Draft Drought Plan 2022

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Our drought plan is set out in three sections, a short executive summary, a non-technical summary and our main drought plan.

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Drought Plan – Executive Summary

Drought Plans are a requirement under s39B of the Water Industry Act 1991 (WIA), as introduced by the Water Act 2003. This Drought Plan fulfils the requirement to produce a Drought Plan as outlined in the Act and is in line with the guidelines provided by the Environment Agency[1].

We have undertaken a pre-consultation exercise and invited key organisations to indicate any requirements they wished to see addressed in our Drought Plan. The organisations consulted included the Environment Agency, Natural England, Ofwat, Defra and other Water Companies in the south east of England. We have considered the responses received as a result of this pre-consultation in the preparation of our Draft Plan.

Our draft Drought Plan has been submitted to the Secretary of State, and any amendments have been competed to allow publishing for an 8 week public consultation.

Our draft Drought Plan builds on our last Drought Plan that was approved in May 2020 and published on our website[2]. Our draft Drought Plan retains the same methodologies and we have made the following changes:

Changes since our last plan:

- We have reduced the output associated with the Thames Gateway Water Treatment works from 150 Ml/d to 100 Ml/d and removed the Hoddesdon transfer scheme from the plan which reduces drought capability by 12.5 Ml/d.
- We have updated and improved our approach to testing our drought plan against more severe droughts, we have updated this analysis for all of our water resource zones.
- We have updated our levels of service to align with the Environment Agency guidelines and with Water Resources in the South East (WRSE). Previously we included a staggered implementation of Temporary Use Ban (TUB) restrictions. We have now amended this so that a full TUB would be implemented at Level 2 of our levels of service. This is aligned with all water companies in the South East who all implement TUBs as a Level 2 drought measure with a level of service of 1:10 years.
- We have worked with the other WRSE water companies to align our implementation of specific demand restrictions and associated exemptions.
- We have developed new 'More Before level 4 measures' in line with the new requirement set out in the Environment Agency Guidance. Working with the WRSE water companies we have aligned our 'More Before level 4' demand management measures. 'More Before level 4' measures include significant demand reductions and additional emergency water sources, for example mobile desalination plants.

We have undertaken a Strategic Environmental Assessment (SEA) for our draft Drought Plan. The SEA provides a formal review of the environmental impact of the options for drought management included within our plan. This ensures that all the drought management options have been

[1] Environment Agency, Water Company Drought Plan guideline v1.2, 2020
[2] https://www.thameswater.co.uk/about-us/regulation/drought-plan

assessed for environmental impact in a comprehensive and consistent manner and the results of the assessment reported systematically. We have also undertaken a Habitats Regulations Assessment (HRA) to ensure that our plan does not adversely affect the integrity of European designated sites. Information from the SEA Environmental Report and the HRA Screening Report has been used to inform the Drought Plan Appendix C tables. We have used this, together with operational considerations, to prioritise the options for implementation in a drought.

For our drought plan to be considered effective, or fit for purpose, we consider that it must meet the following criteria:

- Forecasting the impact of drought - the methodology must be capable of predicting the risk to security of supply.
- Planning ahead - protocols should facilitate:
  - the full sequencing of measures to be taken to avoid or minimise the need for emergency measures
  - timely introduction of measures to maximise benefits and allow for their implementation
  - proactive communication to customers on their participation.
  - a reliable assessment to show that the measures being either considered or actually implemented are consistent with the Company's Levels of Service.

We have tested the effectiveness of our drought plan by simulating water resources conditions that are worse than any in the historical record, the stochastic droughts. The assessment demonstrates that all six water resource zones are resilient to a severe drought of up to 1:500 year drought. Our London WRZ is shown to be robust to a 1:500 year drought with the use of Drought Permits and 'More Before Level 4 measures'. Our drought plan protocols, which are used to trigger the demand and supply options, introduced the appropriate measures sufficiently early to allow subsequent measures to also be introduced in good time in a drought. This maximises the benefit of the measures and provides adequate lead times for subsequent more stringent measures. The protocols therefore demonstrate that we are able to avert the need for Level 4 emergency measures in a severe drought.

The stochastic droughts analysis illustrates the flexibility and robustness of London's water resources system as operated within the London protocol, even under an extreme scenario not yet seen in the historical record. However, these scenarios highlight the reliance on drought permits or orders for extended periods of time and the potential need for 'More Before Level 4' measures. This reliance on drought permits for long periods would have a significant adverse impact on the environment. With the south east being an area of severe water stress, increased resilience to severe droughts whilst protecting the environment will require further resource development. In the meantime, before our further resource development is complete, we are exploring ways in which we could mitigate the impact of our Drought Permit options through river restoration options.

In summary, our draft Drought Plan indicates that our security of supply is considered robust for the next 5 years to achieve protection for customers to a 1:100 year drought and to 1:500 year drought, although at the detriment of the environment although we are reviewing ways to mitigate this impact. We will continue to review the resilience of our sources to ensure security of supply beyond a normal year.

Drought Plan Technical Summary

Introduction

This is a technical summary of the sections of our Drought Plan. A further document has been published which provides a non-technical summary of the contents called the Drought Plan Summary. The main sections held in this report provide a description of our tactical response to a drought event and are further supported by a series of appendices.

Following approval to proceed from Defra we will consult on the plan for a period of 8 weeks, after which we will produce a revised draft Drought Plan and a Statement of Response for further review by Defra. Comments on our draft Drought Plan should be sent to Water.resources@defra.gov.uk

Our Statement of Response, which provides a summary of how we have responded to all the comments received during the consultation, will be published within 15 weeks from when we start the public consultation. The Secretary of State will review these documents and the outcome of this review is expected to be announced in Spring 2022 or earlier, following which our Drought Plan will be published if approved.

We look forward to receiving and answering your comments.

Overview of Drought Plan 2021

Our Drought Plan sets out our short-term tactical response to a drought event. Our plan meets the requirements of the Environment Agency's Drought Plan Guidance[3] and is required to be updated every five years. It is based on the supply-demand balance at the time it is produced and remains valid for the subsequent five years, in this case up to 2027. Complementary to the Drought Plan is our Water Resource Management Plan 2019 (WRMP19), produced every 5 years and last updated in April 2020[4]. The current WRMP aligns to our Drought Plan, providing a detailed programme of activities required to ensure we have enough water to meet the requirements of growth, climate change, environmental improvements from today and out to the year 2100. Our current WRMP will also increase protection to severe 1 in 200 year drought events by 2030/31.

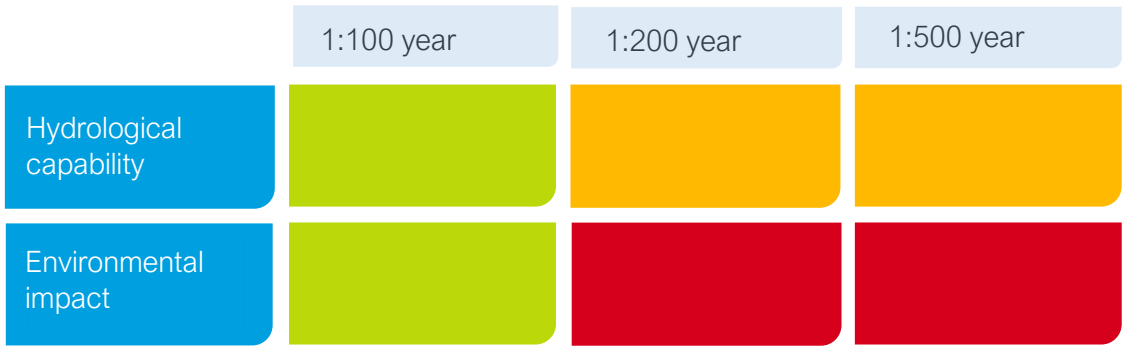
This Drought Plan shows that with our existing assets we can meet the following:

i) Our planned levels of service, for the twentieth century droughts in the historic record
ii) A range of more severe drought scenarios, although with less resilience.

We have carried out detailed analysis of more severe droughts of drought severity 1:200 and 1:500 years using a stochastic approach. This analysis shows that we can maintain supply with our drought management measures, including new demand savings during severe droughts, but it also shows that our current asset base will be placed under great strain, impacting the capability of the water system and would potentially have a significant detrimental effect on the environment and ecology.

[3] Environment Agency, Water Company Drought Plan guideline v1.2, 2020
[4] https://www.thameswater.co.uk/about-us/regulation/water-resources

Historic Droughts and Stochastic Drought Events



Key

Green	No adverse environmental impact and hydrologically resilient
Amber	Hydrological stress but resilient water supply
Red	Adverse environmental impact

Figure 1 Our resilience to Droughts

A key feature of our Drought Plan is the potential to use Drought Permits in a severe drought. Drought Permits are a means whereby we can get temporary permission from the Environment Agency to increase abstraction at specific sites in a severe drought. It is expected that more severe water use restrictions could be required for longer than 6 months, and this would exacerbate the detrimental environmental impact of our Drought Permits and Drought Orders. Furthermore, the associated water use restrictions also have the potential for a significant detrimental effect on a number of small businesses.

Some of our drought permit sites may have an adverse impact on Chalk and other sensitive streams, but the measures would only be used in extreme circumstances. We are working to reduce our reliance on the use of these sensitive sources in a drought through measures to increase our resilience to severe drought and these plans are set out in our WRMP. Our WRMP sets out how we intend to become more resilient to droughts of a severity of 1:200 years by 2030/31. Once we have increased our resilience, we would then not need to rely on these drought permits in droughts of that severity. We would still need to retain the Drought Permit options, but they would be used only in very extreme circumstances when we experience droughts of greater severity. For these options we are exploring ways in which we could mitigate the impact of our Drought Permit options through river restoration options.

As stated above, our Drought Plan covers the period up to 2027 and therefore does not take account of the increasing population, climate change, or potential reductions in existing licensed abstraction. These factors are all forecast to have a significant effect in the Thames catchment, but this will principally be seen after the period up to 2027. Our Water Resources Management Plan 2019 has forecast significant growth of population in Thames Water's supply area, a large proportion of which is expected to be in London. An increasing incidence of droughts and more extreme weather events is forecast in response to climate change, with summer rainfall expected to decrease by approximately 18% in the 2050s.

The associated increasing demand and reduced water availability have the potential to significantly affect the underlying supply demand balance and therefore the extent to which our Drought Plan could be relied upon to robustly protect customers from Level 4 water use restrictions in future periods. These aspects will be explored and developed further in our WRMP24 which will describe our longer-term supply and demand position, which is expected to cover the period 2025-2100.

The assessment of current water availability in our Drought Plan also assumes that all existing resources are operating to their expected capacity.

Our Drought Plan highlights the need for the Water Resources Management Plan to provide the additional resource requirement to address the future forecast supply and demand balance deficit and drought risk.

In summary, our Drought Plan indicates that our security of supply is considered robust for the next 5 years.

Material Changes Since the Last Drought Plan (2017)

The material changes we have made in this Drought Plan include the reduction in the output associated with the Thames Gateway Water Treatment works, from 150 Ml/d to 100 Ml/d, and the removal of the Hoddesdon transfer scheme from the plan which further reduces drought capability by 12.5 Ml/d. We have also updated our detailed analysis of the impact of more severe droughts using a stochastic approach. We have moved 4 Drought Permit options to More before Level 4' options. These 'More before Level 4' options are in place to further reduce the risk of reaching the Service Level 4, which would call on such actions as standpipes in the street.

