Revised Draft Water Resources Management Plan

Technical Appendix CC - Lessons Learnt from the 2022 Drought

Appendix CC - Lessons Learnt from the 2022 Drought

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Overview

The drought in 2022 "stress-tested" a number of our schemes, strategies and plans in responding to drought. As per requirements set out in the updated Water Resources Planning Guidance, section 9.5.2[1], this appendix reviews the experiences during the drought and outlines lessons and areas of improvement that could be captured with our Drought Plan and WRMP going forwards. The requirements include reviewing how we can improve resilience of our supply system, reviewing our planned level of service and various aspects of our supply-demand balance planning such as bulk supply agreements and demand forecast scenarios.

To address these requirements, each section in this appendix covers aspects of our supply system, drought measures and supply demand balance planning, with a summary of the learning points for each of these. There is a section outlining key projects aimed at improving our resilience following some of the learning points, as well as a section collating all learnings and proposed actions for the Drought Plan and WRMP.

[1] Water Resources Planning Guideline, Water resources planning guideline - GOV.UK (www.gov.uk)

The 2022 drought and review of our response

CC.1 In this section we describe the events of the drought and our response. We also provide some initial assessment of the severity of the drought and review our planned level of service in that context.

Onset of drought in 2022

CC.2 The drought of 2022 for discussion in this Appendix refers to the period from May 2022 to December 2022, during which time our water resources position was deteriorated and many of our Drought Plan measures were in place. It should be noted that this definition does exclude the antecedent conditions that play a significant role in the onset of the drought, and the months following the drought where recovery progressed through later winter and early spring of 2023. A summary timeline of events is shown in Figure CC-1.

CC.3 The recharge period (the time of year when we can expect aquifer and river recharge with increased rainfall and reduced soil moisture deficits) from Oct 21 to Mar 22 saw slightly lower than average rainfall across the Thames catchment (85% LTA[2]), with exceptionally low rainfall in November 2021 and January 2022. This led to Below Normal groundwater levels at many sites at the end of the recharge period. Flows in the River Lee, the Upper Thames and Lower Thames were below average at the end of March. At the same time reservoir storage remained above average with enough flow in the River Thames to sustain healthy reservoir storage levels.

CC.4 Dry weather continued through spring and early summer, with below average rainfall persisting through April May and June. Naturalised river flows in the Thames at Teddington reduced below the 3000 Ml/d awareness level (3000 Ml/d being the river flow below which we tend to see our reservoir levels fall) in mid-June. With reduced abstraction due to low flow constraints and increasing customer demand during warm dry weather, reservoir storage began to decline.

CC.5 There was exceptionally hot and dry weather throughout the summer, with record breaking temperatures in July, leading to rapid reduction in river flows and reservoir storage, and steep recession of groundwater levels. London reservoir storage crossed Level 1 on the Lower Thames Control Diagram (LTCD)[3] on the 21st July, prompting enhanced media campaigns and the use of strategic schemes such as NLARS (North London Artificial Recharge Scheme). A drought was declared across much of the country on 12th August, particularly areas of the south and central parts of England, including the Thames area.[4]

CC.6 Thames Water introduced extensive media campaigns in May to inform customers of the water resources position and encourage less water usage. A Temporary Use Ban (TUB) was announced across the Thames Water supply area 17th August 2022, coming into

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[2] Long-term Average rainfall is based on rainfall data from 1883 to 2018.

[3] See Appendix I - Deployable Output for further explanation of the Lower Thames Control Diagram and Operating Agreement.

[4] Environment Agency chairs National Drought Group as parts of country move into drought - GOV.UK (www.gov.uk)

effect on 24th August 2022. This places restrictions mostly on domestic uses such as hosepipes, with some exemptions which are explained in our Drought Plan.[5] The TUB ended on 22nd November 2022.

CC.7 The crossing of Level 2 LTCD in early August and challenges faced in West London (discussed further in London WRZ section) prompted a request to the EA to start the West Berkshire Groundwater Scheme (WBGWS) to support abstraction in the Lower Thames (learning from this is discussed in Strategic Schemes section).

CC.8 In SWOX the rapid decline of reservoir storage and significantly low flows in the Upper Thames prompted applications for drought permits at four sites in the zone. Of the four permits applied for, Farmoor was granted for use until March 2023. The permit was not used and applications for the remaining permits were eventually withdrawn in November when heavy rainfall removed the need for them. Our experience has not led to the identification of new drought permits being required, although some improvements to the process of permit applications are being scoped. Further information on drought permits is discussed in the Drought Permits section.

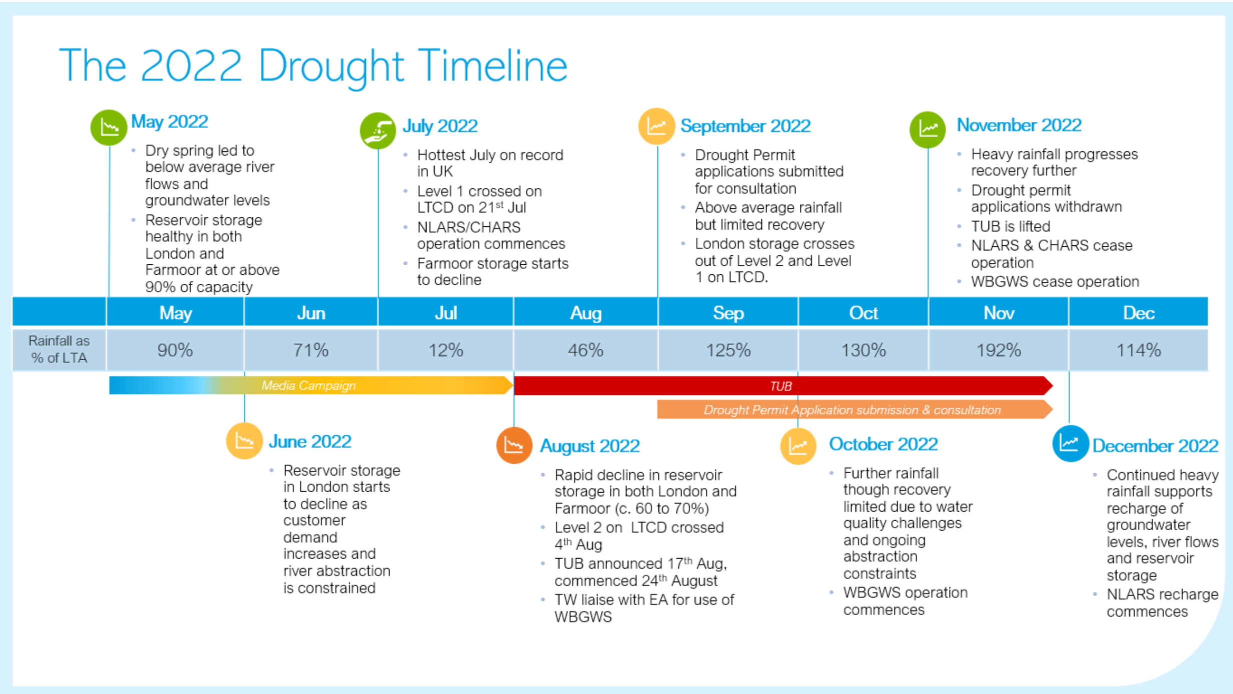

Figure CC-1: Timeline of events and actions during the 2022 drought

Severity of drought

Rainfall

CC.9 Analysis has been undertaken to assess the severity of drought based on Standardised Precipitation Index (SPI), and using our water resources model to assess system response. Using SPI (), we can assess the severity of the drought event in terms of rainfall

[5] Our drought plan | Regulation | About us | Thames Water

accumulation. Negative SPI values indicate lower than median precipitation. Table CC-1 gives reference SPI values for context, although note these references apply to any duration of rainfall accumulation. Table CC-2 shows the lowest SPI values reached during 2022 considering different accumulation periods, compared with the minimum SPI values reached during notable drought events. This demonstrates that the summer of 2022 (6-month SPI) was Extremely Dry, and that the 12-month accumulation across 2021-22 would also be classified as Extremely Dry. The summer of 2022 was, however, not as dry as 6-month periods have been during other major drought events. The drought event was less severe when considering longer accumulation periods, being within the Normal range for 24-month accumulation and being on the border between Moderately Dry and Very Dry when considering an 18-month rainfall accumulation.

CC.10 Other droughts that have had significant consequences for our supplies have (as can be seen in) involved longer dry periods. The 2022 event was clearly an extreme event, but it was not an extreme event of the type that would be expected to have major consequences for our supplies.

SPI-n Range	Qualitative Description	Approximate Return Period
> 1	Moderately Wet	N/A in drought context
-1 < x < 1	Normal	N/A in drought context
-1.5 < x < 1	Moderately Dry	Up to around 1 in 6 years
-2 < x < 1.5	Very dry	Up to around 1 in 15
x < -2	Extremely Dry	Around 1 in 40, or greater

Table CC-1: SPI Values and Drought Severity

Period	1921	1933-34	1944	1976	1989-92	2022
3-month	-2.827	-2.526	-2.527	-3.031	-2.856	-2.055
6-month	-3.996	-2.732	-2.925	-4.436	-3.031	-2.438
12-month	-3.753	-2.774	-2.362	-3.585	-2.382	-2.167
18-month	-3.129	-2.709	-2.556	-3.029	-1.945	-1.537
24-month	-2.409	-2.732	-1.915	-1.881	-2.589	-0.908

Table CC-2: Lowest SPI-n Figures during different historical drought events, Thames Catchment Area. Data from UK Water Resources Portal[6]

London modelling assessment

CC.11 In order to build a more complete picture of the severity of the 2022 drought event, we have used rainfall, potential evapotranspiration and river flow data to run our water

[6] UK Centre for Ecology & Hydrology, 2023, https://eip.ceh.ac.uk/hydrology/water-resources/

resources model. This allows us to determine the severity of the drought's impact on our supplies, considering 'system response'. This was done using our WARMS (Aquator) model. Aquator has a more detailed representation of our network and we generally use for our short-term (<12months) predictive modelling and annual return reporting. Note that this is not the same model used for the WRMP24 supply forecast, a newly developed Pywr model (a sub-model to the WRSE Regional Simulation Model) has been used. This model uses a more aggregated network model, is faster to run and so is better suited for longer term planning on a coarser spatial scale (see Section 4 - Supply Forecast).

CC.12 We ran our Aquator water resources model using our AR22 Baseline Deployable Output model setup for the period 1920 to 2022 at the AR22 DO demand level. Note the AR22 DO demand level is significantly above the level of demand experienced last year for our London Water Resource Zone (WRZ). We captured the minimum reservoir storage in each year (April to March) and have ranked these (Figure CC-2A). These results show that modelled storage in 2022 was the 13th lowest across the 102-year period. The 2022 drought event was less severe, in system response terms, than 1921, 1934, 1944 and 1976. The 2022 drought event was of comparable severity for our reservoir storage to known moderately severe drought events, such as 1996, 1989, and 2011.

