final Decision Letter** for DWI Scheme reference: SVT3 – PFAS, which supported our PFAS proposals submitted in March – based on Tier 3 sites. *This became a Section 19 Undertaking (SVT-2023-00007) AMP8 Witches Oak PFAS.*
October 2023 – **PR24 submission to Ofwat**	We submitted our **SVE 13 Raw Water Deterioration business case** to Ofwat, which reflected the above regulatory position and support from DWI i.e. mitigation for two Tier 3 sites only.
November 2023	The DWI provided **feedback** to water companies on their **AMP8 PFAS strategies**. It recognised *"…….a need to have a more adaptive and precautionary approach to PFAS for the next five years. Without intervention, we would anticipate PFAS becoming an increasing risk….".* The feedback included a draft **Section 19 Undertaking (SVT-2023-00014)** to be submitted to deliver on these and this included a **requirement to implement mitigation at Tier 2 sites**, as well as the Tier 3 sites.
December 2023	The **DWI** released a **letter** which clarified the following: *"For all sources that fall into **Tier 2**, companies should design a proactive and systematic risk reduction strategy **implementing***

	*a prioritised **mitigation** methodology to progressively reduce PFAS concentrations in drinking water."*
February 2024	The chair of the **Water UK**'s Clean Water Committee (CWC), wrote to the **DWI** on behalf of members seeking to further **clarify** the requirements for Tier 2 sites, beyond the previous requirement for enhanced monitoring. The DWI responded to CWC members with the following guidance: *"Watch and wait is not the expected action in relation to Tier 2… Where there is a Tier 2 source or one that is seen to be approaching Tier 2 we expect that the company will consider the risk and take the appropriate actions to mitigate the site to a consistent Tier1 or below."* The DWI also clarified the timeframe for Tier 2 sites: *"The timings and approach that a company takes in order to achieve this are not being mandated; however the company needs to demonstrate a clear understanding of the risk, the appropriately considered timeline for action and the proposed outcome for that source after action(s)."*
April to June 2024	DWI issued formal draft Section 19 Undertakings for signing, which included risk reduction for Tier 2 sites.
August 2024	DWI issued revised guidance (**DWI Information Letter 03/2024**) on 21st August which sets Tiers based on the 'sum of' all PFAS compounds, whereas previously this was based on individual PFAS concentrations. Also inclusion of 6:2 FTAB in the list of PFAS parameters that must be analysed by water companies. Also collates and supersedes all the previous guidance.

Appendix B: Tier 2 site PFAS data

B.1 Church Wilne WTW – Tier 2 PFAS data

Figures B.1.1 and B.1.2 present our most up to date PFAS data for Church Wilne WTW.

Figure B.1.1: PFAS and concentrations – Church Wilne WTW raw water (routine & investigational samples)