We work closely with other water companies in the South East to co-ordinate drought planning and align our plans as much as possible, particularly in relation to the drought communications and imposition of restrictions. We have developed our plan in liaison with these other companies through the Water Resources South East (WRSE) Drought Group, which is a subgroup of the WRSE regional planning group set up to develop a regional approach to water resources planning in the south east of England.

Water Supply & Drought in the Thames Catchment

Approximately 80% of our water supply is derived from the abstraction of river water (largely from the upper and lower Thames) and the remainder is derived from groundwater abstraction. We also have a desalination plant located at Beckton on the Thames Tideway which can provide 100 Ml/d of supply during drought periods, high demand periods or emergencies. Winter rainfall provides the longer-term stock of water resource in the form of higher groundwater levels and consequent higher baseflows into streams and rivers.

In South East England, drought is the result of several months or more of below average rainfall spanning at least one winter. The low groundwater levels and river flows that result from this type of dry period, in turn, mean that water availability from rivers and boreholes becomes increasingly reduced and reservoir levels become increasingly lower. In short, a water company's ability to supply its customers can be put at risk. During periods of drought Thames Water's water supply

becomes increasingly dependent upon groundwater in the major aquifers of the Thames catchment.

For the Thames catchment a water resources drought is caused by a prolonged period of below average winter rainfall. The four worst droughts for water resources on record and those which form the basis of London's deployable output are: 1920/21, 1933/34, 1943/44 and 1975/76. All four droughts were characterised by a prolonged period of around 12 to 18 months of below average rainfall.

In contrast to London, the upper Thames (Swindon and Oxfordshire Water Resources Zone-SWOX WRZ) is sometimes vulnerable to shorter periods of below average rainfall due to the nature of the underlying geology. The SWOX WRZ is more typical of the rest of the South East in terms of drought vulnerability and this can be important when it comes to explaining to the public differences in the timing of imposing water use restrictions across South East companies. Our other WRZs (SWA, Guildford, Kennet Valley and Henley) are reliant on a combination of river abstraction and groundwater sources or are entirely reliant on groundwater sources.

The fundamental requirement for a robust Drought Plan is a comprehensive and reliable hydrometric network from which an accurate assessment of the ongoing water resources situation in all parts of the Thames catchment can be established and reliable forecasts undertaken. We use the Environment Agency's hydrometric network of rainfall, river flow and groundwater level measurement to provide this key information.

Water Resource Strategy and Drought Management

A Water Company's conformance to its stated Levels of Service is a direct reflection of the combined effectiveness of its WRMP and Drought Plan. It is therefore important that the two sets of plans should be consistent with each other.

A fundamental assumption in our Drought Plan is that the risk to Levels of Service is minimal when all water resource zones (WRZs) are in supply demand balance. The balance between supply and demand has been reviewed for all our WRZs within our published WRMP19.

Our Levels of Service for water supply restrictions are set out below in Table 1.

Table 1 Planned Levels of Service

Restriction Level	Frequency of Occurrence	Water use restrictions
Level 1	1 year in 5 on average	Intensive media campaign
Level 2	1 year in 10 on average	TUB and Enhanced media campaign
Level 3	1 year in 20 on average	NEUBs requiring the granting of a drought order and Drought Permits. Note these would be applied in a staged manner
Level 4	Never (in reality this equates to ~ 1 year in 100 years on average)	If extreme measures (such as standpipes and rota cuts) were necessary, their implementation would require an Emergency Drought Order

London Water Resource Zone

Due to its importance as the nation's capital and size of population, drought management of the London WRZ plays the central and pivotal role in our Drought Plan. Moreover, company-wide measures will normally be triggered as a result of the water situation impacting on the London WRZ.

Central to the operation of London's water supply is the Lower Thames Operating Agreement (LTOA) between Thames Water and the Environment Agency. This controls the amount of water that can be abstracted above Teddington Weir but has also been used historically as a mechanism for providing definitive guidance on managing water use restrictions. As part of the LTOA, the Lower Thames Control Diagram (LTCD) is the operational tool to manage drought measures. As reservoir storage levels drop the LTCD is designed to trigger when these drought measures come into operation. These trigger points correspond to our Service Levels, from 1 to 4. Under the current protocol the LTCD provides the definitive guidance for the latest time at which measures would be implemented. We updated our protocol for drought management following the 2012 drought event. This allows for the earlier introduction of drought measures than required by simply following the guide within the LTCD. This is necessary so that measures are actioned early enough in a severe drought to ensure more severe restrictions can be brought on-line in good time if needed. The LTCD therefore represents a likely latest point at which measures should be introduced.

An example of the LTCD is shown in Figure 2. The diagram is divided into a set of four minimum environmental flow zones/constraints (800 Ml/d, 600 - 700 Ml/d, 300 - 400 Ml/d and 300 Ml/d) and the set of Levels 1 to 4 control curves which are linked to our Levels of Service.

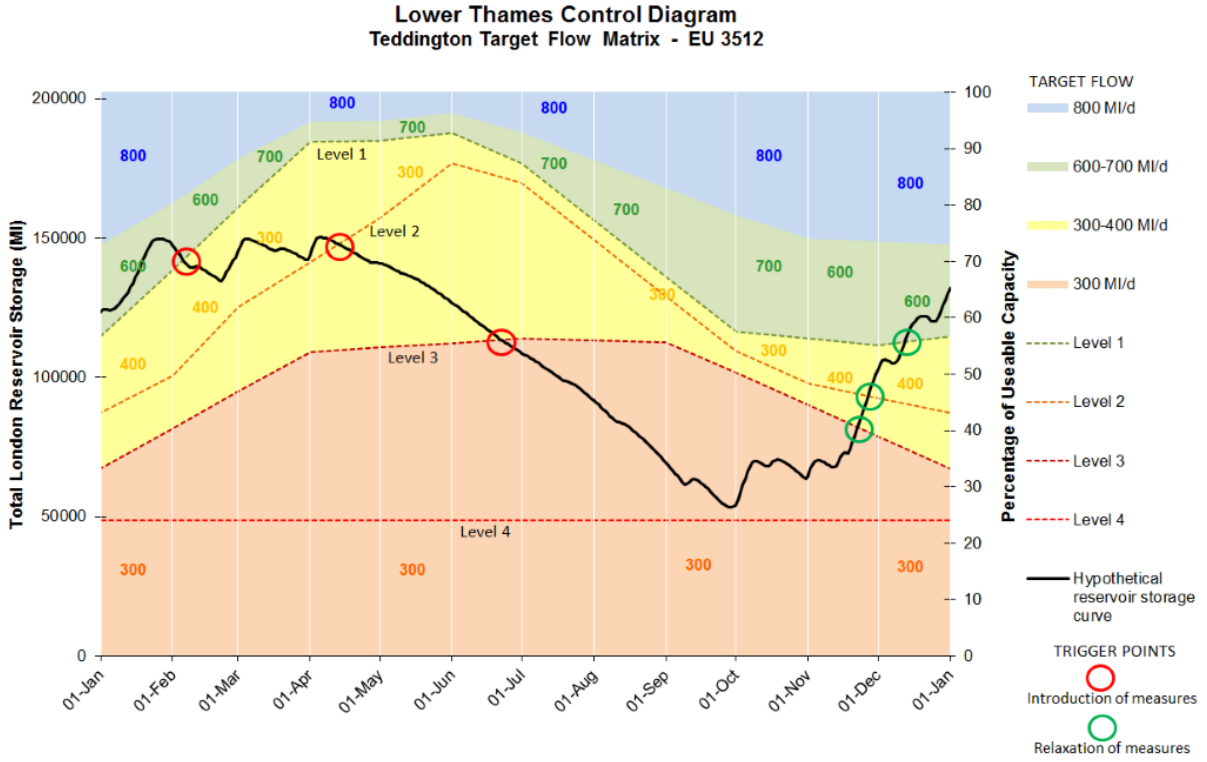


Figure 2 Example of the Lower Thames Control Diagram (LTCD)

Drought Management Protocol

Our Drought Plan protocol is designed to provide triggers for introduction of drought plan measures that are proportionate to the drought risk being experienced. It is also designed to enable the measures to be brought on line sufficiently early so that all subsequent measures can be implemented in time and in sequence so that the risk of reaching very severe measures under Level 4 is minimised as far as possible.

The key elements of the protocol are used to identify overall drought risk based on the combination of regional groundwater levels, river flows and reservoir storage. This enables us to set a Drought Event Risk level (DEL) for which specific measures need to be introduced.

This assessment uses both the current situation together with predictions of how bad the drought could get under a reasonable worst-case scenario. We then use the forecast lead time for each option and the required sequential nature of the imposition of drought measures to determine when the first elements in that sequence need to be implemented. This is also carried out for all the subsequent measures through to the point at which the most severe measures would be required. This provides an overall timeline for implementation of all the measures so that they can be prepared in advance and then implemented in succession in a timely manner.

Therefore, in summary the key requirements of the protocol set out in our drought plan are:

- Sequencing of measures to avoid or minimise the need for Emergency Drought Orders (EDOs), see Table 2.
- Timely introduction of drought measures to maximise demand savings and supply-side benefits and allow for their implementation.
- Proactive communication to customers.
- A reliable assessment to show that the measures being either considered or actually implemented are consistent with our Levels of Service. NB Because of its dominance in relation to our other WRZs this is a test that currently is only applied to the London WRZ.

This approach enables us to put measures in place early when a drought has the risk of being very severe and the principal identifier of this risk is the effect that a sustained shortage of rainfall has on groundwater storage. This is particularly important where there has been a shortage of rainfall in winter that means groundwater levels do not recover prior to the summer in our major aquifers, especially the Chalk.

Table 2 Drought Measures Indicative Timescale for London

Measure	Time to Implement (Weeks)			
Media campaign	2			
Temporary Use Ban		3		
NEUB/drought permit			10	
Emergency drought order (EDO)				10
Elapsed time (WEEKS)	2	5	15	25

London and SWOX WRZs are known as conjunctive use zones as the water resources are derived from a combination of river abstraction, raw water reservoir storage and groundwater sources. For both zones, the critical element in the system is the level of reservoir storage, which in turn is dependent upon river flow. The drought management measures for the London zone consist of:

- Demand-side measures in which water use restrictions associated with Thames Water's Levels of Service play a major role and are triggered by the prevailing / predicted protocol.
- Supply-side measures in which several strategic drought schemes play a major role in augmenting the London zone's supply capability.

Both the supply and demand-side measures form an integral part of London's deployable output. Because of the dominant nature of the London WRZ, it will generally be the case that the water use restrictions introduced in the London WRZ will also be applied to the rest of Thames Water's supply area. Nonetheless, the Drought Plan recognises that there may be situations in which more local measures may need to be introduced for the other WRZs, consequently, protocols have also been developed for these zones.