CC.13 Reservoir drawdown is dependent on the demand on the network. In order to show the drawdown range that might be expected, we ran our water resources model with an AR22 DO level of demand, and a 'DYAA DI' level of demand (Figure CC-2B). These results demonstrate that, if we had modelled the event prior to its occurrence, we would have predicted that TUBs may be necessary, and that we would certainly anticipate implementation of a TUB.

CC.14 We can also compare the observed storage with modelled storage. If our model setup aligns closely with the operational and hydrological reality (acknowledging that there will have to be some assumptions used in the model that differ from reality to some degree), we would anticipate the black line (observed) match closely with the red line (modelled). We can see that our reservoir storage trajectory during the 2022 drought event is similar to that which is modelled, but that observed storage was lower than anticipated, particularly during the late summer. Observed storage did not decline as quickly as our model suggests from September onwards, likely due to the significant drop in demand which was seen due to the implementation of TUBs and wetter weather (our modelled demand profile assumes the continuation of dry conditions). The speed with which our reservoirs were refilled is significantly slower than would be expected from our modelling, owing to water quality risks experienced at the time, with intense periods of rainfall increasing the turbidity of the river and constraining abstraction. Investigating how we can capture these constraints in our water resources modelling will allow us to improve our shorter-term planning. We should also consider ways to mitigate the impact of water quality constraints on our ability to recover reservoir storage while continuing to supply wholesome water.

SWOX modelling assessment

CC.15 We ran our water resources model for the SWOX WRZ, again at DO and DYAA DI levels of demand. Figure CC-2C shows a similar picture to analysis for London, i.e., that, based on minimum modelled reservoir storage level reached, the impact of the 2022 drought sits in the range of moderate drought events which would be anticipated to occur around once every 10 years. Figure CC-2D shows a comparison between modelled and observed storage at Farmoor, indicating a gap between observed and modelled storage. Further analysis (Figure CC-3) shows that this is due to a modelled over-prediction of flows available for abstraction at Farmoor, with the average over-prediction during the drawdown event being 14%. Figure CC-4 shows a comparison of modelled and observed storage where a 14% reduction in flows is made, and this shows a greater degree of improvement, but again demonstrates a gap between observed and modelled storage. The gap between observed and modelled storage, when accounting for the difference in river flows, is likely due to the availability of groundwater sources – our modelling would assume that all sources are being operated at their "DO" level of output at all times, when several sources were available at levels less than this during the drought. It is also noted that observed storage in Farmoor had reduced by approximately 4-5% in May following a period of heavy rainfall leading to high turbidity and constraining abstraction. This meant the storage decline in the summer started from a lower position – the model shows storage being completely full before the decline. Going forwards we will explore how outages and operational constraints can be captured within the water resources model. This would enable improved short-term planning. It is also important to ensure our understanding of source availability and Deployable Outputs are accurate. Updating Deployable Outputs and ensuring the model aligns remain a part of business-as-usual reporting, we should continue to ensure that our Deployable Outputs reflect our sites' capability to the best of our knowledge, to allow accurate monitoring of performance against our long-term supply demand balance forecast.

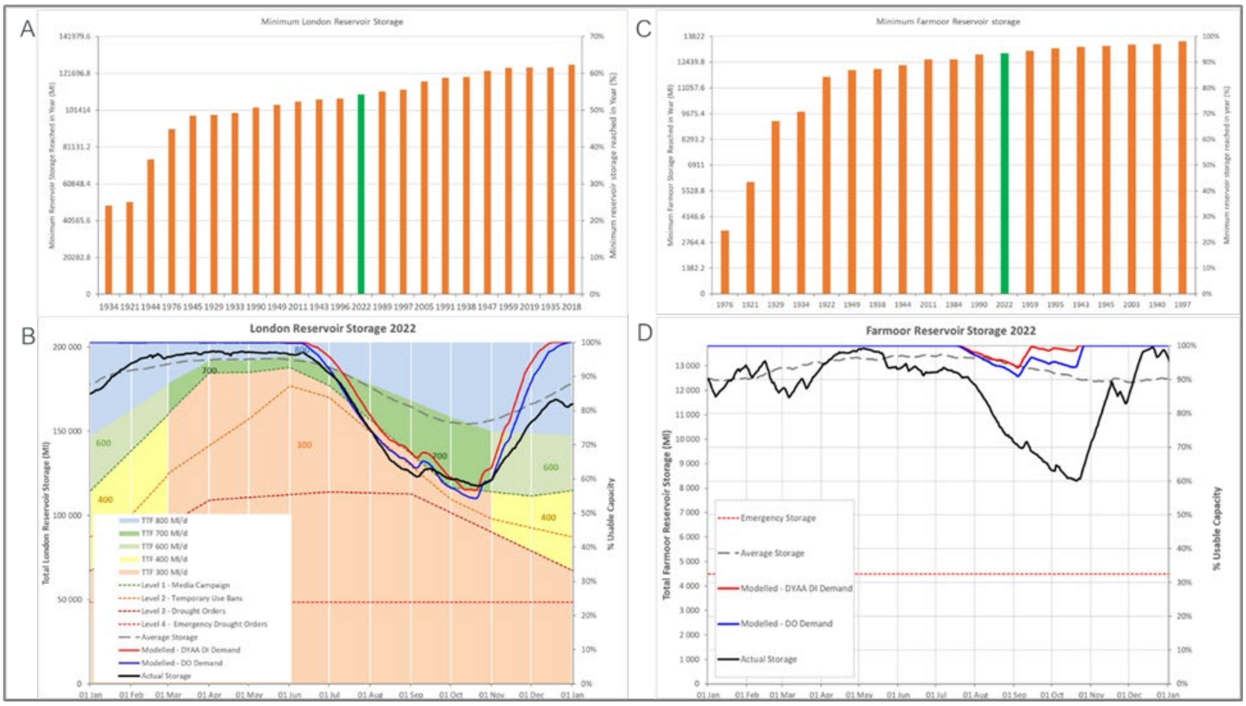

Figure CC-2: A. Minimum modelled London storage reached in different drought events. B. Observed and modelled London reservoir storage in 2022. C. Minimum Farmoor Storage Reached in Different Drought Events. D. Observed and modelled Farmoor storage in 2022