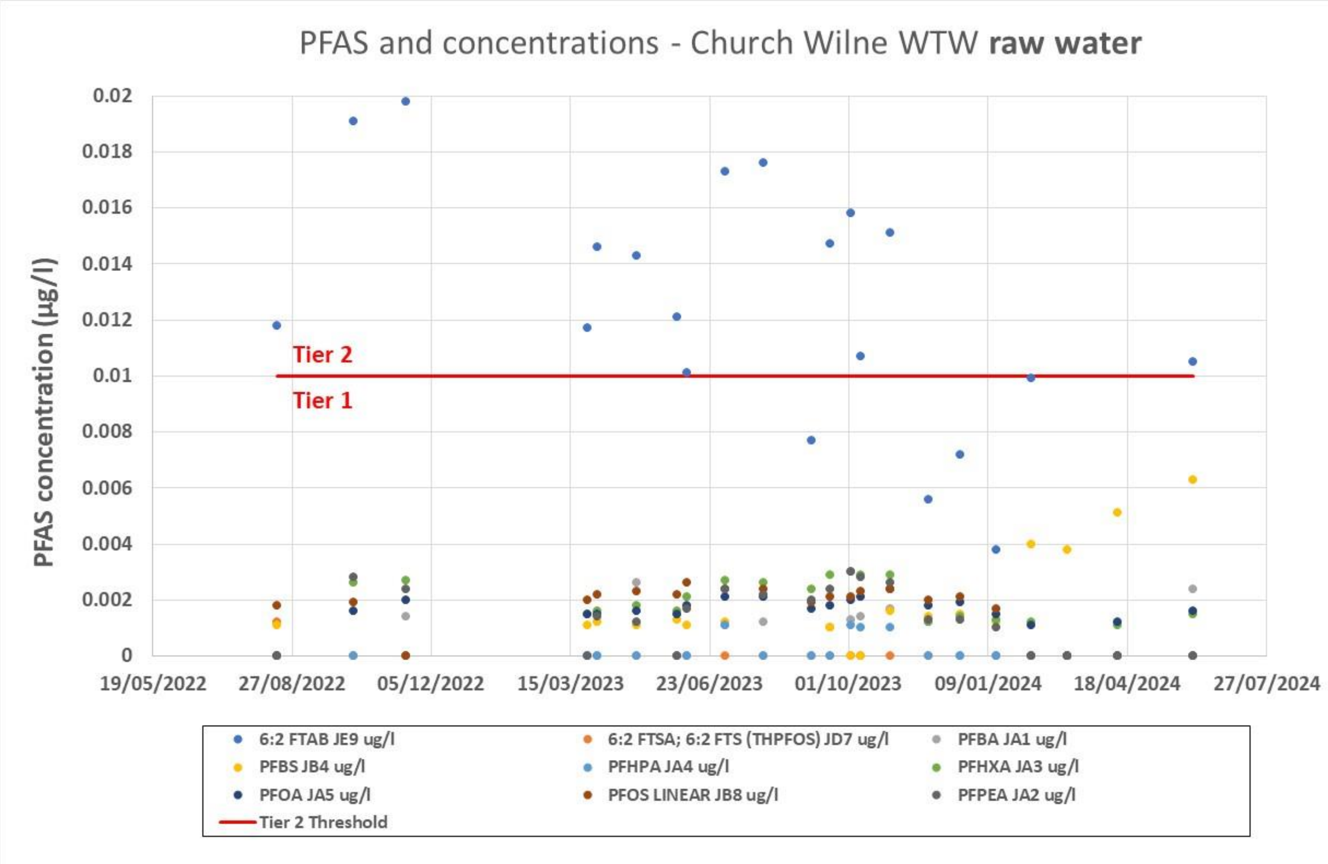
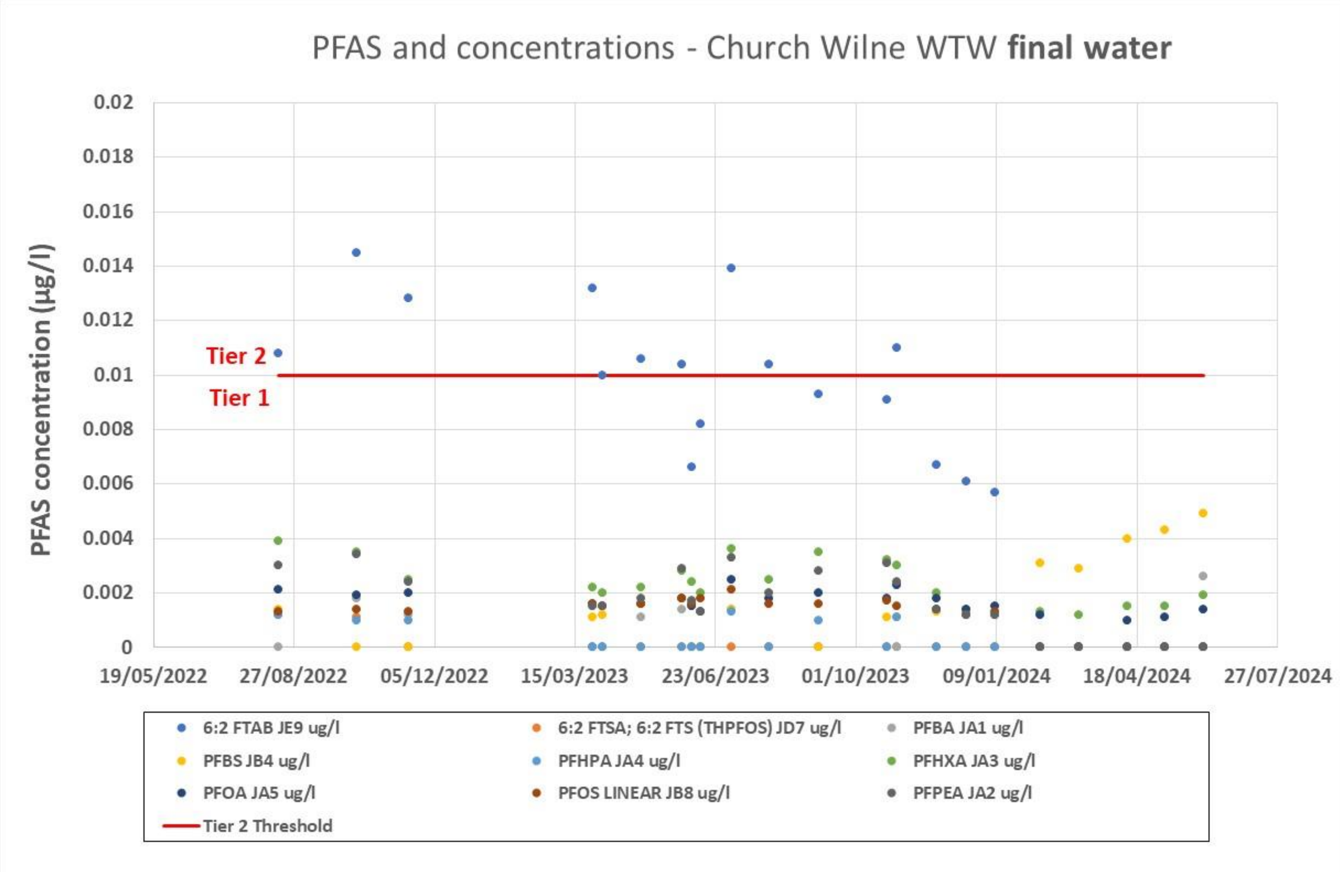