The SWOX methodology is similar to that of London and based on the prevailing/predicted assessment. The introduction of water use restrictions is determined, in the first instance, by the London protocol. However, it is supplemented with a trigger for submitting Non Essential Use Bans (NEUBs) and drought permit applications based on the level of natural flow (200 Ml/d) in the River Thames at Farmoor, where our largest Thames Valley storage reservoir outside London is situated. Unlike the London WRZ, there are no supply-side strategic drought schemes built into the zone's deployable output; the major supply-side augmentation comes mainly in the form of increased abstraction from existing sources introduced through the drought permit mechanism.

The protocols for the Kennet Valley and Guildford WRZs are based on critical low flows in the River Kennet and River Wey, respectively, which act as the trigger mechanism for the introduction of drought measures.

Slough/Wycombe/Aylesbury and Henley WRZs are entirely supplied by groundwater sources, which historically have remained robust during drought. In SWA we have reduced our impact on the environment in recent years through implementing sustainability reductions e.g. at Pann Mill on the River Wye and we will implement further reductions with the closure of Hawridge by 2025. The protocol for these zones is based on tracking key regional observation boreholes together with the performance of selected groundwater sources in relation to their deployable output.

Demand-side measures

We have a number of different drought management measures that aim to reduce customer demand during a drought. The different options are detailed in Table 3.

Most of the demand-side measures are associated with our Levels of Service and involve the sequential escalation of customer communications, followed by water use restrictions. The aim of the measures is to mitigate the need for Level 4 emergency restrictions.

These measures are a sub-set of baseline demand management, which is, of course, a major on-going activity for Thames Water comprising leakage reduction, the progressive roll out of household metering and the promotion of water efficiency. During the course of a drought, leakage reduction, principally find and fix, and water efficiency can to some extent be enhanced. However, enhancement of meter installation over and above the on-going programme is not regarded as effective or efficient during the relatively short duration of a drought event.

In accordance with its stated Levels of Service (Table 1), unless there are good reasons for doing so, Thames Water will not impose water use restrictions on its customers (household and non-household). Therefore, the sequencing of the severity of the measures is commensurate with increasing risk to security of supply. The full range of demand-side measures are given below in Table 3 along with the respective drought event risk level (DEL).

Table 3 Demand-side measures

Measure	Description of measure	Drought Event Risk Level	Level of service
Media /water efficiency campaign	Wide-scale media activity and advertising to encourage voluntary reduction in water usage	DEL1	Level 1
Enhanced media /water efficiency campaign	Enhancement of above activity	DEL2	Level 2
Leakage reduction	Increased leakage activity / Network pressure management	DEL1-DEL2	Not applicable
Temporary Use Ban	11 categories of use (largely domestic), banning the use of a hosepipe.	DEL2	Level 2
Drought Direction 2011 measures (formerly non-essential use Ordinary Drought Order)	Application to Defra to grant 10 categories of non-essential use affecting commercial businesses.	DEL 3	Level 3
Emergency Drought Order	Application to Defra to grant an emergency drought order, including rota cuts and stand pipes.	DEL 4	Level 4

We retain the proposal to introduce all eleven categories of usage of the Temporary Use Ban legislation in a single phase that replaces the previous hosepipe ban restrictions as part of Level 2 of our Levels of Service. However, within this set of restrictions, there are exemptions detailed in our Drought Plan for reasons such as health and safety or to minimise the impact on businesses.

The new exemptions policy represents an approach that minimises any complication to the message to customers. It is considered that the exemptions would also be acceptable to the rest of the companies in the South East, and consistent with the companies imposing similar exemptions.
Drought Direction 2011 non-essential use ban (DD11 NEUB) restrictions replace the previous ordinary drought order for banning non-essential use as part of Level 3 of the Company's Levels of Service. It is proposed to apply to Defra for granting the introduction of all ten categories of use in a single phase.

'More Before Level 4' measures – demand side measures

'More Before Level 4' is a new requirement included in the EA's guidelines to review additional drought measures that could be included to reduce the risk of reaching Level 4 restrictions (emergency level). Our Drought Plan includes the following additional demand measures:

- Reductions in water pressure
- Restricting supplies to large commercial users
- Heightened, widespread communications campaign to request customers to use less water.

We have worked with WRSE to develop a potential communications campaign to request customers to make very significant reductions in their usage in the event of the risk of emergency restrictions. This would include provision of advice on how water use reductions could be made to constrain household use to approximately 80-100 litres/person/day or lower.

Supply-side measures

We have a number of different options available to increase the amount of water we are able to abstract to supply customers. The supply-side measures are detailed below. Note that drought permits/orders, are not part of our stated Levels of Service, but are measures that are introduced during the course of a drought to increase the amount of water available for supply.
Supply-side measures can be categorised into:

- Optimisation of existing sources
- Strategic schemes
- Bulk supplies
- Drought permits or Orders
- Recommissioning of disused sources
- In extremis options

Strategic schemes

Strategic schemes are sources of water that are permitted for use but are not used as part of our day to day' baseline supply. They also often have separate operating agreements agreed with the Environment Agency detailing under what conditions the schemes can be used. The strategic schemes included within our drought plan provide a significant additional volume of water, mostly for our London WRZ and are detailed in Table 4.

Table 4 Benefit provided by Strategic Schemes

Scheme	Benefit Ml/d
North London Artificial Recharge Scheme (NLARS)*	220 to 156
Thames Gateway Water Treatment Works (TGWTW)*	Up to 100
West Berkshire Groundwater Scheme (WBGWS)*	126 to 67
Small scale groundwater schemes • ELRED, Stratford Box and Old Ford • Chingford Artificial Recharge Scheme (CHARS)	 26.7 15.1 to 10.6

*The operation of NLARS, TGWTW and WBGWS is subject to separate operating agreements with the EA.

Bulk Supplies

Bulk supplies are transfers of either raw or treated water exported or imported between neighbouring water company areas. Our policy is to honour the existing bulk supply agreements during periods of drought.

Table 5 sets out the current bulk exports. It can be seen that there is a maximum commitment during drought to export approximately 73 Ml/d of raw water and 12 Ml/d of treated water.

Table 5 London WRZ- Current Bulk Supply Agreements

Imports	Exports
None	Essex and Suffolk Water - 91 M/ld average and 118.2 Ml/d peak raw water transfer from Lee Valley to Chingford area. Thames Water and Essex and Suffolk Water agreed a reduction to this bulk supply provision in 2014 such that the provision to Essex and Suffolk Water is reduced 71 Ml/d on average through the year arising from a profile of no less than 60 Ml/d for Jan-Mar each year and 75 Ml/d during the remainder of the year. There is agreement to reduce export by 25% where Thames Water has implemented a TUB and Essex and Suffolk Water have not.
	Affinity Water - 2 Ml/d raw water to Sunnymeads WTW; 11.8 Ml/d treated water via Fortis Green (2015-2018), up to a maximum of 27Ml/d and 0.2 Ml/d at Hampstead Lane;
	SES Water - agreement exists to supply up to 13.6 Ml/d. SES Water have only required 5 Ml/d in recent years. This would be reduced from 5 Ml/d to 0 Ml/d during drought.

Drought Permits

Drought permits are concerned with abstraction from our existing sources that is outside of the conditions stated in the abstraction licence. Drought permit options represent an important supply-side resource relevant to all WRZs. Drought permits are prioritised based on a proposed implementation order linked to the magnitude of environmental impact, water resources benefit and ease of implementation. The high priority options are those that are likely to be implemented ahead of the lower priority options, principally on the grounds of lesser environmental impact. However, in an actual drought, other factors will also be taken into account in determining which drought permits should be applied for, such as ease of implementation and water resources contribution to areas of need. Therefore, the actual order of implementation of drought permit options in a drought may vary slightly from this categorisation although the priority order would form the basis of the order in which options are used in a drought.

The EA is responsible for granting a drought permit and, in so doing, it must be satisfied that the benefits to supply outweigh the potential environmental impacts.

The Secretary of State is responsible for granting drought orders and, in so doing, must be satisfied that the benefits outweigh the potential environmental, economic and other impacts.

More Before Level 4 – Supply side measures

More before Level 4 supply side options would be considered in situations more severe than Level 3 of our Levels of Service hierarchy. These include:

- tankering
- emergency raw water pipeline transfers
- reduction in bulk supplies
- temporary desalination units
- and alternative sources for non-potable use.

In addition, a drought permit option for the Lower Thames may include an allowance for the back-pumping of water over Molesey and Teddington weirs in order to ensure that all the water available in the Lower Thames can be taken at the existing intakes.

Working with Other Water Companies (WRSE)

We work closely with other water companies in the South East to co-ordinate drought planning to align our plans as much as possible particularly in relation to the drought communications and imposition of restrictions. We have developed our plan in liaison with other companies through the WRSE Drought Group. This has enabled us to align the approach to imposition of TUBs and NEUBs in the event that a drought requires imposition of these measures across the south east of England. We have broadly aligned the exemptions that would be allowed if TUBs and NEUBs were implemented. We also work closely with the other WRSE companies on communications and would co-ordinate the timing and messaging of our media and communication campaigns as much as possible in a drought. We have also worked to align our drought levels so that all the companies drought awareness levels are essentially the same, however, due to the differences in

the water resources systems for each company this does not mean that we would always implement the same measures at the same time although we will strive to align our measures as much as possible during a drought.

Communications Strategy

Communication before, during and after a drought event is of paramount importance. In the context of the drought protocols, this section sets out Thames Water's communication strategy in regard to its customers and stakeholders.

An important factor in developing our drought protocol has been the requirement to keep customers and stakeholders well informed during the course of a drought. With this in mind the overall objectives of our communication plan are:

- To keep the public fully aware of the development of the drought and the potential impacts of planned measures.
- To simply and clearly provide information on how to prepare for, adapt to and mitigate water use restrictions.
- To promote and enhance ongoing water-efficiency messages.

Key Messages

Timely and clear messages are vital for a successful communications plan. The messages must be consistent, appropriate and effective, reflecting accurately the escalation or de-escalation of the drought and its impacts.

Drought messages will cover three main dimensions:

- Evidence-based information about the water resource situation (rainfall, reservoir levels) and the probability of further restrictions.
- Proactive information about what customers and the public can do to reduce water usage and mitigate the impacts of the drought (dealing with restrictions and water usage efficiency measures).
- Full information about our contribution to reduce the impacts of the drought (leakage reductions, information campaigns etc).

The messages will also be co-ordinated across water company boundaries and with other relevant organisations to ensure consistent communications to customers.

Means of Communication

To gain maximum coverage, communication throughout the drought event will be primarily based on public information through our media relations, including social media channels. Newspapers, radio and TV will reach a wide range of stakeholders and raise general awareness about the status of the drought and the need to reduce water demand.

Our website is particularly useful for regularly updating drought-related information and water efficiency advice as well as featuring special events or publicity as and when required. Links to

other sites of interest also leads to a greater recognition of partnership working initiatives with key stakeholders and regulatory bodies.

We'll use social media, including Twitter, LinkedIn and Facebook, alongside media and web communications channels to reinforce drought messages to customers familiar with digital media.

When to Communicate

The timing and nature of the specific communication activities will be closely aligned with the potential escalation or de-escalation of the drought according to the overall Drought Plan. As a general rule, basic public communication through internet and media will continue throughout the drought. During a drought, campaigns and individual communication with key stakeholders will be specifically planned according to the escalation or de-escalation of the drought.