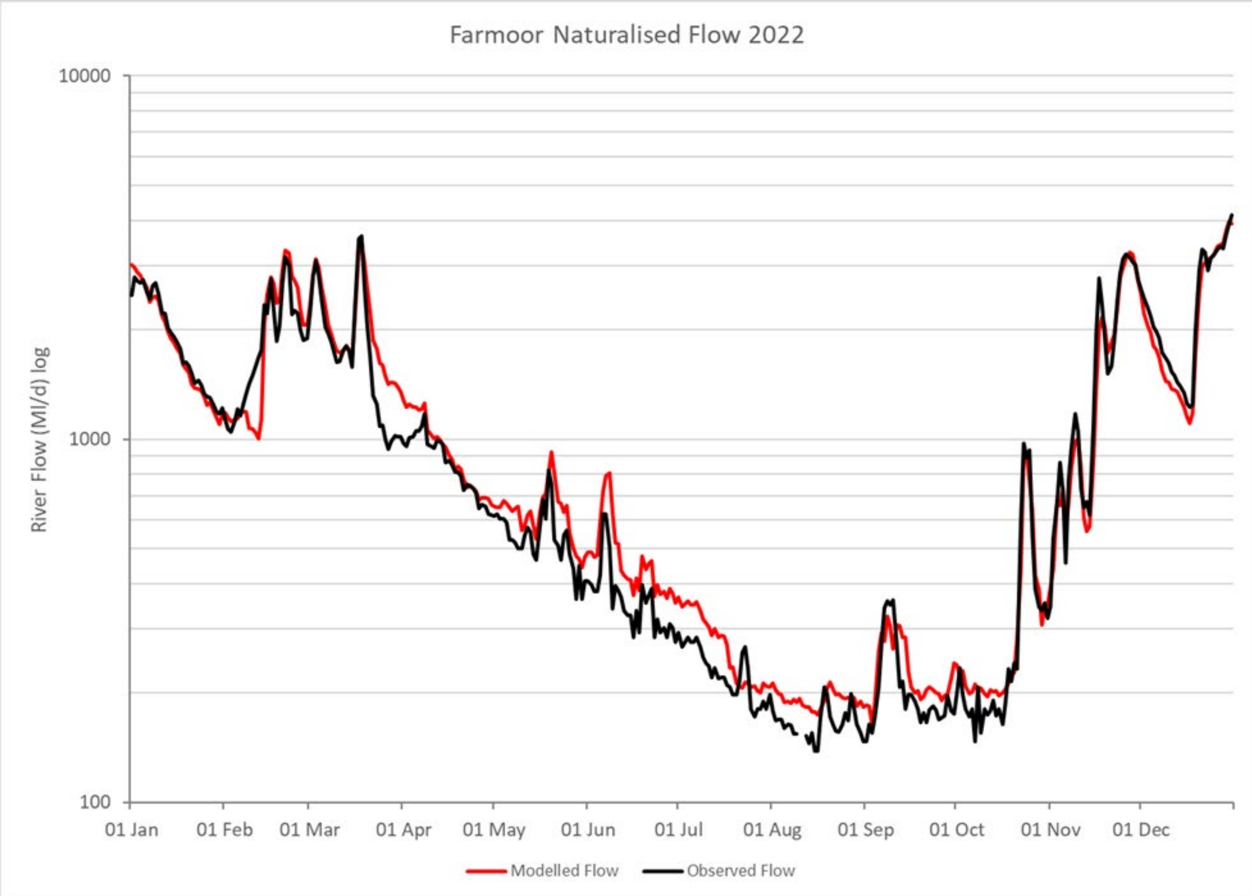

Figure CC-3: Modelled and Observed Farmoor Flows from the 2022 Drought

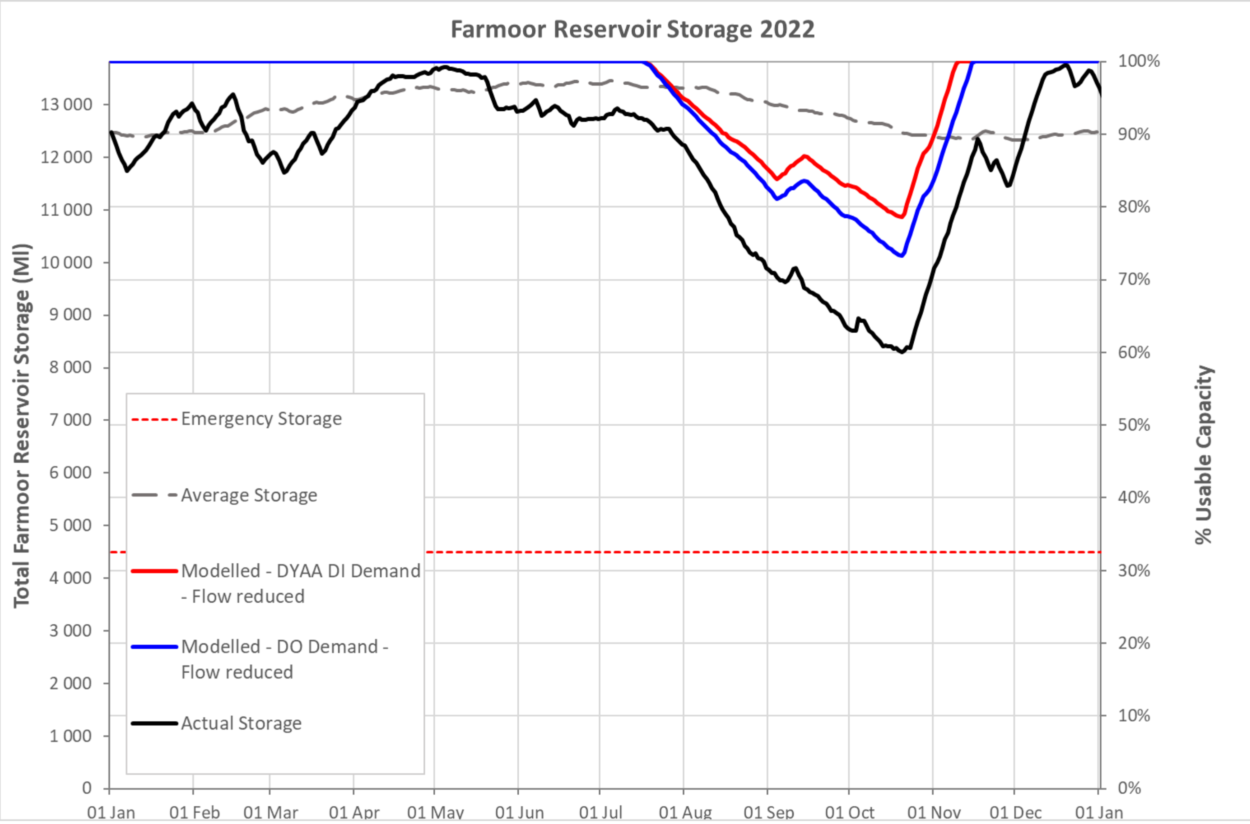

Figure CC-4: Farmoor Reservoir Storage - 2022 Drought - Modelled (with 14% flow reduction) and Observed

CC.16 Our overall categorisation of the 2022 drought event for London and SWOX's water resources system is that it was a severe event, but it is not an event that would be expected to cause major system-level consequences. More severe events than the 2022 drought would, excluding the impacts of climate change, be expected to occur every ten years or so. Had the event been preceded by a dry summer in 2021, or if it were followed by a relatively dry winter and dry summer, the event would have been very severe. Differences between our modelling assumptions and operational reality can lead to significant differences between observed and modelled storage during drought events. Therefore, it is important that our models are set up to reflect operational constraints, and that our assets are maintained such that they are able to provide the supplies that they are designed to provide and that our Deployable Outputs appropriately reflect this. While these improvements will not directly influence the long-term planning, addressing the ability to capture constraints in the Aquator model and upholding asset maintenance will allow for improved short-term planning and response to drought events. While keeping our Deployable Outputs up to date will ensure we are accurately monitoring performance against our plan.

Review of Planned Level of Service

CC.17 Our WRMP sets out targets agreed with our customers, defined by the average frequency that drought measures should be implemented, this is our level of service. (See Section 1 of rdWRMP24). Following our experience through the drought, it is worthwhile reviewing our response to the drought and how this compares to our planned level of service., i.e. whether or not we implemented drought measures at the severity of drought we planned to.

CC.18 In the previous section, we assessed that the deficit of rainfall over the preceding months of the drought was classified as "Extremely Dry" based on SPI, according to the indices from UK CEH and that this rating suggested a return period of 1 in 40 years. Over the course of the drought, we implemented a media campaign, a TUB across our supply area, and submitted applications for drought permits in the SWOX WRZ (though some applications were withdrawn, and the one which was granted was not used). As a reminder, the frequency of drought measures as set out in section 1 of our dWRMP24 is in below.

Level	Description	Actions
1	Impending drought Frequency: once every 5 years on average	Begin an awareness campaign – typically via radio, newspapers, social media and other online channels – to tell customers about an impending drought, let them know how serious it is and ask them to use water sparingly. We'll work with a wide range of organisations to spread the message, including water retailers. The campaign will be continued throughout the drought.
2	Early stages of a drought Frequency: once every 10 years on average	• Step up the awareness campaign and encourage customers to reduce their water use through advice and installing water efficiency gadgets in customers' homes. • Restrict the use of sprinklers and hosepipes in and around the home for uses including watering gardens, topping up ponds, filling paddling and swimming pools, cleaning cars – this is referred to as a Temporary Use Ban. Some vulnerable customers, such as blue badge holders, would be granted exemptions.
3	Severe drought Frequency: once every 20 years on average	• Restrict non-essential water use. This would affect businesses, and restrict activities such as cleaning windows at industrial plants and suppressing dust on construction sites. The government would have to grant a Drought Order to allow us to introduce these restrictions. We'd notify customers at least ten weeks before introducing these measures. • Apply to the Environment Agency for Drought Permits to allow us to take more water from certain sources.
More before 4	Additional measures for the most serious droughts Frequency: once every 50 to 100 years on average	Step up actions to reduce demand and provide additional supplies to try to avoid reaching emergency restrictions (Level 4). Actions would include: • Widespread communications asking customers to make significant reductions in their water use, aiming for around 80-100 litres/person/day. (On average our customers use around 140 litres/person/day) • Bring online additional supply, such as emergency raw water pipeline transfers, temporary desalination units and alternative sources for non-potable use.
4	Extreme drought We plan never to reach this level, which would involve a drought worse than any on record (since 1920).	Extreme measures to reduce water use, such as rota cuts (when water usage is restricted at certain periods of time) and standpipes in the street for customers to collect water. This would have a massive impact on society and the economy, and the government would need to grant an Emergency Drought Order.

Table CC-3: Our levels of service and actions we would take during a drought

CC.19 The dry weather preceding and during the summer warranted the use of enhanced communications to customers to encourage water efficiency. This is a Level 1 measure, and we plan to use communications campaigns every 1 in 5 years. The severity of the rainfall deficit as well as system modelling would indicate that implementing a media campaign was therefore appropriate.

CC.20 Modelling of the event from a system response point of review (using DO demand) indicates that the event was around a 1 in 10 event, similar severity to our Level 2 level of service. The "DI DYAA demand" scenario of modelling implies that TUBs may not have been needed, however even in this scenario, the rate of decline of reservoir storage in June would have indicated it was prudent to consider restrictions in a timely manner in the event that storage decline continued. We also take into account other factors of the water resources situation through our Drought Event Level, informed by the Overall Risk

Indicator, as set out in our Drought Plan. The overall risk indicator takes into account prevailing and projected risk for reservoir storage, river flows and groundwater levels. During July 2022 our water resources position and ORI indicated a move from DEL1 to DEL2, at this level, a TUB is recommended. As such we began preparations to implement a TUB as soon as feasible.

CC.21 When considering the modelling for the Farmoor reservoir system, it would appear that the severity is slightly lower than in London, the reasons for this have been discussed (a combination of operational constraints and potentially modelling uncertainty), however we would not implement a TUB on only one WRZ in any case, rather the whole supply area to ensure the best benefit and also to minimise confusion to our customers who may be in neighbouring WRZs.

CC.22 We also began applications for drought permits in the SWOX WRZ as soon as was appropriate to do so. The process and timing of drought permits is discussed further in the Drought Permits section. With regard to a review of our planned level of service, this measure is expected during a 1 in 20 event. The assessment of the rainfall deficit suggests a severity worse than this, whilst the system response modelling suggest a lower frequency drought. We feel that our response in submitting drought applications remains appropriate given the rainfall deficit and that we escalated this measure in line with our drought plan. However, there are some learning points arising from the timing and completion of the application process.

CC.23 Overall, when considering the rainfall deficit, the resultant deterioration of the water resource position and system response modelling, our escalation of drought measures are assessed to be appropriate and in line with our Drought Plan. However, there are some learnings from this experience in order to reduce our vulnerability to drought and ensure our assets are well maintained. In some cases, a review of Deployable Outputs is prudent, as-well as ensuring our models are aligned with the reality of asset availability and operability, especially with regard to the recovery of reservoir storage.

Lessons and recommendations

The key learnings from our assessment of the severity of drought and our response to the drought are:

- Modelling of the Farmoor reservoir during drought showed less drawdown of storage than observed in 2022. Thus far reasons for this include overestimation of river flows in the model and potentially maximised DOs and abstractions. We will investigate the gap between modelled and observed storage further to assess whether adjustments may be needed in the model, in our operational strategy and/or in our Deployable Outputs, in order to improve short term planning and response to drought.
- Modelling of London reservoir storage during the drought showed faster recovery of storage than observed, this is due to water quality constraints in abstraction with intense rainfall over the recharge period. We will investigate what can be done to improve our ability to recover storage during periods of intense rainfall following a drought, whilst ensuring we continue to supply wholesome water.

London WRZ

Lower Thames abstraction

CC.25 Total reservoir storage reached its lowest through the event in October 2022 (despite some limited recovery in September). It was noted that throughout the drought that storage in the Lee Valley reservoirs (north-east London) remained above or near average in part supported by the use of NLARS/CHARS, whilst storage in West London had drawn down to significantly low levels in some reservoirs. This section discusses the challenges faced and learning from the impact of the 2022 drought on this part of the network.

CC.26 For a visual representation of where the West London and Lee Valley reservoirs are in relation to each other, see Figure CC-5, note that the "Thames Valley" reservoirs in this diagram is the same as the "West London" reservoirs referred to throughout this document. This is the same diagram presented in Appendix A – Water Resources Zone Integrity.