Figure B.1.2: PFAS and concentrations – Church Wilne WTW final water (routine & investigational samples).



The key points to note from this data are:

- several types of PFAS are present in both the raw and final water supply at Church Wilne.
- the concentrations of 6:2 FTAB in particular are consistently at Tier 2 i.e. ≥0.01 µg/l and <0.1 µg/l - so unlikely to be linked to measurement error.
- pre and post treatment sampling is showing that the existing WTW cannot remove PFAS (hardly any difference between).
- therefore under the terms of the Section 19 undertaking we need to take action to reduce to at least Tier 1 concentrations.

B.2 Whitacre WTW – Tier 2 PFAS

Figures B.2.1 and B.2.2 presents our most up to date PFAS data for Whitacre WTW.

Figure B.2.1: PFAS and concentrations – Whitacre WTW raw water

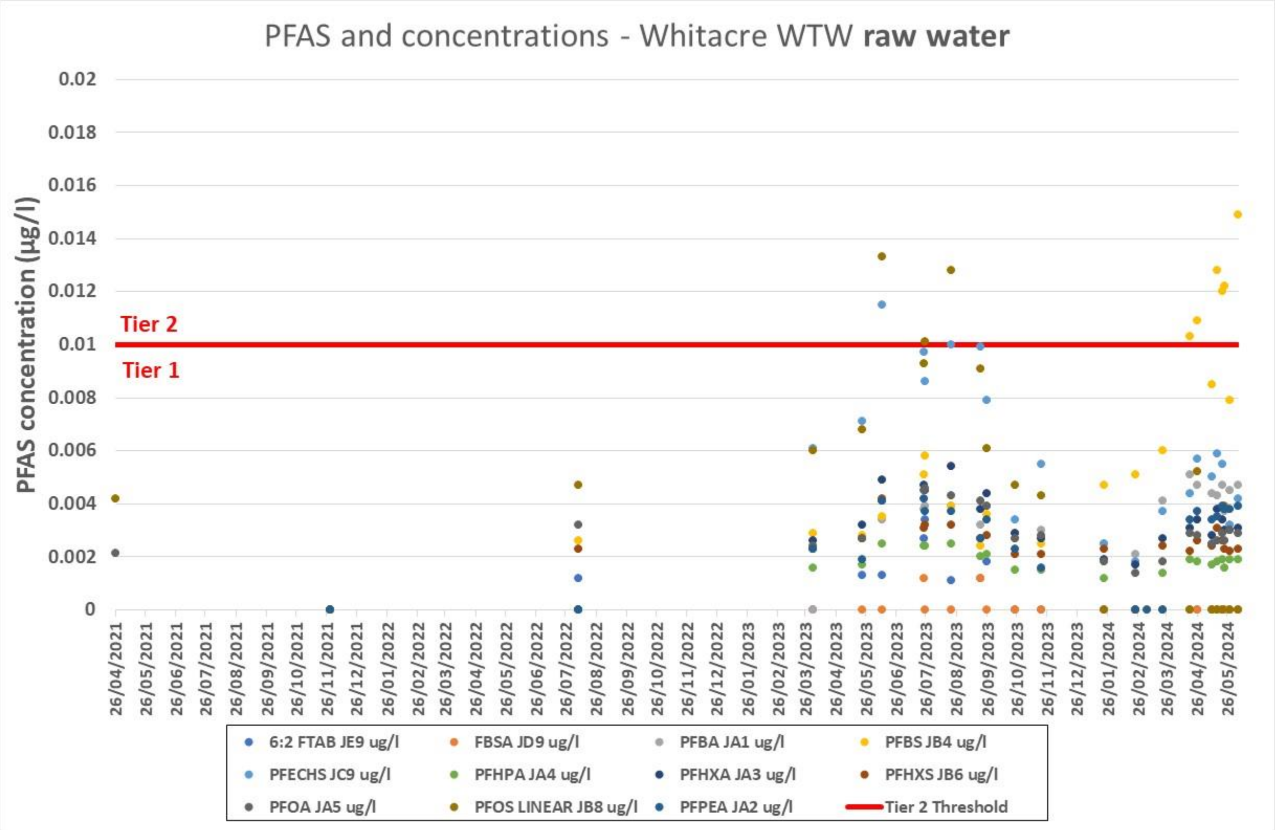
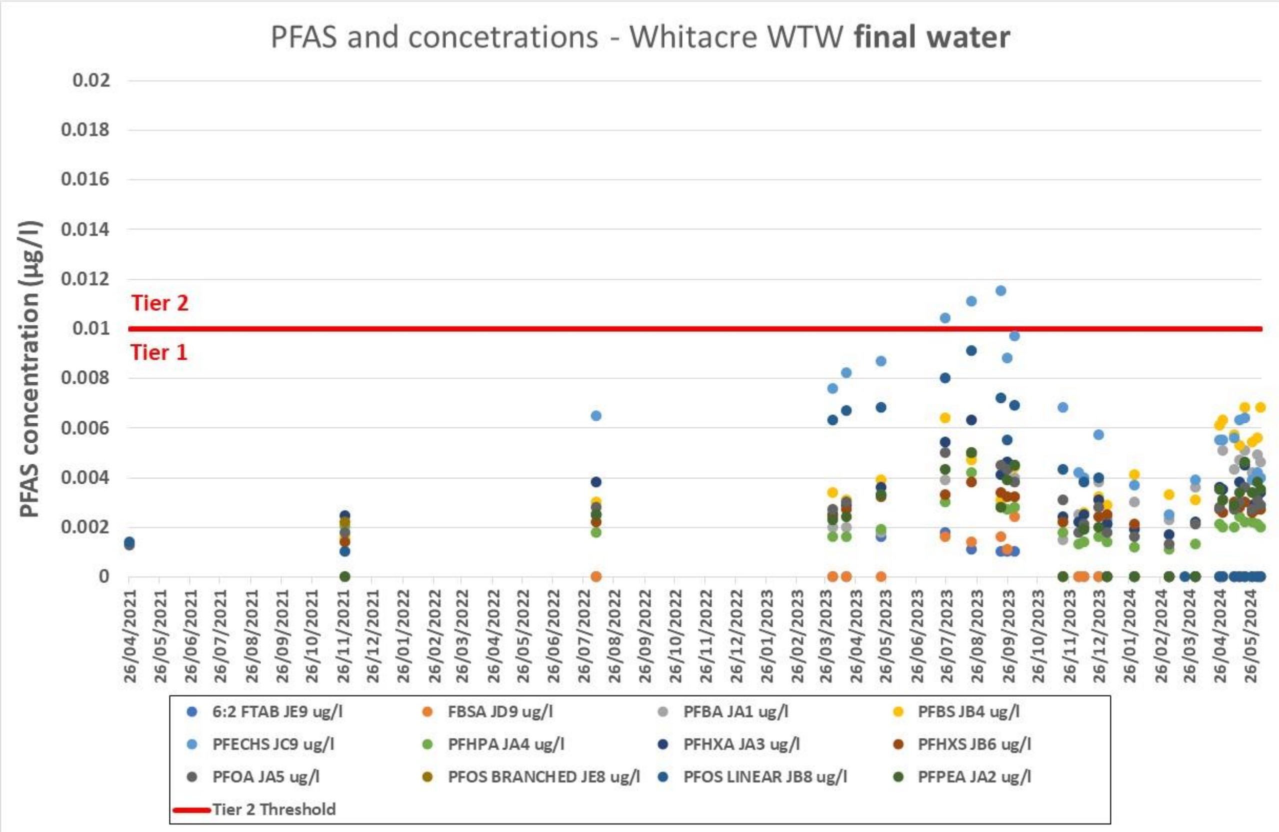