The implementation of specific drought measures (drought triggers) will be key milestones for review and adaptation of specific communication measures, namely:

- The crossing of enhanced media campaign triggers on the relevant control diagrams
- The announcement and implementation of a TUB, including its formal notification and allowance for and consideration of representations
- The application for and implementation of a NEUB
- The applications for drought permits (if required)
- The preparation, application and implementation of Emergency Drought Orders (if required)
- The relaxation of the above restrictions as the situation improves

Effectiveness of Plan, Resilience to More Severe Drought Events

It is important to understand the impact of more severe droughts than those that have occurred in the historical record. In recognition of this requirement water companies are required to test their Drought Plans against a range of more severe droughts. This has been done principally by adopting a stochastic approach to assess the potential for more extreme drought occurring over an extended period of record and attempting to characterise the likelihood of such a drought through estimation of its return period. The ability to cope with more severe droughts is then tested by assessing what measures are required and determining the ability to maintain supplies through such severe droughts. We have tested our plan against droughts of greater severity than those in the historic record addressing the requirement to test our plan against droughts of severity of 1:200 years, and we have also tested the response to droughts of 1:500 years.

The protocols for each of the six WRZs have been tested for flexibility and robustness using stochastic analysis. In all cases, the protocols triggered the appropriate demand and supply measures sufficiently early to maximise their benefit and provide adequate lead times for subsequent more stringent measures, thereby averting Level 4 emergency measures. The early implementation of demand-side measures is a key feature of the protocol enabling the measures to be implemented in time to reduce the risk of Level 4.

Under extreme low flow conditions, the London, SWOX and Kennet Valley zones were dependent upon drought permit options in order to maintain a supply capability that did not need the back-up of Level 4 emergency measures. Additionally, for Kennet Valley, the WBGWS is shown to be a

key element in ensuring its robustness and the protocol for London facilitates the scheme's timely introduction for both zones.

London

The approach for the London system has been to use stochastic analysis of drought resilience. The use of this approach enables a simulated time series to be produced which is of much greater length than the historical record. The analysis used contains quantified estimates of the relative probability of the drought events that were used to test the relevant sources. These have been described in terms of 'Return Period' as this concept is readily understood by practitioners.

The stochastic test scenarios (drought severity of 1:200 and 1:500 years) illustrate the hydrological robustness of London's water resources system as operated within the London protocol with prompt implementation of drought permits and orders, even under extreme scenarios not seen in the historic record, although to the significant detriment of the environment. The London protocol initiates a company-wide set of demand management measures at an early stage. This is sufficiently early to meet the requirements for all the other zones. In this respect, the London protocol is seen as integrating the rest of the supply area's drought management plan. However, these scenarios highlight the reliance on drought permits or orders for extended periods of time. This reliance on such long durations of drought permit and drought order installation would have a significant adverse impact on the environment and small businesses and so indicate that to meet the challenge of potentially very severe droughts in the future, greater resource development is required in order to protect the environment from potentially severe damage in droughts of this return period.

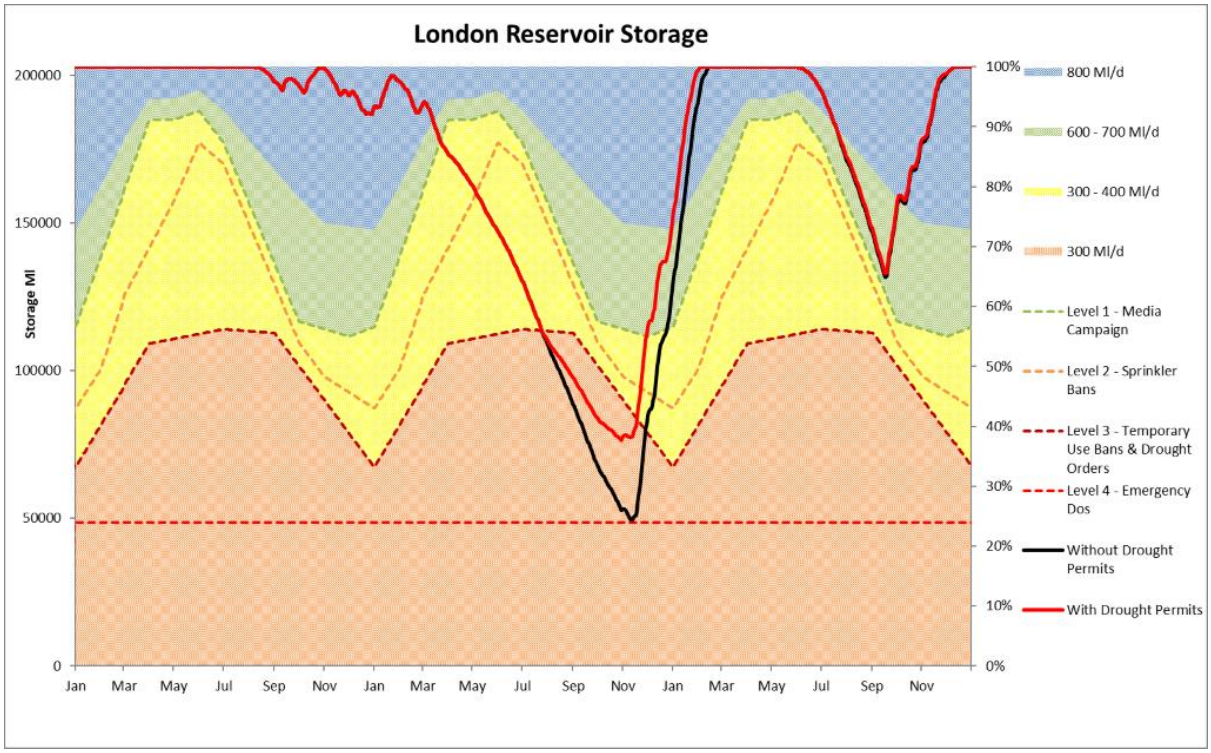


Figure 3 Impact of a Generated 'Severe' Drought Event (modelled 1 in 200 Return Period) on Aggregated London Reservoir Storage

In the severe example (1:200 year drought severity) shown in Figure 3, it can be seen that without drought permits the 'median' 1 in 200-year event would come very near (but not quite) to requiring emergency drought orders to be triggered. The London WRZ also proved to be robust to a 1:500 year drought event with the implementation of drought permits but showed that it is likely that there would also be the need for 'More before Level 4' measures to reduce demand and supplement supplies. With drought permits in place, while TUBs and NEUBs would be needed for several months, we would not require the implementation of emergency drought orders, however it is likely that preparations for their use would be made as it is not possible to determine when a drought will end whilst it is being experienced. These events would, however, imply a significant (c. 6 month or greater) period during which drought permits, TUBs, and NEUBs would be implemented, the impacts of which should not be discounted.

SWOX

In the same way as for London, analysis of the impact of stochastically generated droughts has been undertaken for SWOX. The droughts selected for analysis in the London WRZ were also run through the SWOX component of WARMS. The droughts are the same as those selected for London (i.e. these are 1 in 200 and 1 in 500 droughts for London but not necessarily for SWOX). Because these are not statistically 1:500 year droughts for SWOX, in order to test the SWOX system rigorously we have assumed a higher level of demand for the 1:500 drought than the dry year annual average demand. The results show that with this higher demand, plus an allowance for outage, plus an allowance for bulk supplies, we would be resilient to an approximate 1 in 500-year drought without the imposition of emergency drought orders in SWOX.

Our previous analysis has shown that Farmoor's key vulnerability is to events such as 1975-1976, which was very intense but relatively short, rather than events such as 1921-22 or 1932-34. The stochastics test scenarios illustrate the ability of SWOX's water resources system as operated within the SWOX protocol, even under an extreme scenario not yet seen in the historic record to maintain supply throughout a very severe drought. However, as for London, these scenarios highlight the reliance on drought permits or orders for extended periods of time. This reliance on such long durations of drought permit implementation would have a significant adverse impact on the environment and so indicate that to meet the challenge of potentially very severe droughts in the future greater resource development is required in order to protect the environment from potentially severe damage in droughts of this return period.

Other Water Resource Zones

We have also tested the drought plan for the Kennet Valley, Guildford, SWA and Henley WRZs against more severe droughts. In contrast to our previous plan we now have rainfall-runoff models available for the two key main surface water resources in these WRZs (the River Kennet at Theale and the River Wey at Tilford), and so a stochastically based analysis has been carried out. The results of the analysis for these WRZs indicate that the surface water and groundwater sources appear to be very resilient to drought risk. However, it should be noted that for Kennet Valley, the WBGWS is shown to be a key element in providing its robustness and the protocol for London facilitates the scheme's timely introduction for both zones. However, in a very severe drought, there may also be the requirement for support from drought permits in the Kennet Valley and SWA WRZs. For the Guildford and Henley WRZs, the likelihood of requiring drought permits is extremely slim although drought permit options are included in our plan for these zones.

Draft Drought Plan 2022

Main Drought Plan

Section 1 - Introduction and Regulatory Requirements

1.1. Introduction

Our Drought Plan sets out the management actions we need to implement in a drought. The plan therefore covers the following key issues:

- Our triggers for drought actions
- The demand side options we would use and when we would implement them
- The supply side options we would use and when we would implement them
- How and when we will communicate with customers and stakeholders in a drought
- The impact that some of our supply options may have on the environment
- Our ability to maintain supplies during a more severe drought than we have experienced in the historic record.

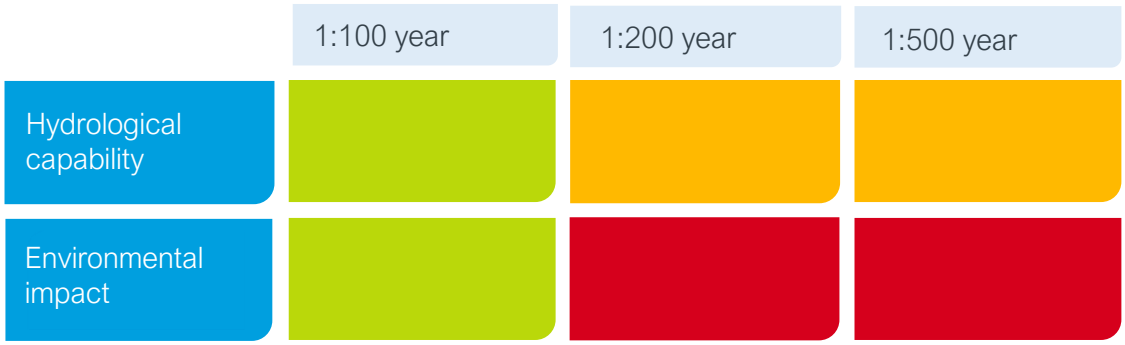
Our Drought plan is designed to cover our short-term tactical response in a drought but does not address the longer-term planning issues such as future growth and climate change. Our Drought Plan is updated every five years and so is based on the supply-demand balance at the time it is produced and for the subsequent five years, in this case up to 2027. Our plan for how we will tackle the longer term issues of growth, climate change and measures to address environmental impact is detailed in our Water Resource Management Plan (WRMP) which is also updated every five years and sets out our preferred investment plan for the period to 2100.