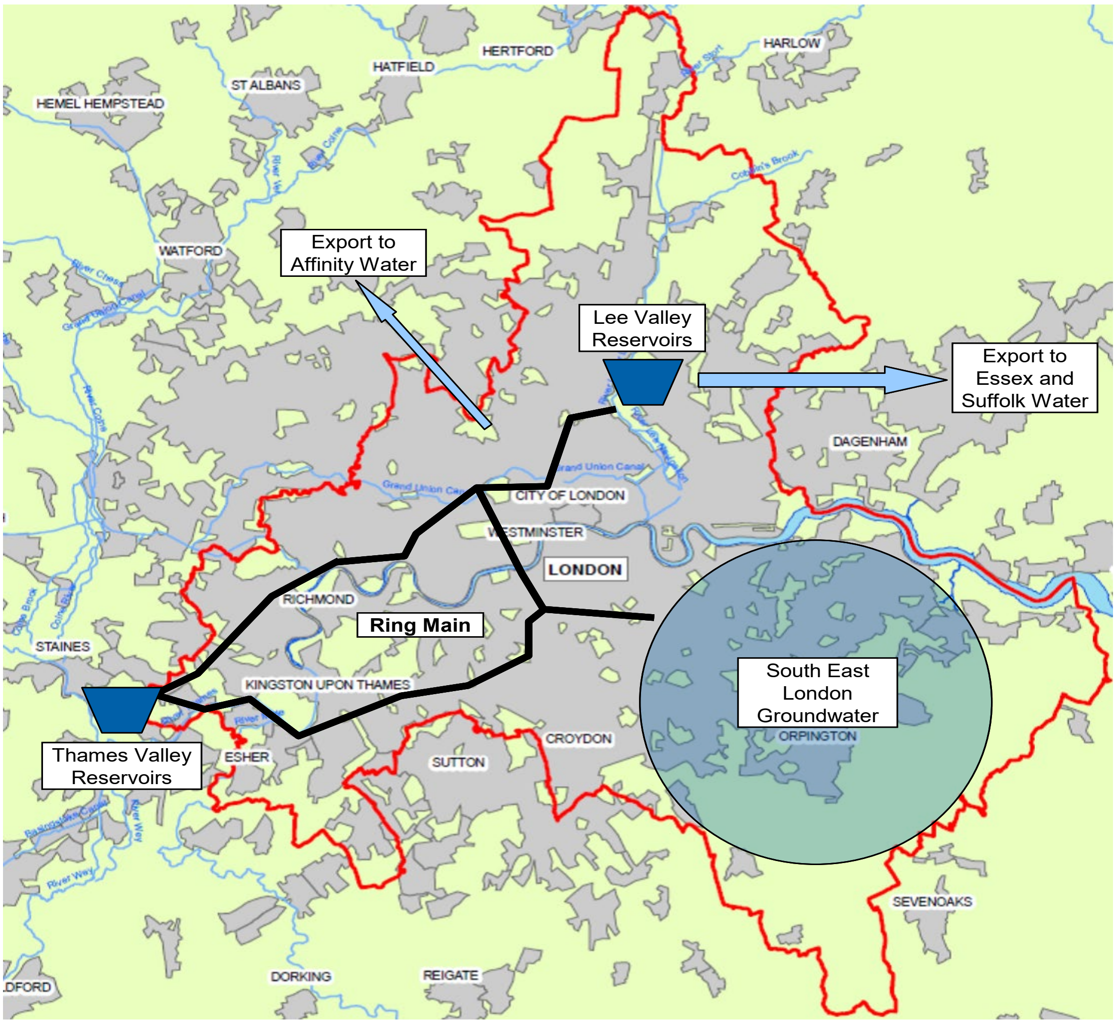

Figure CC-5: Principal features of the London WRZ. Shows Lee Valley reservoirs in relation to West London ("Thames Valley") reservoirs

CC.27 The ten reservoirs in West London are fed by four abstraction points along the lower Thames (the abstraction point at the Thames Lee Tunnel supports the Lee Valley reservoirs in north-east London). Abstraction at these West London points are for the most part governed by the Teddington Target Flow (TTF), downstream of the river Wey, Mole and Hogsmill. Abstraction is also governed by constraints at a number of weirs along this stretch of the river (Bell Weir, Chertsey Weir etc) as seen in . Abstractions subject to these constraints are managed through liaison with operational teams and river control officers at the EA. For the purpose of this discussion the "southern group" of reservoirs refers to those downstream of Shepperton Weir in Figure CC-6, namely Queen Elizabeth II, Knight, Bessborough and Island Barn.

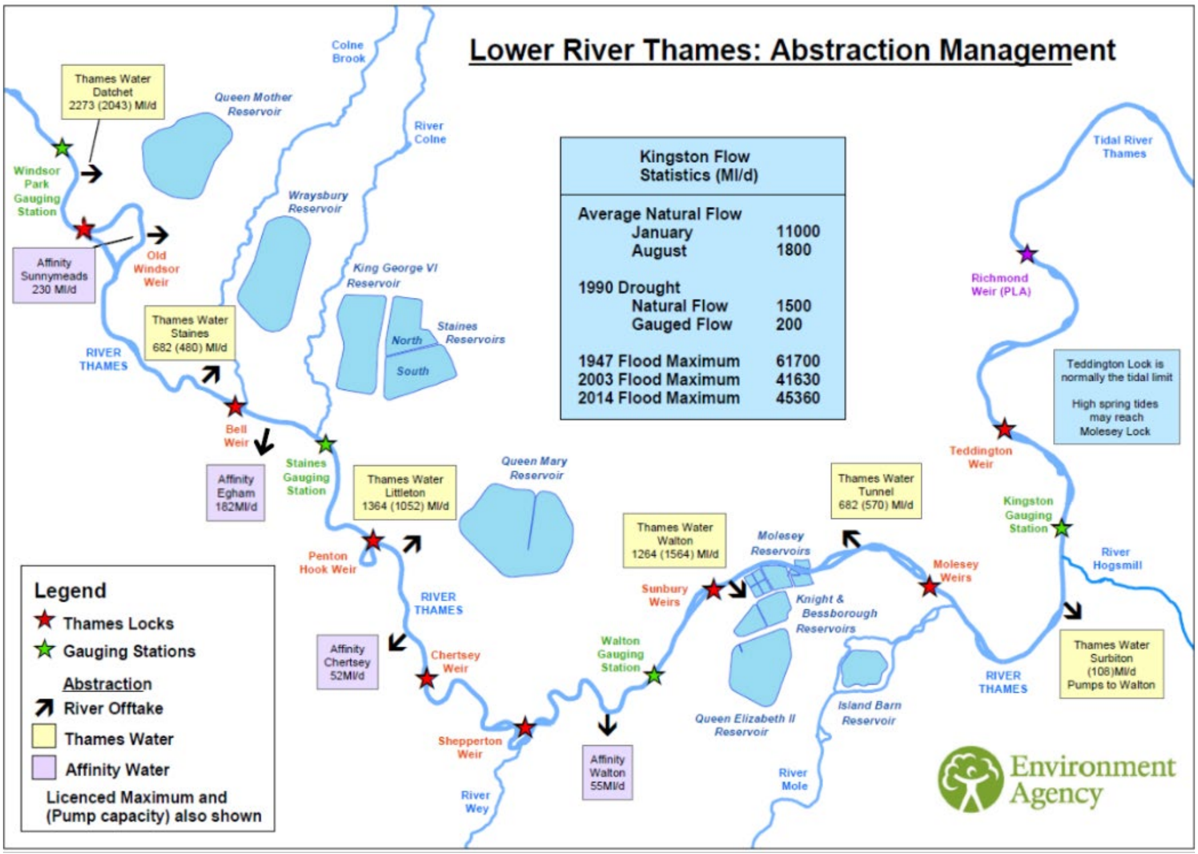

Figure CC-6: Lower River Thames Abstraction points, Environment Agency

CC.28 Over the summer, storage in each of the West London reservoirs differed based on their location relative to Shepperton weir. In the Queen Mary, Queen Mother and Wraysbury reservoirs, storage reached exceptionally low levels (~30% of capacity) prompting concerns around potential loss of supply to Ashford Common WTW, due to insufficient driving head (not enough water is entering the pump to maintain sufficient flow into the works) and possible water quality limitations (this concern was a key driver in requesting use of the WBGWS). In the lower reaches (downstream of Shepperton Weir), there were some challenges, but storage did not reach as low and recovered more quickly through autumn. The Queen Elizabeth II reservoir (the largest of the reservoirs in the southern group) reached its lowest in mid-August at 53% of capacity. It became apparent that there was sufficient water downstream of Shepperton Weir to abstract into the southern group of reservoirs (and into the Thames Lee Tunnel) due to the tributaries supporting flow in the river Thames, particularly the River Wey. In contrast, constraints at the weirs further upstream limited the ability to abstract into the larger reservoirs. This challenge has highlighted a need to understand more about the management of our abstractions and the Environment Agency's weirs, and how the river behaves during drought in order to improve operational sourcing strategy and to ensure we are making the right decisions when selecting solutions to any risks identified in our plan, should they exist.

CC.29 In light of the experience of the drought, the flexibility and resilience of our assets is being reviewed, with commissioned studies to look at how we can improve capability to abstract at lower flows. Some of the resilience schemes that have already been scoped are discussed in the Improving resilience section. Understanding the management of weirs and flow of the Thames in each reach is key to ensuring we plan and secure resilience for this part of the network, we therefore plan to conduct further studies to improve our understanding. Detail of the investigations and actions we aim to undertake have been captured in a revision (between dWRMP24 and rdWRMP24) to the monitoring plan in Section 11.

Dead/emergency storage

CC.30 The Lower Thames Control Diagram assumes Emergency storage as 30 days' worth of storage under demand in a 1 in 100 drought and without any assumed demand savings. This reflects a total volume of 48503 Ml across the London reservoir system. Although aggregate London storage did not draw down as low as the emergency storage level, the challenges in West London described above led to concerns of reaching levels of storage in some individual reservoirs that could lead to difficulties retrieving or treating the water, while other reservoirs had not drawn down as low. Adjustments to sourcing to prevent further drawdown in some reservoirs were made to ensure potential issues of driving head or water quality did not become a supply issue. During this time, it became apparent that further understanding of constraints in individual reservoirs during drought is required to ensure these are carefully considered when planning our response and, if feasible as part of our short-term predictive modelling.

CC.31 Our current modelling assumptions are based on usable storage – this reflects our understanding of Restricted Top Water Level (i.e. the "dead" storage due to not being able to fill reservoirs to the very top to avoid risk of structural damage). The emergency storage level also accounts for this restriction and is considered appropriate. However, some of the assumed emergency storage will be at levels susceptible to turbidity and/or driving head issues, further work is required to clarify the extent of this and whether some of this should be considered "dead" storage. Determining the amount of currently "dead" storage, and assessing the need for investment to ensure our emergency storage assumptions are correct is required, including the need for pumping within the reservoirs at low levels.

CC.32 Overall, we currently consider that the aggregated emergency storage level and volume of available water in our reservoirs assumed in our modelling for WRMP24 is appropriate. However, having a better understanding of the individual constraints will ensure that we are adopting the appropriate strategy during periods of dry weather.

London Water Resource Zone integrity

CC.33 During the drought the challenges to meet demand in London and the difference in flow in the Lower Thames described above led to concerns around the integrity of the London WRZ. We remain assured that the Thames Water Ring Main (TWRM) provides integrity to the London WRZ by allowing treated water from our Large Processing Plants (LPPs) to be distributed around the network.

CC.34 As per Appendix A, and the Water Resources Planning guidelines, the supply and demand management within a WRZ should be self-contained such that the customers within that zone face the same risk and level of service. Had the challenges in the West London reservoirs in 2022 continued such that we were limited at Ashford Common WTW, this would not have impacted customers in just West London, but much of the customers across the London WRZs. This is because the water from Ashford Common WTW feeds into the TWRM in order supply the whole network (see Figure CC- 5). That is to say, although the reservoir storage systems faced differing issues between West London and Lee valley, the customers across these areas and throughout the London WRZ still face the same risk.