Figure B.2.2: PFAS and concentrations – Whitacre WTW final water



The key points to note from this data are:

- several types of PFAS are present in both the raw and final water supply at Whitacre.
- Tier 2 status was reached in spring 2023 due to PFECHS, and of more concern, PFOS which has documented human health impacts and its use is banned.
- more recently in spring 2024, Tier 2 concentrations appeared for PFBS.
- therefore under the terms of the Section 19 undertaking we need to take action to reduce to at least Tier 1 concentrations.
- Tier 1 sampling frequency is not adequate enough to determine what is going on – this confirms our more robust approach to sampling, which we describe in more detail in our catchment investigations section (Section 2.2), where we are trying to determine whether these PFAS are a seasonal issue or linked to a live or historic catchment / pollution issue.

Appendix C: Our pilot plant PFAS trials programme

Table C: Our pilot plant PFAS trials programme

Pilot plant trial	What are we testing and why?	Timescales
GAC pilot plant	GAC - Rapid small scale column testing (RSSCT) by WRc (offsite) • Spiking of Trent water with PFAS. • To determine breakthrough curves for PFAS compounds of concern – quickly allows us to assess number of bed volumes required which helps scale up and to inform pilot plant configuration. • Assesses competition with metals, organics & pesticides.	Phase 1 testing complete. Analytical results outstanding by 10 May 2024, and final report expected by 14 June 2024. Phase 2 testing complete
	One and two stage arrangement of four GAC filter columns, in series, treating Trent water (WO): • First stage containing Chemviron Carbsorb 40 plus ('standard media'), representing our normal process for pesticide removal on site. • Second stage columns containing PFAS selective media. One column has Chemviron F400 media and the other CPL CH600 media. • Results presented in Figure 7 show that PFAS breakthrough started to occur very early (one month) for standard GAC media. PFAS-selective media is consistently keeping PFAS to Tier 1 or below limits of detection for the last three months. Dissolved Organic Carbon is also being managed too, which can compete with PFAS for GAC adsorption.	Four columns in place since December 2023.
	Additional 18 columns to test different process configuration, and to include Derwent water: • First stage and second stage both using PFAS-selective media i.e. no use of existing standard media. • Consideration of lead and lag operation of the two stage columns i.e. switching first-stage columns after exhausted to second-stage columns for polishing, and vice versa to maximise PFAS removal, accepting complications for retro-fitting at full scale.	Due to start August 2024, with a valid results set in June 2025.
	Effectiveness of GAC regeneration and reactivation for PFAS removal. Spent GAC column media will be sent to Chemviron and CPL to do this testing.	December 2024
PAC (Acticarb) pilot plant	PAC - bench top testing by WRc	Proposed start date TBC, to follow Phase 2 RSSCT.

	• To identify best PAC product, optimal contact time and dose for PFAS removal on River Trent water. • Will aid in optimisation of Acticarb. • NB. This was our proposed solution for Witches Oak in our SVE13 Raw Water Deterioration business case submitted September 2023.	