Our Drought Plan has been compiled in line with the Environment Agency's Guideline[5] and sets out how we achieve protection against more severe droughts than have occurred in the historic record. Our Drought Plan shows that Thames Water can meet with the existing asset base:

i) Our planned levels of service, for the twentieth century droughts in the historic record, and
ii) A range of more severe drought scenarios (1 in 200 year and 1 in 500 year frequency of occurrence), although with less resilience.

We have carried out detailed analysis of more severe droughts using a stochastic approach. This analysis shows that we can maintain supply, but it also shows that our current asset base will be placed under great strain, impacting the capability of the water system and having a significant detrimental effect on the environment and ecology. Figure 4 below shows diagrammatically our capability for a 1:100 year drought and the impact that occurs for more extreme droughts.

[5] Water Company Drought Plan guideline December 2020 UPDATE FINAL, EA, Dec 2020



Key

Green	No adverse environmental impact and hydrologically resilient
Amber	Hydrological stress but resilient water supply
Red	Adverse environmental impact

Figure 4 Range of severe drought levels and impact on resilience.

In extreme drought conditions it is expected that more severe water use restrictions would be required for longer than 6 months, and this would exacerbate the effect of our Drought Permits and Drought Orders. Furthermore, the associated water use restrictions also have the potential to have a significant detrimental effect on a number of small businesses.

A key feature of our Drought Plan is the need to use Drought Permits in a severe drought. Drought Permits are a means whereby we can request temporary permission from the Environment Agency to increase abstraction at certain sites. Some of these sites may have an adverse impact on Chalk water courses and other sensitive streams, but the measures would only be used in extreme circumstances, and with the permission of the Environment Agency or the Government. We are working to reduce the potential need to rely on the use of these sensitive sources in a drought. This will be achieved through measures to increase our resilience to severe drought and will be set out in our WRMP. Our plan is to become resilient to droughts of a severity of 1:200 years by 2030/31 and also an expectation to be resilient to droughts of 1:500 years by 2040. When we have developed the increased level of drought protection for our customers the environmentally damaging drought permits would be required much less frequently. They would be used only in very extreme circumstances when we experience droughts of greater severity than 1:500, assuming the required options are constructed within our WRMP. For these options we are exploring ways in which we could mitigate the impact of our Drought Permit options through river restoration options.

Our Drought Plan highlights the need for the Water Resources Management Plan to provide significant new resources to address the future supply and demand balance and drought risk arising from population growth, climate change and the loss of existing abstraction licences associated with potential sustainability reductions.

In summary, this Drought Plan indicates that there are significant potential issues for the future, but our security of supply is considered robust for the next 5 years. The analysis undertaken for more severe droughts confirms our ability to maintain supply to our customers although with likely detrimental impact on the environment.

1.1.1. Regulatory Requirements

Drought Plans are a requirement under s39B of the Water Industry Act 1991 (WIA), as introduced by the Water Act 2003. This Drought Plan fulfils the requirement to produce a Drought Plan as outlined in the Act. This document has been produced in line with the guidelines provided by the EA (guidance contained in 'Water Company Drought Plan Guideline, September 2020 (version 1.1), referred to herein as 'Drought Plan Guidelines').

We last updated our Drought Plan in April 2017 to include:

- amendments responding to comments received from the EA on our 2013 Drought Plan; and
- amendments to comply with the EA Drought Plan Guidelines (2015) in respect of the Strategic Environmental Assessment (SEA) and Habitats Regulation Assessment (HRA).

Section 1.4 below provides further detail on these additions and amendments to the Drought Plan for the draft Drought Plan 2022.

1.1.2. Commercial Confidentiality

We have not identified any commercial confidentiality issues associated with our Drought Plan.

1.2. National Security

With respect to National Security, we have followed the guidance outlined in Defra Protective Security Guidance for the Water Industry, Issue 2, December 2019. The Advice Note states that certain information "must not" be published, the guidance includes information that would be of interest to terrorists or those with malicious intent because it provides useful location information. As such, information referenced in this advice note cannot be placed in the public domain. Appendix M has therefore been redacted; this appendix relates to the Environmental Assessment Reports (EARs) for drought permit options across our Water Resource Zones. These reports contain detailed site-specific operational information, maps and grid references as by its very nature the environmental impact assessment work has to be detailed and site specific.

1.3. Public Consultation

1.3.1. Consultation process

Water companies are required to produce Drought Plans under s39B of the Water Industry Act 1991 (WIA), as introduced by the Water Act 2003. Prior to completion of final drought plans water companies are required to publish their Draft Drought Management Plan (Draft Plan) and to send the Draft Plan to those persons prescribed in the Drought Plan Direction 2020.

We have undertaken a pre-consultation exercise to invite key organisations to indicate any requirements they wished to see addressed in the Draft Plan. The organisations consulted were: the

Environment Agency, Natural England, Ofwat, Defra, other Water Companies (including Affinity Water, SES Water, Essex and Suffolk Water, Southern Water, South East Water and Anglian Water), the Consumer Council for Water and retailers and New Appointments and Variations (NAVs). We have considered the responses received as a result of this pre-consultation in the preparation of the Draft Plan. We have consulted with a number of stakeholders previously, e.g. RWE Generation UK and we have retained the information from these consultations within the plan.

1.3.2. Publication process

By 1st April 2021, this draft plan was submitted to the Secretary of State to be checked for information contrary to national security and/or commercial confidentiality. After this process is completed, the Secretary of State notified us on any alterations required in respect to national security or commercial confidentiality and directed us to make the appropriate amendments before publishing our draft plan for consultation.

We will then publish our draft plan on our website and in paper form if necessary. A 7-week period of consultation will follow during which time any representations on the draft should be sent to the Secretary of State, who will send copies of the representations to us. We will then assess the representations and produce a statement of response detailing any changes we have made to the draft Drought Plan as a result of the representations along with the reasons for these changes. Conversely, where changes have not been made as a result of the representations, we will explain why not. The statement of response will be published on our website and we will notify anyone that made representations when the statement of response is published.

We will prepare the revised draft Plan, taking into account any directions received from the Secretary of State, the Environment Agency and will check the plan to ensure it complies with directions.

Our Final Drought Plan will be available on our website.

1.4. Defra Directions 2020

In April 2020 Defra published its updated Drought Plan (England) Direction. The Directions require the following: A water undertaker must address the following matters in its drought plan

a) how the water undertaker's management structure will manage, communicate and make decisions when using its drought plan
b) the drought management measures that a water undertaker expects to take to maintain supply for the onset, duration and abatement of all potential droughts covered by its plan;
c) how the sequencing of measures has been designed to limit impacts on customers and the environment;
d) the magnitude and duration of the drought scenarios against which the drought plan has been tested to provide security of supply;
e) the permits, orders and any other authorisations that the water undertaker expects to need in order to implement the drought management measures in its drought plan including mitigation and prevention measures;
f) any pre-application steps agreed to ensure that the water undertaker is able to make any necessary applications in a timely manner to those bodies responsible for granting permits, orders and any other authorisations during the onset, duration and abatement of all droughts covered by its drought plan;

g) the measures that will be used to monitor, prevent and mitigate any adverse effect on the environment resulting from the implementation of drought management measures;
h) the compensation payments that a water undertaker expects to make as a result of the implementation of a drought management measure;
i) how a water undertaker will review the ongoing effectiveness of its drought plan and act on its review;
j) how the drought plan is consistent with the water undertaker's Water Resources Management Plan and any voluntary steps that will be taken to collaborate regionally on drought management measures.

1.5. Additions and amendments to Drought Plan 2017 retained for Drought Plan 2022

1.5.1. Water Companies in the South East

We have continued to work with the other water companies in Water Resources South East to align our implementation of demand restrictions and associated exemptions. We have also been working to align our 'More before level 4' demand management measures.

1.5.2. EA liaison on Drought Plan and pre-consultation engagement

We have been in close consultation with the EA during the process of compiling this Drought Plan. The principal change to the Drought Plan has been the reduction in the output associated with the Thames Gateway Water Treatment works from 150 Ml/d to 100 Ml/d and the removal of the Hoddesdon transfer scheme from the plan which reduces drought capability by 12.5 Ml/d. We have also built on our approach to testing our drought plan against more severe droughts and included updated analysis for all of our water resource zones and updated our testing of the plan against more severe drought, which is covered in more detail in section 8.

The Environmental Assessment Reports (EARs) for each of the drought permit/ order options have been completed and the need for any changes discussed with the Environment Agency. We have updated Appendix C, which sets out the basis for the use of drought permit options and their priority order.

1.5.3. Approach to Strategic Environmental Assessment (SEA) and Habitats Regulation Assessment (HRA)

We have undertaken a Strategic Environmental Assessment (SEA) for our draft Drought Plan. The SEA has been undertaken in order to provide a formal review of the environmental impact of the options for drought management included within this plan, particularly drought permit options. This ensures that all the drought management options have been assessed for environmental impact in a comprehensive and consistent manner and the results of the assessment reported systematically.

The SEA was undertaken according to the Practical Guide[6]. Our SEA Scoping Report was issued to the statutory consultees (Environment Agency (EA), Natural England (NE) and English Heritage (EH) in July 2020. This provided an opportunity for the statutory consultees to provide views on the

[6] Office of the Deputy Prime Minister (2005). *A Practical Guide to the Strategic Environmental Assessment Directive*.

proposed scope and level of detail of the SEA Environmental Report. The SEA Environmental Report will be published with the draft Drought Plan in 2021.

The SEA Environmental Report provides information regarding the environmental effects of the drought options included within the Plan. Each drought option was assessed to determine the likely effects against a series of SEA objectives which were derived from environmental objectives established in law, policy or other plans and programmes, and from a review of the baseline information. A cumulative effects assessment was also undertaken which involved examining the likely significant effects of each of the drought options in combination with each other (both intra- and inter- water resource zone) and in combination with the implementation of other relevant plans and programmes. We have also undertaken an HRA of our Drought Plan, which was carried out in parallel with the SEA and reported separately in the HRA Screening Report. Information on potential impacts of drought options from the SEA and the HRA was used to inform the Drought Plan, for example in Appendix C where, together with operational considerations, it was used to assist in assigning priority levels of the options for implementation in a drought.

The Environmental Assessment Reports (EARs) produced to accompany potential drought permit options were reviewed and updated during 2020. We have worked closely with the EA to ensure they are satisfied with the approach and outcomes of the EARs reports. We have also worked with Natural England and we do not have any DP options that have significant adverse effects on designated sites.

In preparation for and during a drought we will work closely with the EA in the process of drought permit applications.

1.6. Review process

In line with regulatory requirements, our Drought Plan will be reviewed every four years and three months and an updated plan produced. The review will take into account any changes in our drought management activities as well as any significant changes in our Water Resources Management Plan (WRMP), see Section 3, which are relevant to the Drought Plan.

An annual review of the Drought Plan will also be carried out, and any issues associated with our Drought Plan will be identified. If issues identified are deemed to constitute a material change, we will revise our Drought Plan in accordance with the procedure laid out in the Water Industry Act; the statutory consultation will be completed within 8 weeks and the revised Drought Plan will be submitted to the Secretary of State within 6 months of submission to the EA.