CC.35 There is however, some learning following the drought pertaining to adjustment of sourcing strategy and, as described, further understanding of variability of the river flows in the Thames and its tributaries and understanding of management of these rivers is needed to ensure we adopt the best strategy to supply London during periods of low flow. We also note that understanding of the constraints of each individual reservoir is key to adopting a flexible strategy during drought to ensure there is not a supply risk.

River Thames Scheme (RTS)

CC.36 There is an additional concern that the River Thames Flood Scheme could present additional risks during drought in the future (planned for construction by 2030), which need to be accounted for when we consider schemes to secure resilience of our London network. The aim of the River Thames Scheme is to alleviate flood risk. The development of RTS would involve new channels that bypass some of our key abstraction intakes in West London. This leads to further depletion of our ability to abstract where there were already challenges during the drought last year, as described above. There is also concern that there could be less available water in the river Thames, and heightened water quality issues following a drought. These factors are likely to heighten the drought risk that London faces and as such Thames Water will continue to liaise with the RTS team as we review the abstraction constraints experienced above Shepperton weir last year. Learning phases and checks have been added to our monitoring plan (See Section 11) to ensure we are taking these risks into account in our decision making.

Lessons and recommendations

Below we list the key learnings from drought and its impact in the London WRZ.

- The Thames Water Ring Main continues to provide integrity to the WRZ and its customers retain the same level of risk across the zone
- However, there was a difference in reservoir levels between the West London reservoirs and Lee Valley reservoirs, and so better understanding of the management and hydrology of the Lower River Thames is needed. Studies are underway to investigate this
- There is a need to ensure abstraction can be maximised where possible during periods of low flow. Thames Water needs to ensure asset health and flexibility is maintained and improved by continuing to follow the existing programme of maintenance and upgrades
- Storage in some reservoirs drew down to significantly low levels, prompting concerns around treatability and driving head. We need to improve understanding and awareness of constraints in individual reservoirs at low levels when we have abstraction restrictions
- Based on the further understanding of individual reservoir constraints, it may be useful to explore how these constraints are addressed in the Aquator model where the London reservoirs are currently aggregated, including assumptions around emergency storage

Thames Valley WRZs

CC.37 In this section the experience and learning from the 2022 drought is discussed for the Thames Valley WRZs, namely SWOX (Swindon and Oxfordshire), SWA (Slough-Wycombe-Aylesbury), Guildford, Kennet Valley and Henley.

SWOX (Swindon and Oxfordshire)

CC.38 During the drought, storage in Farmoor reservoir declined through July and August, reaching the lowest levels since 2003. Farmoor reservoir feeds two water treatment works (Swinford and Farmoor WTWs) which account for almost half of supply to SWOX while the other half is supplied by a number of groundwater sources. Sourcing strategy from Farmoor combined with outputs at the groundwater site were adjusted and optimised during the drought to alleviate pressure on the reservoir. The need for emergency licences, drought permit applications and adjusted sourcing in order to preserve storage and maintain supply to the SWOX WRZ have highlighted some challenges in the resilience of this WRZ, but also presented a learning opportunity through “stress testing” the network and our drought options.

Reservoir storage

CC.39 The rapid rate of decline combined with high demands led to concerns around the treatability at lower levels if the decline continued at such a rate through autumn 2022. Heavy rain in autumn stopped the decline and supported a quick recovery through November. However, the experience over the late summer provided an opportunity to learn more about the water quality and strategy for sourcing at lower levels of the reservoir. This learning has been documented for operational use in future droughts.

CC.40 At the operational level there are warning levels that indicate treatability of the water in the Farmoor reservoir could start becoming a problem (this is separate from the emergency storage level assumed in Aquator and discussed below). As the warning levels were approached, sourcing strategy was adjusted to limit risk, as-well as planning and preparation for further drawdown. This included testing of lower outtakes and conducting surveys of the basin. This improved understanding of our ability to pump and treat water at the lower levels within the reservoir and combined with the experience in London whereby reservoirs were useable at much lower levels we have gained more confidence in our ability to retrieve and treat water at low levels in the Farmoor reservoir.

CC.41 It remains that more understanding of the constraints and variability of these constraints is required, such as understanding if there are any differences in the individual reservoirs; the pumps at different levels and when potential air entrainment could become an issue; the degree of silting in the basin etc. Understanding these constraints will determine whether there is a degree of dead storage in the reservoir and inform whether our current assumptions around emergency storage in modelling need to be adjusted. However, based on the experience and improved confidence we have gained through the drought, we believe the 33% emergency storage level is appropriate.

Drought permits and emergency licences

CC.42 To alleviate pressure from the Farmoor reservoir, output from groundwater sources were maximised where possible. The need to meet exceptionally high demands combined with challenges with the Farringdon to Blunsdon main led to the need to make use of emergency licences and prompted applications for drought permits for the first time in over 30 years. Permits were applied for in Farmoor, Axford, Meysey Hampton and Baunton. Of the four permits applied for, Farmoor was granted on the condition that a minimum of 54Ml/d of flow in the River Thames at Farmoor was maintained. Although this permit was issued and in place until March 2023, the heavy rainfall through autumn and winter meant we did not use it. Applications for the remaining permits were eventually withdrawn in November when heavy rainfall reduced the need for them. Our experience has not led to the identification of new drought permits being required, although some improvements to the process of permit applications are being scoped, such as updating the “shelf-ready” EARs (Environmental Assessment Reports).

Other WRZs

CC.43 In the other WRZs in our supply area, we were able to supply enough water to meet demand, though with some challenges for example in the Kennet Valley WRZ where process capacity issues at Fobney coincided with reduced output at Pangbourne due to flow constraints during a period of peak demand. A number of projects have been scoped in order to improve the resilience of our assets across the supply area, some are set out in the Improving resilience section. It should also be noted here, with regard to Water Resource Zone integrity, that as per Appendix A we consider our current boundaries for all Thames Valley WRZs to be appropriate and that our customers within these zones continue to experience the same level of risk.

Lessons and recommendations

Below we list the key learnings from the 2022 drought in relation to its impact in the Thames Valley WRZs.

- Experience in the SWOX WRZ highlighted some challenges in the resilience of this WRZ which necessitated the application of drought permits and use of emergency licences to ease operational demand from the Farmoor reservoir.
- Drawdown of Farmoor reservoir in drought presented an opportunity to "stress test" the network and our ability to retrieve and treat the water at low levels. We should aim to further this learning to better understand the constraint and variability in the reservoir and whether this has any influence on our current emergency storage level.
- There were challenges with the Farringdon to Blunsdon main which put further pressure on groundwater sources. A programme of upgrades to the main is already underway and is continuing.
- Improvements to the preparations of drought permits would make the process more efficient through the upgrade of shelf ready EARs. This work is already underway and is continuing.
- In other WRZs, some challenges were met during the drought with some sites meeting process capacity issues or outages for other reason, Thames Water should continue with ongoing projects to improve the resilience of sites across the Thames Valley WRZs.

Availability of sources and Deployable Outputs

CC.44 The water currently available for supply (as Deployable Output (DO)) and assessed differences between WRMP19 and rdWRMP24 are discussed in detail in Appendix I of the WRMP24. This section reflects on any updated understanding of DO following the 2022 drought.

Source Deployable Outputs

CC.45 During the reporting year 2022-2023 the source Deployable Outputs at two sites in the SWOX WRZ were revised, these reductions related to existing ongoing issues which were highlighted further during the drought.

CC.46 Gatehampton source DO has been reduced due to control issues resulting from a misalignment between the booster pumps at Cleeve WTW and the borehole pumps at Gatehampton, meaning that peak licensed output can't be realised. The water quality challenges that arise when Gatehampton boreholes trip, caused by turbidity on start-up, are being addressed by a new permanent run to waste (RTW). The design is being progressed, and the Environment Agency is being consulted to make sure that the proposal is acceptable. The expectation is that the RTW will be fully operational prior to summer 2024. The Gatehampton RTW will improve site resilience, however the booster pumps at Cleeve WTW need to be upgraded in order to fully recover the source DO. This work is linked to the provision of a RTW at Cleeve WTW. The solution is challenging due to the location of the WTW, and various options have been investigated. A preferred solution has been identified, however due to long delivery times on key items, it is not expected that the DO will be recovered until early in AMP8.

CC.47 Chinnor suffers with high iron and associated high turbidity, and it has been necessary to restrict use to times of high demand to minimise the risk of water quality impacts on the network. The AR23 source DO reflects the operational use during this 12-month period. Chinnor WTW was issued with a DWI Notice in November relating to iron and turbidity. Work is currently being carried out to enable continuation of the short-term mode of operation, whilst a treatment upgrade is being designed to provide a permanent solution. An outline design has been proposed, with an expected completion and associated recovery of source DO in Year 2 of AMP8.

CC.48 Note that these reductions were made as part of our business-as-usual review of Deployable Outputs for annual reporting. As a result of the timing of this, these reductions have not been captured as part of our supply forecast in rdWRMP24.

Strategic Schemes

North London Recharge Scheme (NLARS) and Chingford artificial Recharge Scheme (CHARS)

CC.49 A small number of NLARS boreholes were abstracting from 6th July 2022 and pumping into the New River to support flow during a tunnel inspection. The escalation of dry weather and crossing of Level 1 on the lower Thames control diagram on 21st July led to the use of the NLARS and CHARS boreholes during drought. The CHARS boreholes began supply from 13th July, with NLARS boreholes commencing supply from 25th July.

Ramp up of the schemes continued through the summer supporting reservoir storage and ability to meet demand in the Lee Valley. It is noted that the output of NLARS and CHARS during the drought should be reviewed against the Deployable Output, however there is some uncertainty associated with the scheme captured in target headroom in our supply demand balance planning.

CC.50 NLARS and CHARS use ceased before the end of November 2022 and recharge of the aquifers commenced in late December 2022, continuing through winter and spring until the beginning of June 2023. An assessment of aquifer storage took place once in December a few weeks after abstraction ceased, and once again in mid-June a few weeks after recharge ceased. The storage assessment is set out in Table CC-4, showing that following abstraction during drought the storage reduced by ~20% of capacity, and then storage was restored by early summer 2023.

Date of assessment	Storage: Enfield-Haringey (New River)	Storage: Lee Valley
March 2021	98%	98%
December 2022	79%	79%
June 2023	95%	99%

Table CC-4: State of aquifer storage before and after use of NLARS and CHARS

CC.51 Overall use of the NLARS (and CHARS) scheme was successfully implemented during drought and provided valuable resilience to the Lee Valley reservoir system. The aquifer has been successfully recharged and remains available for future droughts. Following use of the scheme it may be useful to review the average and peak output of the schemes against our Deployable Output and level of uncertainty captured in headroom for supply demand balance planning.