1.7. Material Changes Since the Last Drought Plan (2017)

1.7.1. Thames Gateway Water Treatment Works and Hoddesdon

The material changes included in this Drought Plan are the reduction in the output associated with the Thames Gateway Water Treatment works, from 150 Ml/d to 100 Ml/d, and the removal of the Hoddesdon transfer scheme from the plan which reduces drought capability by 12.5 Ml/d. We have also updated our detailed analysis of more severe droughts using a stochastic approach, details of this can be found in Section 8.

1.7.2. Updated our levels of service

We have updated our levels of service to align with the Environment Agency guidelines 'Water Company Drought Plan guideline, December 2020'. Previously we included a staggered implementation of Temporary Use Ban (TUB) restrictions, with an equivalent of an unattended hosepipe and sprinkler ban being introduced at Level 2 and a full TUB at level 3. We have now amended this so that a full TUB would be implemented at Level 2 of our levels of service. We have worked with other water companies in the south east of England through the WRSE Drought Group and all water companies are now aligned to implement TUBs as a level 2 drought measure with a level of service of 1:10 years.

Section 2 Water Supply in the Thames Catchment and Drought

2.1. Water supply and the importance of groundwater

Approximately 80% of our water supply is derived from surface water abstraction (largely from the upper and lower River Thames) and the remainder is derived from groundwater abstraction. However, as for most of South East England, during periods of prolonged low rainfall leading to a serious drought water supply is largely sustained by groundwater abstraction and baseflow within rivers, the latter being derived from the outflow of groundwater from the major aquifers within the catchment. Therefore, during periods of drought our water supply becomes increasingly dependent upon groundwater in the major aquifers of the Thames catchment. Winter rainfall provides the longer-term stock of water resource in the form of higher groundwater levels and consequent higher baseflows into streams and rivers.

2.2. Annual recharge cycle

For drought management purposes water resource availability is best regarded in terms of an annual cycle of winter replenishment (October through to March) and summer use. Because of the colder conditions and sparse vegetation, evapotranspiration is much lower in the winter months than during the spring and summer months. Consequently, the cooler winter months facilitate both recharge down to the water table in permeable areas and surface runoff over the impermeable formations directly into streams and rivers. It is during this winter period that groundwater levels rise reaching a peak usually sometime in late winter or early spring. Reservoirs are filled from the resulting high river flows. Thus, winter recharge provides the longer-term stock of water resource in the form of higher groundwater levels and consequent higher baseflows into streams and rivers.

Under normal annual rainfall conditions, the flow in the River Thames is sufficient to satisfy demand for most of the year without the need to draw down raw water reservoir storage significantly. It is usually only during late summer and early autumn that reservoir storage is drawn down to meet demand. For normal years London's reservoir storage will typically only fall to 70-80% by October-November. For above average rainfall years (above average winter rainfall possibly coupled with a wet summer) the higher river flows will generally be sufficient to satisfy demand all year round without the need to draw on reservoir storage.
In contrast, for below average rainfall years (low winter rainfall) the rise in groundwater levels and baseflows are proportionately lower with the consequence that, unless there are significant periods of rainfall over the spring and summer, the draw on reservoir storage will be above average, and levels will consequently be lower.

2.3. Historic droughts and drought vulnerability

For the Thames catchment a water resources drought is caused by a prolonged period of below average winter rainfall. The four worst droughts for water resources on record (the period from 1900) and those which form the basis of London's deployable output are: 1920/21, 1933/34, 1943/44 and 1975/76. All four droughts were characterised by a prolonged period of around 12 to 18 months of below average rainfall.

In contrast to London, the upper Thames (Swindon and Oxfordshire WRZ - SWOX WRZ) is sometimes vulnerable to shorter periods of below average rainfall. This is due to the geological nature of the

upper Thames which is largely fed by the baseflow from the Great and Inferior Oolites. Compared to the other major aquifers, notably the Chalk of the Berkshire Downs and Chilterns, these formations do not store as much groundwater and the throughput from recharge to baseflow is relatively rapid, as is the consequent recession under low rainfall conditions.

It is also worth noting that in terms of drought vulnerability the upper Thames is more typical of the rest of South East England. Although mainly comprised of chalk aquifers, the individual catchments in the rest of the South East tend to be considerably smaller in area than the Thames catchment. In addition, the yield from groundwater sources in these smaller catchments tends to reduce more rapidly with lowering water table levels than the principal groundwater sources that serve the Thames Water supply area. This general vulnerability of the South East region compared to London can be important when it comes to explaining to the public why Thames Water has not introduced water use restrictions, but other neighbouring companies have done so.

We recognise that the droughts that have occurred in the period of record for London, as described above, do not represent the potential level of severity that could be experienced over a much longer time period. This has been recognised by the Environment Agency and consequently water companies are required to test their Drought Plans against more severe droughts. This assessment is included in this Drought Plan. The assessment has been done principally by adopting a stochastic approach to assess the potential for more extreme drought occurring over an extended period of record and attempting to characterise the likelihood of such a drought through estimation of its return period. The ability to cope with more severe droughts is then tested by assessing what measures are required and determining the ability to maintain supplies through such severe droughts. This is covered in more detail in section 8.

2.4. Monitoring the Water Resource Situation

It is important for our Drought Plan to have a comprehensive and reliable monitoring network to allow an accurate assessment of the water resources situation in the Thames supply area. This also allows reliable forecasts of the potential water resource situation to be undertaken. For our water supply area, the essential data requirements are as follows:

- Daily measurements of London and Farmoor total reservoir storage.
- River flow at key locations related to principal reservoirs – key measurement points are above Teddington Weir (limit of freshwater Thames) and Farmoor on the River Thames.
- Abstraction levels of key groundwater and surface water sources.
- Demand for each water resource zone.
- Key hydrological variables are monitored throughout the catchment such as river flows at a wide range of locations, groundwater levels, rainfall and soil moisture deficits (SMDs).

Much of the monitoring of hydrological variables is dependent upon the EA's hydrometric network. Enhanced monitoring of key variables will be implemented at the onset of a drought event.

Groundwater Monitoring

One of the most important indicators of the onset of drought conditions is the hydrological status of the catchment, with particular focus on groundwater levels as this provides a measure of how much resource is stored in the catchment through aquifer storage. The status of the groundwater levels in the Thames catchment is fundamental to understanding the impacts of drought. Therefore, the monitoring of groundwater levels by the EA is an important component of the drought event decision-making process.

At the start of a drought event, the frequency of groundwater data collection by the EA and Thames Water will be increased at key regional observation boreholes (OBHs). We will also work closely with the EA on groundwater monitoring, and it is expected that it will be able to transfer key groundwater data at a greater frequency to complement other data sources. Similarly, the frequency of tracking and analysis of abstraction source groundwater levels will increase.

2.5. Water Situation Report (WSR)

A Water Situation Report is regularly produced for the Thames Water supply area. This report is produced on a monthly basis during periods of normal resource availability and more frequently during drought periods. The report provides information and statistics covering the key water resources variables for management during drought including:

- Water resource situation summary sheet.
- Rainfall data.
- Soil moisture deficit (SMD).
- Groundwater levels.
- River flows.
- Reservoir levels and storage predictions.
- Flow constraint status.
- North London Artificial Recharge System operation – abstraction, recharge and storage status.
- Water Treatment Works outputs – aggregates for London and Thames Valley.

A more detailed outline of the Water Situation Report is included in Appendix D.

Section 3. Water Resource Strategy and Drought Management

3.3. Links between our Water Resources Management Plan (WRMP), Regional WRMP and the Drought Plan

The WRMP is a strategic plan which sets out how the company plans to maintain the balance between supply and demand for water for a minimum planning period of 25 years, although companies with particularly complex planning problems are encouraged to take a longer-term view. Our WRMP19 looks at an 80 year planning period to 2100. Our WRMP sets out the frequency with which we would expect our drought measures, as set out in our Drought Plan, to be required, this is known as our levels of service. The aim of the WRMP is to ensure that we can meet customer demands for water in a dry year without the need for drought interventions at a frequency that exceeds the stated level of service. During drought periods our drought plan is used as the tactical plan which describes how drought interventions are implemented, setting out how each measure will be implemented over the course of a drought. Our ability to maintain our levels of service is therefore a direct reflection of the combined effectiveness of our WRMP[7] and Drought Plan.

We have considered the drought actions that are likely to be included in the Regional WRMP and we have worked with WRSE to align measures with our Drought Plan where possible. Where appropriate we have also aligned our Drought Plan with other plans, including Business Plans and River Basin Management Plans.

3.4. Levels of service

In a succession of dry years, measures to reduce demand for water e.g. Temporary Use Bans (TUBs) and Non-essential Use Bans (NEUBs), and measures to allow increased abstraction, outside that permitted by an abstraction licence, may be required. Such measures are known as drought interventions. Drought interventions either have a direct effect on customers (e.g. TUBs) or the environment (e.g. drought permits for temporary changes to abstraction licences). We set targets regarding the average frequency with which such interventions will be implemented. These are known as levels of service. The aim of the WRMP is to ensure that we can meet customer demands for water in a dry year without the need for drought interventions at a frequency that exceeds the stated level of service. Our Drought Plan sets out the measures required during dry years in line with our levels of service. Our levels of service are shown in Table 1.
We have tested our Drought Plan against more severe droughts than have been experienced in the historic record and the outcome of this assessment is set out in section 8.

[7] https://www.thameswater.co.uk/about-us/regulation/water-resources

Table 4 Levels of Service

Restriction Level	Frequency of Occurrence	Water use restrictions
Level 1	1 year in 5 on average	Intensive media campaign
Level 2	1 year in 10 on average	TUB and Enhanced media campaign
Level 3	1 year in 20 on average	NEUBs requiring the granting of a drought order and Drought Permits. Note these would be applied in a staged manner
Level 4	Never (in reality this equates to ~ 1 year in 100 years on average)*	If extreme measures (such as standpipes and rota cuts) were necessary, their implementation would require an Emergency Drought Order

*Level of service currently 1:100 until 2030 when a new water resource option at Deephams is implemented which will improve supply demand balance so that we are resilient to droughts of 1:200 years without use of drought permits.

3.5. Thames Water's Water Resource Zones

For planning purposes our supply area is divided into six water resource zones (WRZs) as presented in Figure 5. A WRZ describes an area within which the abstraction and distribution of water to meet demand is largely self-contained and all customers experience the same risk of supply failure and the same level of service.

London WRZ is the largest of the six zones and covers much of the Greater London area. The water resources for London are largely based on abstraction from the River Thames, which is stored in reservoirs, and the remainder from underground sources (aquifers) via boreholes.

The next largest zone is the Swindon and Oxfordshire (SWOX) WRZ. This zone is supplied mainly from groundwater (60%), supported by river abstraction and a reservoir, sited near Oxford.

The other zones to the west of London are Kennet Valley (includes Reading and Newbury); Henley; Slough, Wycombe and Aylesbury (SWA) and Guildford. These latter four zones are largely reliant on groundwater abstraction although there are abstractions directly from local rivers, notably the River Kennet in Reading and the River Wey near Guildford. See Figure 5.