West Berkshire Groundwater Scheme (WBGWS)

CC.52 The need and operation of WBGWS was discussed with the EA from August 2022. Following agreement for the site's use and some delays to operation, the scheme commenced in late October. The schemes can provide a benefit to the River Kennet which is passed on to the River Thames, allowing for increased abstraction in the Lower Thames. In 2022 the scheme ran for a total of 30 days. With coincident heavy rain and limited operation time, there is limited understanding of the benefit that the scheme provided in October/November 2022. It would be useful to reflect on the lead time experienced in getting the scheme operational in 2022 and to test the operation of the scheme in order to gain a practical understanding of the benefits the scheme can provide to abstraction in both the Lower Thames and the River Kennet and to test the Deployable Output.

Old Ford and Stratford Box

CC.53 Old Ford and Stratford Box boreholes were unavailable for supply during the drought. However, some trials were conducted during 2022, confirming that the water quality is of an acceptable level for treatment at Coppermills WTW. The remaining issues relate to a lack of working safety features required for operation at Stratford Box. A programme of work to upgrade these features and recommission the site has been set out, with expected completion in the summer of 2024.

Thames Gateway WTW

CC.54 Thames Gateway desalination plant (Thames Gateway WTW) was not available during the drought. This was due to an electrical fire in the late autumn of 2021, and then a planned outage in May 2022 to carry a second phase of AMP7 investment. At this time the risk was assessed of a planned outage of the plant and was seen as low risk assuming no extreme dry weather event. As it is now known, an 'exceptional drought' started in the summer of 2022, with the Thames Gateway desalination plant then not available. Due to weather patterns and support of NLAR/CHARS the Lee Valley London reservoirs were at good levels throughout the drought leaving a limited need for the Thames Gateway desalination plant.

CC.55 Following the onset of the drought, key elements of the 'Phase 2' work, targeting health and safety improvements, were fast tracked to aim for a February 2023 return to supply at up to 50 Ml/d. Following the identification of a failure in one of the joints on newly installed air pipework (that led to the air main pipework and fittings needing to be being replaced) this work was completed in May 2023, in line with the revised timescales that were shared with stakeholders in January.

CC.56 As the plant was being test run ready to be placed into supply we became aware of national issues with carbon dioxide stocks. This is used to remineralise the water to make it fit for human consumption. As stocks were not delivered the plant could not be placed into supply until supplies reached the required stock level and testing could be completed. The Thames Gateway Desalination plant was successfully tested at 25 Ml/d in July 2023.

CC.57 We will continue to keep stakeholders and regulators informed of developments at our Gateway WTW.

CC.58 With the completion of this 'fast track' phase, a further 'non fast track' stage of phase 2 will continue during the AMP7 so that the plant is able to operate at a reliable 50 Ml/d. This work includes improved Reverse Osmosis (RO) racks leak collection and drainage, improved undercroft drainage and floor surface upgrades, and design and procurement activities for chemical improvement works.

CC.59 It has also been noted that we are awaiting DWI accreditation of new Reverse Osmosis membranes to enable the site to produce more than 50 Ml/d. The sole laboratory used by DWI for Regulation 31 testing is moving premises, which has delayed their previously advised June 2023 Regulation 31 approval date for the new RO membranes. Enquiries have concluded that it will be 6-12 months before the new lab will be able to start re-testing for Regulation 31 purposes. The new RO membranes, which can only be manufactured post Regulation 31 approval, are estimated to arrive 3-6 months post Regulation 31 sanction. These timelines indicate that the site could be limited to 50 Ml/d until after summer 2024. Discussions with DWI, the lab and the membrane supplier are ongoing.

CC.60 During 2022 we reviewed and revised the Deployable Output of the plant. It became apparent that the plant itself would not be able to achieve a Deployable Output of 100

Ml/d. Meetings were held with the EA, Defra and Ofwat to review this decision to reduce the Deployable Output to 50 Ml/d in our water resources modelling. This has also been taken into account in our WRMP24 planning, with further funding included in our PR24 business plan to improve the capability and resilience of the plant to provide a Deployable Output of 75 Ml/d by 2030.

East London Resource Development schemes (ELRED)

CC.61 Following recommissioning of the site in late summer of 2021, the ELRED scheme was operating into supply for most of 2022. The site provided valuable resilience throughout the drought as it provides water direct to supply zone, alleviating pressure from Coppermills WTW. Following the drought, the site has continued to run. If it is valuable and feasible to operate the scheme outside of drought then, it would be useful to reflect on operation of this scheme going forwards.

Lessons and recommendations

Below we list the key learnings from drought and its impact on source availability and declared Deployable Outputs (DO).

- Some sites have had their Deployable Outputs updated following the drought and business-as-usual review for annual reporting. Where the Deployable Output of sites (including strategic drought schemes) have been revised, planned work should continue at these sites to recover the loss of DO.
- The West Berkshire Groundwater Scheme was used for the first-time during drought, albeit for a short period due to heavy rainfall and flooding risks. Collaboration with the EA to consider test running the site would be beneficial, in order to gain a practical understanding of the scheme benefit.
- The NLARs and CHARs schemes provided valuable resilience to the Lee Valley system during the drought. A review of the observed output against the Deployable Output and assumed uncertainty captured in supply demand headroom may be useful.
- Thames Gateway and Stratford Box were not available during the drought and are undergoing upgrades, these upgrades should continue to ensure the schemes are available for supply as per the planned programme of work.
- The ELRED scheme has been operating into supply continuously following the drought and has proven, that when running smoothly, it is a valuable source of resilience for the London WRZ during both drought and normal conditions. We should reflect on the use of the scheme and confirm its operation strategy going forwards.

Outage

CC.62 Appendix J sets out the approach to calculating outage allowance and our baseline WRMP24 outage allowance. This section briefly compares the reported actual outage this year, with our rdWRMP24 outage allowance, to assess whether outages during the drought have impacted the level of risk that we should be capturing.

CC.63 A comparison of AR23 actual outage and rdWRMP24 outage allowance shows that while there is some variation, outage allowance is generally similar to actual outage. This suggests our outage allowance is capturing an appropriate level of risk including during drought periods.

CC.64 Some differences in Actual Outage AR23 and Outage Allowance forecast can be seen. During the drought many sites were maximised and performed as required during the drought. Some ongoing issues were highlighted during this period, such as at Chinnor and Gatehampton, where Deployable Outputs have been reduced as a result (thereby reducing the outage contribution). Some sites such as Latton did have unforeseen challenges such as a power failure during the summer, these types of events led to the critical period actual outage being higher for this year, particularly in the SWOX WRZ. At SWA, actual outage has reduced in comparison with outage allowance due to recent reductions in outages at Hawridge and Hampden, as well as a DO reduction at Hampden. There is also a reduction in the London actual outage owing largely to the write-down of the Thames Gateway WTW DO for this reporting year.

CC.65 While the degree of outage this year was not particularly abnormal, we aim to have all our sites available for supply as needed. While unforeseen challenges can always happen, we should continue to complete work outlined in our maintenance programmes to improve resilience and minimise the likelihood of unplanned outages as-well as reduce the impact if either planned or unplanned outages occur during the year.

Lessons and recommendations

Below we list the key learnings from comparing outage for reporting year 2022-23 with our rdWRMP24 outage.

- Last year's reporting year actual outage was similar to outage allowance, highlighting that we are capturing an appropriate level of risk in our supply demand balance planning.
- Continue with work already outlined to reduce the likelihood of unplanned outages occurring and reduce the impact on supply if unplanned or planned outages do occur.

Demand forecast

Distribution Input

CC.66 As per Section 3, our base line demand for WRMP24 has been produced based on 2021-22 dry year distribution input (DI). These values are generally higher than WRMP19 forecast. A comparison of dry year DI for 2022-23, with WRMP24 shows similar results. This reporting year's observed demand has been uplifted to a 1 in 10 'dry year' (method described in S3 and Appendix H). Observed critical period demand was high in some WRZs following the drought event over the summer leading to increased usage and dry weather leakage. Uplift volumes are therefore small or in some cases negative because the observed year was around or near to a 1 in 10 year. Impacts of COVID-19 on demand continue to be challenging to quantify with confidence to include in our demand forecast, and so uncertainty is captured within target headroom. In the long-term, work is needed to understand the any lifestyle change and resultant impact on demand over a longer period following the pandemic.

Demand savings – Temporary Use Ban

CC.67 Following the prolonged dry weather over the summer, a Temporary Use Ban (TUB) was implemented from 24th August 2022 (announced 17th August) until 22nd November 2022. Prior to the TUB and throughout the duration of the ban, we implemented media campaigns to communicate to our customers the importance of water efficiency. While there was a reduction in demand at the time, work is required to understand the impact that the TUB and media campaigns had on demand alongside changes in weather and other factors influencing customer demand.

CC.68 The current assumed benefits in our WRMP are based on the following:

- Assessment of demand saving benefits from the 2006 TUB
- Updates to assessments of demand savings based on changes in legislation around the scope of TUB that were made in 2010
- Updates to assessments of demand savings benefits based on understanding of improvements to leakage reduction

CC.69 The benefits experienced in 2022 could be different to our current assumptions for a number of reasons:

- Changes in patterns of demand responses – PCC has likely reduced with efforts over the last couple of decades to increase water efficiency
- Understanding of power of TUBs and previous changes in legislation - Previous assumptions of benefits would have been based on limited real data, as TUBs do not occur regularly
- Timing of implementation of TUB – We introduced the TUB in late August, at a time where the benefits are naturally likely to be lower than in June or July as many customers are away on holiday. It also began to rain heavier in August which would have naturally reduced usage

CC.70 In terms of our supply demand balance planning, target headroom includes allowances for uncertainties in our demand forecast. However, we need to investigate the factors that influence customer demand and the benefits of demand saving measures in order to ensure our demand and supply forecast reflect the latest understanding going forwards.

Leakage

CC.71 Table CC-5 shows our annual average outturn leakage for 2021-22 and 2022-23 alongside our target reduction between the same two years. As per our WRMP AR23 report, provisional company annual average outturn leakage increased by around 4%, while the target outcome was a reduction of around 9%.

Out-turn year Total Leakage (Ml/d)	2021-22	2022-23	Change	AMP8 Target reduction 2021-22 to 2022-23
Total leakage	593.8	619.7	+25.9	-51.6 (-9%)

Table CC-5: Summary of 2021-22 and 2022-23 outturn total leakage

CC.72 Leakage increased during the drought when hot and dry weather lead to increased Soil Moisture Deficit (SMD), causing increased groundwater movement and resulting in more dry weather bursts than normal. Leakage also increased during the winter when exceptionally cold weather resulted in freeze-thaw bursts. These did not cause an immediate impact on water resources. The risk experienced was more from the capability of our treatment and distribution network to keep up with a short-term demand need.