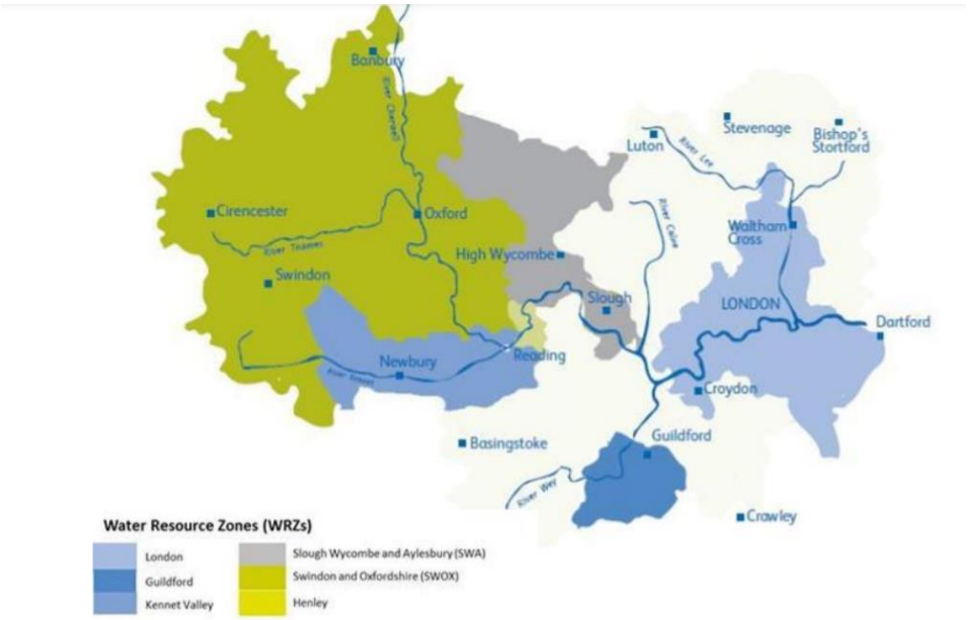


Figure 5 Our Water Resource Zones

3.6. The London WRZ and the Lower Thames Operating Agreement

The drought management of our largest WRZ, London, plays the central and pivotal role in our Drought Plan. Due to its strategic importance company-wide measures will normally be triggered as a result of the water situation impacting on the London WRZ.

The water resources for London are largely based on abstraction from the River Thames, which is stored in reservoirs, and the remainder from underground sources (aquifers) via boreholes.

Fundamental to the operation of London's water supply is the control of abstraction from the river Thames, upstream of Teddington Weir, which is the lowest point on the freshwater Thames. The strategy for the control of abstraction is set out in the Lower Thames Operating Agreement (LTOA), which is a legal agreement (Water Resources Act, Section 20 Water Resources Management Scheme) between Thames Water and the EA. The LTOA manages the following;

- abstraction for water supply;
- maintenance of statutory inter-lock river levels for navigation upstream of Teddington Weir;
- maintenance of prescribed environmental flows over Teddington Weir;
- Provides the support for the trigger for water use restrictions through control curves. The triggering of drought actions is managed through our Drought Protocol. The Drought Protocol looks at a variety of measures to trigger actions during a drought. A key measure used in this assessment is the control curves on the Lower Thames Control Diagram (LTCD) and these effectively provide the latest point at which the measures should be triggered in a drought, see Appendix E1 and Appendix F for more details.

The Lower Thames Control Diagram (LTCD), is the operating tool within the LTOA, which provides the day-to-day rules for managing the London WRZ. The diagram is divided into a set of four minimum

environmental flow zones/constraints (800 Ml/d, 600 - 700 Ml/d, 300 - 400 Ml/d and 300 Ml/d) and the set of Levels 1 to 4 control curves which are linked to our Levels of Service.

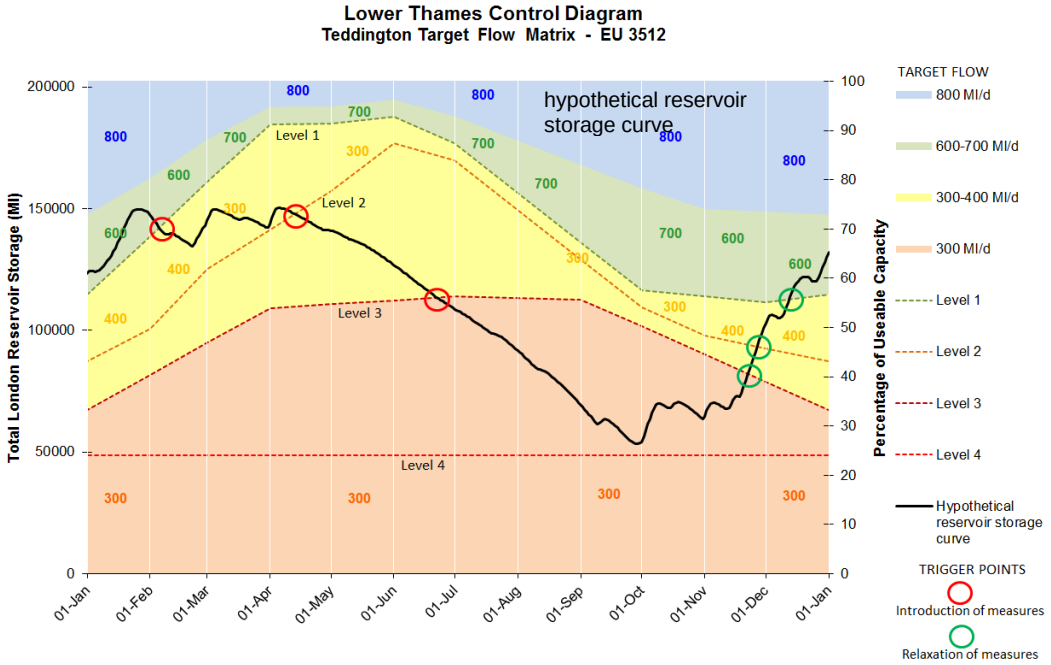


Figure 6 Lower Thames Control Diagram (LTCD)

The LTCD is operated by plotting the total volume of water in storage in the Thames Water London reservoirs during the year. The amount of water that can be abstracted, within the licensed quantity, is determined by the total river flow at Teddington Weir minus the prevailing environmental flow constraint. The flow constraint is determined on the LTCD, by where reservoir storage lies within the four minimum environmental flow zones (the blue, green, yellow and pink zones in Figure 6 Lower Thames Control Diagram (LTCD)).

There is a direct correlation between the control curves on the LTCD and planned Levels of Service Table 4 in two important respects:

The original drought management protocol, set out in 1986 was designed as a definitive guideline to trigger water use restrictions when reservoir storage draws down to intersect a given control curve (Levels 1 to 4) (see Appendix I for further details). Under the historic protocol, when reservoir storage draws down to intersect control curve Level 1, then measures at Level 1 of our Levels of Service are triggered. Similarly, when reservoir storage draws down to control curve Level 2 then the measures at Level 2 of the Levels of Service are triggered and so on through to Levels 3 and 4. This is now used in conjunction with our drought plan protocol as described below.

The average frequency that drought interventions will be required, as shown in Table 4, is a way of describing the severity of the water use restriction measure in question; the more severe droughts and associated measures occur less frequently. We updated our protocol for drought management following the 2012 drought and the protocol is described in Section 4. This allows for the earlier introduction of drought measures than required by simply following the guide within the LTCD. This is necessary so that measures are brought on early enough in a severe drought to ensure more

severe restrictions can be brought on-line in good time if needed. The LTCD therefore represents a likely latest point at which measures should be introduced in a severe drought.

3.7. Abstraction Incentive Mechanism (AIM)

The Abstraction Incentive Mechanism (AIM) is a system introduced by Ofwat in 2016 and is designed to incentivise water companies to use existing flexibility within water resource zones, to reduce abstraction at sites perceived to be environmentally sensitive during periods of low flows.

We have selected four abstraction sources to be included in AIM, which are spread across our WRZs, see details in Table 5 AIM Sources. The sources are:

- New Gauge (London WRZ)
- North Orpington (London WRZ)
- Axford (SWOX WRZ)
- Pangbourne (Kennet Valley WRZ)

The AIM works by the selected abstraction being reduced through substitution to an alternative source, when river flows at a specified gauging point fall below a defined trigger. These triggers have been set and agreed with the Environment Agency. AIM relies on us being able to substitute abstraction at a potentially environmentally damaging source with an alternative source that does not impact on the environment. There are limited cases where this flexibility is available to allow abstraction regimes to be altered. This becomes even more difficult during low flow and drought periods, because all our sources are critical to the provision of security of supply for our customers. Therefore, the reductions proposed under AIM would normally be suspended when we enter a drought (DEL 1 or earlier if necessary) and abstraction would be maximised at AIM sources as necessary to maintain security of supply.

Table 5 AIM Sources

AIM sites		Trigger (river flow) (Ml/d)	Baseline (abstraction) Ml/d
1	RIVER LEE AT NEW GAUGE PUMPING STATION POINT B	60	89.6
2	PANGBOURNE	1.02	31.6
3	AXFORD PUMPING STATION	166	7.85
4	NORTH ORPINGTON PS	11.4	7.16

Section 4. Drought Management Methodology

4.1. Overview

We have developed our drought management protocols and associated methodologies in line with legislation and drought guidance, considering previous droughts. This section describes the protocols for each of the six WRZs.

4.2. Approach for each Water Resources Zone (WRZ)

Drought management decisions must start with a consideration of the impact the drought is having on the supply capability within each WRZ and the approach taken in formulating the drought management protocol is dependent upon the nature of the water resources system within each WRZ. This sub-section provides an overview of the approach for each WRZ and is summarised in Table 6; detailed descriptions are then given in the sections that follow (4.3 to 4.7). Sub-section 4.8 outlines the approach for closing down a drought management event and sub-section 4.9 deals with post drought reviews. We have considered the adoption of environmental triggers for drought actions in addition to the triggers we use based on the water supply position. We have not adopted any specific environmental triggers as the primary function of our Drought Plan is to make provision for the actions to ensure security of supply for our customers. Where action may be required to address the environmental impact of drought the options available to us are principally to encourage customers to reduce demand and we do this through customer communication, this is set out in section 7. The point at which we do this will be determined by a combination of review of the water resource situation, both catchment-wide and locally, supplemented by liaison with the Environment Agency and other environmental stakeholders such as the Rivers Trusts.

4.2.1. London and SWOX WRZs

These WRZs are known as conjunctive use zones as the water resources are derived from a combination of river abstraction, raw water reservoir storage and groundwater sources. For both zones, the critical element in the system is the level of reservoir storage, which in turn is dependent upon river flow. During drought the surface runoff component will tend to be negligible for most of the time (see Section 2), thus, river flow is primarily made up of the baseflow from the catchment's major aquifers.
In total, the drought management measures for the London zone consist of:

- Demand-side measures (see Section 6 for full details) in which water use restrictions associated with Thames Water's Levels of Service play a major role and are triggered by the drought protocol;
- Supply-side measures in which several strategic drought schemes play a major role in augmenting the London zone's supply capability (see Section 6 for full details including trigger mechanism for introducing strategic schemes).

Both the supply and demand-side measures form an integral part of London's deployable output.

In SWOX the protocol is similar to that of London for the introduction of water use restrictions associated with the Levels of Service. However, unlike the London WRZ, there are no supply-side strategic drought schemes built into the zone's deployable output; the major supply-side

augmentation comes mainly in the form of increased abstraction from existing sources introduced at the specified low flow trigger (see Section 4.4.1) through the drought permit mechanism.