CC.73 Our planning includes for a level of in-built protection from hot summers and cold winters, and the expected impact on water demand, where we consider shorter term 'critical periods' of water demand. We include target headroom to provide protection to a number of factors explained within the plan, including under-delivery of options, availability of water etc. However, these extreme events in both summer and winter could become more frequent and it would be prudent to consider such events in our planning scenarios.

Leakage reduction and resilience

CC.74 We have reviewed our operational response to the type of events described above. Improvements include optimising capability at our treatment works, ensuring our service reservoirs are as full as possible to deal with the short-term demand, having extra leakage gangs available to deal with any outbreak of visible leaks, ensuring technicians are available for any assets failing, such as pumps tripping out, and tankers/bowsers etc are on standby to deal with any network pressure shortfalls and ensuring our register of vulnerable customers is up-to-date to keep these people in supply.

CC.75 We undertake a comprehensive water resilience assessment process which identifies components of our water supply systems which do not have the required redundancy, resistance, recovery and/or reliability to prevent an unacceptable impact to customers being realised when fault occurs. This process is a continuation of our work with Ofwat on the AMP7 Water Supply System Resilience Programme Conditional Allowance (WSSRP).

CC.76 Through the resilience assessments we identify critical components of our water systems and identify those hazards to which those system components are vulnerable. These hazards, or failure modes, include extreme heat, freeze events and flooding. Extremities in temperature and rainfall present new failure modes to our critical assets and exasperate existing failure modes.

CC.77 It is our 2050 ambition to develop a resilient network for our customers that achieves no major supply interruptions. A major supply interruption is defined as a supply interruption greater than 48 hours once in a customer's lifetime. We have a water supply resilience long-term delivery strategy (LTDS) which has been designed to mitigate known resilience risks and deliver our 2050 ambition. Low and high climate change scenarios were used in our adaptive planning and the selection of the LTDS core pathway. We are looking to address the deteriorating high lift pump station at Coppermills WTW that supplies c500Ml/d in North London as part of our LTDS.

CC.78 We are reviewing any future improvements to our longer-term water resources planning with the expectation that climate change is likely to cause hotter summers. At the same time we are improving our communication with our customers to manage demand and attempt to reduce peaks during such events, which will improve the enhanced media campaigns within our Drought Plan.

Planning scenarios

CC.79 As it stands, we include both an annual average and critical period in our planning scenarios, for almost all WRZS, but do not use critical period for the London WRZ. This is because the Thames Water Ring Main, and large volume of stored raw water provides flexibility and a means to distribute water around the WRZ to meet peak demands. The constraint to meet peak demands lies in treatment and transmission capabilities. As mentioned in the London WRZ, despite the significant drawdown of storage in some reservoirs, we were still able to distribute water around the network to supply customers around the zone. As such, in our WRMP24, we maintain the use of DYAA planning for all zones and DYCP planning for the Thames Valley zones only where weather related demand patterns in the summer dictate the critical period.

CC.80 However, with the rise of increasingly severe and frequent freeze-thaw and hot weather events, our consideration is that we should further investigate whether inclusion of DYCP scenario(s) for London would be appropriate within WRMP29. It would also be prudent to explore different durations and types of peaks. Such as a cold weather peak to capture leakage driven demand in the winter, as well as exploring longer peaks as opposed to a peak weak. This could be useful to explore as prolonged dry weather is more likely to impact capability at groundwater sources that are water level constrained than a short increase in customer demand. We will review our DYCP planning scenarios for the next WRMP (WRMP29).

Lessons and recommendations

Below we list the key learnings relating to our demand forecast and demand during drought.

- Media campaigns and TUBs were implemented over the summer to reduce customer demand, work is needed to assess the benefit of this and understanding of changes in customer demand patterns
- During 2022 we experienced higher leakage following the hot summer as-well as freeze-thaw in the winter. These types of events are likely to become more frequent. We should continue to make improvements to our ability to respond to leakage events and to maintain supply during events. As well as continuing to make improvement to our network resilience to reduce the likelihood of leakage events.
- With the rise of such events and variability in weather patterns, we should explore different types of critical period planning scenarios, such as winter peaks and longer summer peaks
- The TWRM and stored water continues to provide flexibility to meet London demand, however with increased likelihood of hot weather events, we should consider DYCP planning in the London WRZ

Bulk Supplies

Essex and Suffolk Water

CC.81 During the drought, we engaged and cooperated with Essex and Suffolk Water well on bulk supplies. There is an agreement in place (as described in the Drought Plan) such that Thames Water will reduce this export by 25% if Thames Water have a TUB in place and Essex and Suffolk Water do not. For more severe droughts there isn't a specified agreement, this flexibility is beneficial in order to make decisions at the discretion of the two parties. However, this severity has not occurred yet and the flexibility and agreements that could be made need to be tested to provide re-assurance in the agreement.

CC.82 There is also an additional variation in the agreement with Essex and Suffolk that allows us to request a further reduction in export. This agreement is in place until 2035 and provides us with a benefit of 23 Ml/d (based on DO modelling). However, we did not make use of this agreement during the drought, and it is not clear at what point it would have become most beneficial to use during the 2022 drought. It would therefore be useful going forwards to assess when this reduction would provide a valuable benefit and define a trigger for when to implement it.

Affinity Water

CC.83 During the 2022 drought, Thames Water had a TUB in place while Affinity did not – although Affinity Water also had challenges meeting demand at this time as well as during the freeze-thaw event. Thames water provided the exports required, but there was a need to reduce these exports to ensure supply to our customers and couldn't within the current agreements in place. At an operational level, Thames Water is managing production planning and encouraging engagement with Affinity Water so that in the future requests can be well accounted for in the regular planning sessions (weekly/monthly/annual). Following the experiences during the drought and the freeze-thaw events it has become apparent that the agreements with Affinity need to be reviewed to ensure clear triggers are in place for when to reduce exports and to ensure requests are made within a timely manner.

Didcot agreement

CC.84 We are aware that RWE has reduced abstraction requirements following the closure of Didcot A power station but maintains its existing full abstraction licence with Environment Agency agreement. Our agreement requires us to inform RWE when we would look to utilise their abstraction licence if we required to utilise this volume of water downstream. There is not a specific set of triggers for when to implement the agreement, and we did not make a formal request to RWE during the drought last year. Going forwards, we will consider the need for trigger(s) to allow us to inform RWE if and when this volume of water is being utilised (during both Business-As-Usual and under licence constraints in periods of low flow).

Lessons and recommendations

Below we list the key learnings relating to the use of bulk supply agreements during drought.

- Our collaboration and use of the agreement with Essex and Suffolk water was effective during drought. It would be useful to explore in more detail the possible outcomes during a more severe drought, given the currently flexible guidance in the agreement.
- There is an additional variation in the agreement with Essex and Suffolk which allows us to request further reductions in export. We did not use this agreement during the drought and it is unclear when we should have implemented it. It would be useful to consider developing triggers for implementing this variation.
- Our agreement with Affinity Water does not allow sufficient flexibility to reduce exports when supply to our own customers is at risk. Further clarifications of the agreement, including triggers for reduction in exports would be useful. As well as continued collaboration at an operational level to ensure both parties' needs are embedded within the planning process.
- We did not make use of the Didcot agreement with RWE during the drought. More work is needed to better understand RWE's abstraction and as such the benefits from the agreement that could be used. Clearly defined triggers to implement this agreement would be useful, and we will look to develop these.

Drought Permits

CC.86 During the drought Thames Water prepared applications for four drought permits in the SWOX WRZ. The experience of this has shown that the drought permits as set out in our Drought Plan are sufficient. However, the process for preparing the permits is complex and arduous, noting the lead time between the need for application of drought permits and the consultation period.

CC.87 Guidance in our Drought Plan indicates that we should aim to submit applications when flow in the Thames at Farmoor is below 200 Ml/d, with implementation of drought permits when storage is below 70% or 60%, as set out in Table CC-6. River flows reached 200 Ml/d in early August, while storage reached 70% in early September, and 60% in mid-October. We began preparations for drought permit applications over the summer, in line with our move to DEL3 in August. Applications were submitted for consultation from September through October. While the submissions of applications were sometime after flows reduced below 200 Ml/d, it is noted in our Drought Plan that flows can recede below 200 Ml/d in normal conditions, as such these triggers are coupled with the DEL3 or DEL4 criteria.

Determined action	River Flow trigger (Thames at Farmoor)	Reservoir storage trigger (Jun – Jul)	Reservoir storage trigger (Aug- Sep)	Drought Event Level
Submission of application date	≤ 200 Ml/d	NA	NA	DEL3 or DEL4
Implementation of permit date	≤ 100 Ml/d	≤ 70%	≤ 60%	

Table CC-6: Triggers to determine submission of drought permit application or implementation of permit, as set out in Drought Plan

CC.88 The process of preparing, submitting and consulting on the drought permits in 2022 has highlighted where improvements could be made, with the majority of the focus on updating the existing "shelf-ready" EARs. Improvements to the report format and assessment methodology are being discussed with the EA, with the aim of reducing the amount of additional work that would need to be done at the time of submission. Work on this has already begun, with the Baunton drought permit being a test case to be reviewed by the EA.

CC.89 We are also aware there is need for new infrastructure in order to enable some of these permits – such as back pumping to support use of the Farmoor drought permit. These projects are being scoped and are captured as part of our various programmes to deliver maintenance work, upgrades and new projects. This includes work required to improve resilience of the Farringdon to Blunsdon main, upgrades here are likely to reduce our reliance of emergency licences during prolonged dry weather events.

Lessons and recommendations

Below we list the key learnings relating to the use of bulk supply agreements during drought.

- The drought permits set out in our Drought Plan are sufficient
- Improvements to the "Shelf-Ready" Environment Assessment Reports (EARs) would be useful to enable efficient processing of drought permit applications. Preparation of this is underway in liaison with the EA and should be continued
- Schemes such as back pumping are required to ensure the Farmoor drought permit can be used during periods of low flow, we should continue to support the coping of this project and any other similar projects that are already underway

Improving resilience

CC.90 Several schemes have already been identified - some following the experience during the 2022 drought and others already prior to drought. Many of these projects are underway or are being scoped through a number a studies to ensure a feasible and beneficial approach is taken to develop a scheme. These projects are captured below.

Lower Thames Back pumping over Teddington, Molesey and Shepperton weir.

CC.91 It was noted that during the drought there was reduced availability of water for abstraction in the upper reaches of the Lower Thames. While there is need to investigate further on why this was the case, potential solutions are also being scoped as part of our maintenance and upgrades programmes. One such solution is to pump water from a point downstream of Teddington weir, upstream to Molesey weir and potentially further upstream to Shepperton Weir. The aim of this is to increase ability to abstract upstream of Molesey weir and potentially upstream of Shepperton weir, as well as improve ability to abstract down to 300 Ml/d TTF.

CC.92 Studies are currently underway to better understand what benefit could be achieved from back pumping over each of these weirs under a variety of scenarios including a repeat of 2022.

Back pumping for Farmoor Upper Thames back pumping

CC.93 While we did not use the drought permit granted for Farmoor. It is noted within our Drought Plan that back pumping may be required in order to make the best use of the permit. This is because the Farmoor surface water permit enables us to abstract additional water above the volumes we are normally licenced to take. The proposal is that back pumping from downstream to upstream of the River Thames abstraction point at Farmoor would ensure there is sufficient water to enable increased abstraction at Farmoor reservoir intakes without breaching and low flow constraints. Planning and scoping of the back pumping scheme is currently on going as part of maintenance and upgrades programmes.

Upgrades to the Farringdon to Blundson Main

CC.94 Following the drought of 2022 Thames Water has considered the requirements in relation to its network operation around Farmoor and the principal issue relates to the Farringdon to Blunsdon water main which is being uprated. This work is on track to be completed by the end of December 2023. Our other supplies around Farmoor and in SWOX WRZ are available for supply.

Deephams reuse

CC.95 Deephams re-use is currently in the rdWRMP24 as an option from 2060 - a change from WRMP19 following investigation and engagement with the EA regarding the environmental impact of this option. We continue to assess the feasibility of this option and whether it should be considered as a more Before Level 4 or Drought Permit option.

Datchet RWPS

CC.96 There is a challenge at certain levels in the river we cannot abstract without over-abstracting and therefore need to cease abstracting at the site completely. This is particularly had an impact in West London during the 2022 drought where constraints upstream of Shepperton weir limited abstraction into some of our larger reservoirs. Work has been scoped to improve flexibility at Datchet RWPS so that we can have finer control of the amount we abstract, enabling the ability to abstract small amounts during periods of low flow. This programme of work is planned for completion at the end of AMP7.

Stratford box and Old Ford

CC.97 A programme of work to upgrade the required safety features at Stratford Box and recommission is underway, with expected completion of the programme in the summer of 2024.

Thames Gateway

CC.98 As discussed in the Availability of sources and section. Thames Water will continuing progressing with "Phase 2" of the investment and maintenance to the desalination plant through AMP7, with the aim of the capability of the plant to reach 50 Ml/d and through further investment in AMP8, the aim is to have the plant operate at 75 Ml/d by 2030.

Other projects

CC.99 There are several other projects captured in our maintenance and upgrades programmes that are ongoing. These will either project a direct benefit of additional supply in an area or improve the general resilience of assets. These include projects to potentially bring disused sites back online, securing VSDs (Variable Speed Drives) and other pumps to enable pumping at lower volumes and assessing where there could be single points of failure and so upgrading treatment resilience at some of our LPPs (Large Processing Plants).

Overall learning points and recommendations

This appendix set out to review several aspects of our supply system, drought measures and supply demand balance planning, outlining lessons to take to improve our drought response, resilience and planning. There are number of learning points that have been highlighted, key learning points are:

- In London, there was a difference in individual reservoir storage depending on its placement along the Lower Thames. Better understanding of the management and hydrology of the Lower River Thames is needed. This understanding may inform drought strategy and longer-term resilience planning, as per learning phases and checks described in our monitoring plan.
- Across all zones, a review of the flexibility of abstraction assets is needed to ensure abstraction can be maximised where appropriate, this will be done through continuation of ongoing asset health and maintenance programmes.
- Similarly, resilience of sources across WRZs should be reviewed. Where appropriate, Deployable Outputs may be revised, resilience projects and considering development of new schemes should continue. This includes understanding operational and benefit of strategic drought schemes and continuing with planned refurbishments.
- Further work is needed to understand the benefit of various demand savings measures and any changes in customer demand patterns.
- With the rise of more extreme weather events (cold winters, hot summers) leading to increased demand, we plan to explore different planning scenarios for Dry Year Critical Period to capture such events.

Table CC-7 lists all the key learning points throughout this appendix, noting the recommended action and whether this should be captured within the Drought Plan or Water Resources Management Plan, or whether it is a learning that should be carried out but may not directly fit into either the next Drought Plan or WRMP (‘internal’). It should be noted that for the Drought Plan these recommendations will need to be scoped in more detail to assess whether they require material changes and therefore consultation.

Topic	Learning point	Recommendation	Internal	Drought Plan	WRMP24	WRMP29
Severity and modelling of drought and our response	Modelling of the Farmoor reservoir during drought showed less drawdown of storage than observed in 2022. Due to overestimation of river flows in the model and maximised DOs and abstractions.	Investigate the gap between modelled and observed further to assess whether adjustments may be needed in the model, in our operational strategy and/or to our Deployable Outputs.	✓			
	Modelling of London reservoir storage during the drought showed faster recovery of storage than observed, this is due to water quality constraints in abstraction with intense rainfall over the recharge period.	Investigate what can be done to improve our ability to recover storage during periods of intense rainfall following a drought, whilst ensuring we continue to supply wholesome water.	✓			
London WRZ Integrity & Resilience	Thames Water ring Main continues to provide integrity, however better understanding of the management and hydrology of the Lower River Thames is needed.	Further understanding around the operation and hydrology of the Lower Thames to support sourcing strategy during drought and ongoing resilience projects.	✓	✓	✓	✓
	There is a need to ensure abstraction can be maximised where possible during periods of low flow.	Thames Water needs to ensure asset health and flexibility is maintained and improved by continuing to follow the existing programme of maintenance and upgrades. This includes studies scoping the benefit of Lower Thames back pumping. We will continue to investigate the abstraction constraints above Shepperton weir.	✓			✓

Topic	Learning point	Recommendation	Internal	Drought Plan	WRMP24	WRMP29
	Storage in some reservoirs drew down to significantly low levels, prompting concerns around treatability and driving head.	We need to ensure understanding and awareness of constraints in individual reservoirs at low levels when we have abstraction restrictions.	✓			
		It may also be useful to explore how these constraints are addressed in the Aquator model where the London reservoirs are currently aggregated, including assumptions around emergency storage.	✓			
Thames Valley WRZs Resilience	Experience in the SWOX WRZ highlighted some challenges in the resilience of this WRZ which necessitated the use of drought permits and emergency licences to ease operational demand from the Farmoor reservoir.	Thames Water to review the resilience of sites across the SWOX WRZ.	✓			
	Drawdown of Farmoor reservoir in drought presented an opportunity to "stress test" the network and ability to retrieve and treat the water at low levels.	We should aim to further this learning to better understand the constraint and variability in the reservoir and whether this has any influence on our current emergency storage level.	✓	✓		✓
	In other WRZs, some challenges were met during the drought with some sites meeting process capacity issues or outages for other reason.	Thames Water to review the resilience of sites across the Thames Valley WRZs, and continue with ongoing projects which aim to improve this.	✓		✓	✓

Topic	Learning point	Recommendation	Internal	Drought Plan	WRMP24	WRMP29
Drought Permit Applications and Infrastructure	Improvements to the preparations of drought permits could be made more efficient through the upgrade of shelf ready EARs.	Continue improvements to "Shelf-Ready" EARs, in liaison with the EA with the aim of expediting the process.	✓	✓		
	Investment in infrastructure to ensure benefit of drought permits can be used	Continue with planning and scoping of Farmoor back pumping scheme.	✓	✓		
Availability of sources and Deployable Output	Some sites have had their Deployable Outputs updated following the drought and business-as-usual review for annual reporting.	Where the Deployable Output of sites (including strategic drought schemes) have been revised, planned work should continue at these sites to recover the loss of DO.	✓			✓
	The NLARs and CHARs schemes provided valuable resilience to the Lee Valley system during the drought.	A review of the observed output against the Deployable Output and assumed uncertainty in headroom may be useful.	✓			✓
	The West Berkshire Groundwater Scheme was used for the first-time during drought, albeit for a short period due to heavy rainfall and flooding risks.	Collaboration with the EA to consider test running the site would be beneficial, in order to gain an improved understanding of the scheme benefit.	✓	✓		
	Some strategic drought schemes were not available during drought. Namely Thames Gateway and Stratford Box as they are undergoing upgrades.	These upgrades should continue to ensure the schemes are available for supply as per the planned programme of work.	✓		✓	✓

Topic	Learning point	Recommendation	Internal	Drought Plan	WRMP24	WRMP29
	ELRED provided a useful benefit during both drought and normal conditions.	We should reflect on the use of the scheme and confirm it's operation strategy going forwards.	✓	✓		
Outage	Last year's reporting year actual outage was similar to outage allowance, highlighting that we are capturing an appropriate level of risk in our supply demand balance planning.	Continue to track actual outage as part of BAU supply demand balance analysis.	✓			
		Continue with work already outlined to reduce the likelihood of unplanned outages occurring and reduce the impact on supply if unplanned or planned outages do occur.	✓			✓
Bulk Supply Agreements	Collaboration and use of the agreement with Essex and Suffolk water was effective during drought.	It would be useful to explore in more detail the possible outcomes during a more severe drought, given the currently flexible guidance in the agreement.	✓	✓		✓
	We did not make use of the additional agreement with Essex and Suffolk to reduce export.	It would be useful to consider triggers for implementing this variation.	✓	✓		✓
	We did not make use of the Didcot agreement with RWE during the drought.	More work is needed to better understand RWE's abstraction and as such the benefits from the agreement that could be used. Clearly defined triggers to implement this agreement may also be useful.	✓	✓		✓

Topic	Learning point	Recommendation	Internal	Drought Plan	WRMP24	WRMP29
	Essex and Suffolk transfer - smooth operation of agreement during drought of 2022, but had the conditions continued to deteriorate further agreement would have been needed which are currently flexible in the agreement. Stress testing may be useful.	Review whether stress-testing the agreement under "unusual drought" scenarios would be beneficial in order to determine the nature of the fair apportionment that would be needed.	✓	✓		✓
	Agreement with Affinity Water does not allow sufficient flexibility to reduce exports when supply to our own customers is at risk.	Further clarifications of the agreement, including triggers for reduction in exports would be useful. As well as continued collaboration at an operational level to ensure both parties' needs are embedded within the planning process.	✓	✓		✓
Demand forecast	Assessment of benefit from Temporary Use Ban (and other demand saving measures) is needed.	Continue assessment and developing understanding of customer demand patterns and resulting benefit from demand saving measures. Align understanding to the WaterUK review.	✓	✓		✓
	Leakage for this reporting year was higher than planned due to hot summer as well as a very cold winter. These events are likely to re-occur.	We should continue to make improvements to our ability to respond to leakage events and to maintain supply during events. As well as continuing to make improvement to our network resilience to reduce the likelihood of leakage events.	✓			

Topic	Learning point	Recommendation	Internal	Drought Plan	WRMP24	WRMP29
	With the increasing frequency and variability of hot or cold weather events, we should explore different types of critical period scenarios.	We should explore longer summer peaks and cold weather winter peaks in our planning scenarios.	✓			✓
	The TWRM and stored water continues to provide flexibility to meet London demand however there is increased likely hood of hot weather events which could impact London demand.	We should consider whether DYCP planning in the London WRZ is required in the future.	✓			✓

Table CC-7: Learning points and recommendations following review of 2022 drought