As discussed above, because of the dominant nature of the London WRZ, it will generally be the case that the water use restrictions introduced in the London WRZ will also be applied to the rest of our supply area. Nonetheless, the Drought Plan recognises that there may be situations in which more local measures may need to be introduced for the other WRZs, consequently, protocols have also been developed for these zones such that, if necessary measures can be introduced in any of our WRZs alone if a drought occurs with very localised effects although it is recognise that this is relatively unlikely.

4.2.2. Kennet Valley and Guildford WRZs

Although groundwater provides a major contribution in these zones, the critical drought elements are the surface water sources on the River Kennet and River Wey for Kennet Valley and Guildford, respectively. The protocol for these zones is therefore based on river flow reaching critical low levels which act as the trigger mechanism for the introduction of drought measures. However, as mentioned above, the drought situation in London is the principal factor in determining the drought response in these zones.

4.2.3. Slough Wycombe Aylesbury and Henley WRZs

These two zones are entirely supplied by groundwater sources, which historically have remained robust during drought. That is to say, the critical point at which source outputs decline below their deployable output has never been reached. The approach in these zones, therefore, is to track key regional observation boreholes as well as to track the performance of selected groundwater sources in relation to their deployable output. However, as mentioned above, the drought situation in London is the principal factor in determining the drought response in these zones. This is because in a severe drought measures are likely to be implemented Company-wide and measures implemented in the SWA and Henley WRZs will have a small but positive benefit for London through enabling reduction in abstraction so that the resulting marginal increase in river flow will be experienced in the Lower Thames.

Summary

Table 6 provides a summary of the protocols for each WRZ and for introducing the Levels of Service measures.

Table 6 Summary of protocol methodologies for each WRZ

WRZ	Water Resource System	Protocol for introducing Level of Service measures
London and SWOX	River/Raw water storage/groundwater	Risk-based 'prevailing/predicted' protocol and guided by London protocol
Kennet Valley and Guildford	Run of river/groundwater	Guided by London protocol/ WRZ-specific triggers based on 'threshold' river flow

WRZ	Water Resource System	Protocol for introducing Level of Service measures
Slough, Wycombe, Aylesbury and Henley	Groundwater only	Guided by London protocol/ WRZ –specific triggers based on groundwater tracking

The methodology for the protocols for each WRZ is set out in the following sub-sections.

4.3. Protocol for London WRZ

4.3.1. Introduction and Overview

Our Drought Plan protocol is designed to provide triggers for introduction of drought plan measures that are proportionate to the drought risk being experienced. It is also designed to enable the measures to be brought in sufficiently early so that all subsequent measures can be implemented in time and in sequence in order to ensure that the risk of reaching very severe measures under Level 4 is minimised as much as possible. Ensuring that measures are brought in sufficiently early also supports the environment during times of stress.

The key elements of the protocol are used to identify overall drought risk based on the combination of regional groundwater levels, river flows and reservoir storage. This assessment takes into consideration both the current situation and combines it with predictions of how bad the drought could get under a reasonable worst-case scenario. These risk assessments are used together with the known time it would take to implement measures to establish a timeline based on a scenario selected to represent the worst case scenario of severe lack of rainfall leading to our reservoirs becoming critically low at some point in the future. We then use the required sequential nature of the imposition of drought measures to determine when the first elements in that sequence need to be implemented followed by the series of subsequent measures through to the point at which the most severe measures would be required. This provides a timeline for implementation of all the measures so that they can be prepared in advance and then implemented in succession in a timely manner meaning the most severe measures are in place if the drought does progress to be very severe.

Therefore, in summary the key requirements that the protocol must enable are:

- The full sequencing of measures to be taken to avoid or minimise the need for Emergency Drought Orders (EDOs).
- Timely introduction of those measures to maximise demand savings and supply-side benefits and allow for their implementation.
- Proactive communication to customers on their participation.
- A reliable assessment to show that the measures being either considered or actually implemented are consistent with Thames Water's Levels of Service. NB Because of its dominance this is a test that currently is only applied to the London WRZ.

This approach enables us to put measures in place early when a drought has the risk of being very severe and the principal identifier of this risk is the effect that a sustained shortage of rainfall has on groundwater storage. This is particularly important where there has been a shortage of rainfall in winter so that groundwater levels do not recover prior to the summer in our major aquifers, especially the Chalk.

The methodology within the prevailing/predicted protocol has been developed primarily for application to London WRZ, but due to the similar nature of the two water resources systems, can also be readily applied to the SWOX WRZ, see Section 4.4 below.

Both protocols can be divided into three steps as follows:

Step 1 - Collation of hydrological data, predictions of drought impact and assessment of potential drought severity in terms of historic frequency of occurrence.

Step 2 - Risk assessment using the information from Step 1 to derive a composite indicator of risk to security of supply.

Step 3 - Assignment of drought event level and decision on measures to be taken guided by output from Step 2.

The following description of the methodology is provided to give a greater understanding of the protocols. Appendix F provides a detailed description of the methodology aimed at the practitioner; it also provides worked examples of the 2005, 2006, 1976, 1997 and 2012 drought years to demonstrate the new protocol's effectiveness over a range of droughts.

4.3.2. Protocol – Step by step

4.3.2.1. Step 1 - Hydrological Assessment and Drought Severity Assessment

Step 1 is divided into three parts –Steps 1a, 1b and 1c as follows.

Step 1a - Hydrologic Data Collation

The data constituting the collation of the 'prevailing' situation comprises:

- Up-to-date set of groundwater levels from the EA's network of key observation boreholes sampling the principal aquifers in the Thames catchment.
- River flows - primarily from the Lower Thames at Teddington Weir.
- The latest reservoir storage trends plotted on the LTCD

Step 1b – Predictions

For each of these hydrological variables predictions are made using a range of worst case assumptions in respect of rainfall; 60% of long term average rainfall is the scenario most used, generally for a prediction of 6 months for London The 60% scenario is used because this is broadly equivalent to the rainfall that was experienced during the 1976 water year (October 1975 – September 1976) which is the most severe recent drought for which good records are available.

The predictive tools used are as follows:

Groundwater

Catchmod is the principal tool employed for groundwater level predictions. It is a computer model used by the EA to simulate groundwater levels at selected locations. The model is used to generate predictions of groundwater levels based on scenarios of differing percentages of average rainfall for specific groundwater monitoring sites.

Reservoir storage

The WARMS model is used to simulate scenarios of potential future reservoir storage levels within the LTCD. The WARMS modelling system is made up of a series of mathematical simulation models. It is used for 'what if' behavioural analysis of the Thames Water system. One of the key assumptions within the modelling is the savings that can be made by placing restrictions on our customers during a drought, for example Temporary Use Bans. The modelling reflects the timing of when these restrictions would be in place and the resulting reduction in demand.

River flow

The WARMS model is also used to simulate future river flows for Farmoor on the upper Thames and above Teddington Weir on the lower Thames.

Step 1c - Determination of Frequency of Occurrence

Alongside the collation of data, an assessment is undertaken of the potential drought severity expressed in terms of the return period or frequency of occurrence of the drought event. This is used as an important guide to the conformance between planned Levels of Service and the decisions on measures to be taken in Step 3.

The average flow over the critical period of a drought, typically April to September, has been shown to be a good indicator of its impact on London's river/reservoir water resources system. The potential drought severity is assessed by consideration of where the current drought lies in the ranking in relation to previous droughts in the historic record.

Figure 7 demonstrates the technique using 2012 as an example, which shows that there were no droughts of greater severity than the predicted outcome for 2012 covering the period April to September i.e. given the 60% of long term average rainfall prediction, 2012 would rank most severe. The historic record in this case (2012) is 111 years, therefore as forecasted from the start of February, and in relation to the historic record, the potential severity of the 2012 drought event looked to have a frequency of occurrence of 1 in 22 years. This was assessed on the basis that there would have been 5 droughts of approximately this level of severity in 110 years if the 2012 drought progressed to that level by September. A hosepipe ban was introduced in April 2012 for the Thames Water supply area. This action was seen to be broadly in line with the planned level of service for a Level 3 measure with a 1 in 20 year frequency of occurrence.

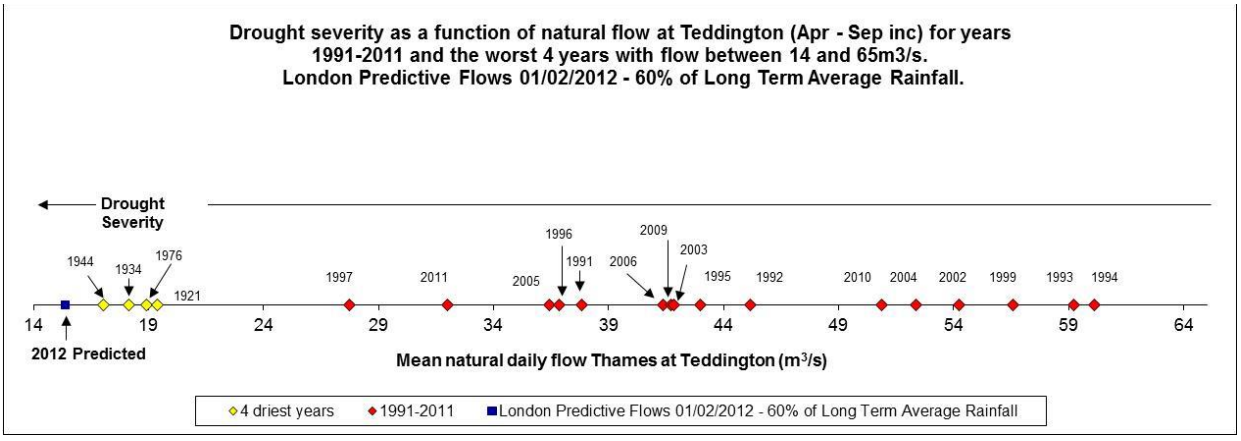


Figure 7 Drought Severity as a Function of Natural Flows at Teddington (April -September) showing the Driest Years Since 1991 and 2011 Prediction and the worst 4 years on record

4.3.2.2. Step 2 - Drought Risk Level Assessment

Step 2 consists of Steps 2a, 2b and 2c described below.

Step 2a- Prevailing and predicted hydrologic risk indicators

Using the output from Step1a, the prevailing and predicted hydrologic data are converted to a corresponding prevailing and predicted set of hydrologic risk indicators for groundwater level (RG), river flows (RR) and reservoir storage (RS); where RG and RR are evaluated in accordance with the EA's percentile banding, Table 7 shows the groundwater and river level percentile bandings. RS is calibrated from the Level 1 to Level 4 control curves in the LTCD, which are shown in Table 8.

Table 7 Groundwater and River flow Level Percentile Bandings

Actual values are based on historic data which is dependent on the extent of the record for each data source.

EA bands		Percentile of the band	Groundwater Risk Level RG	River Flow Risk Level RR
	Exceptionally High	95-100%	R_G0	R_R0
	Notably High	87-95%	R_G0	R_R0
	Above Normal	72-87%	R_G0	R_R0
	Normal	28-72%	R_G0	R_R0
	Below Normal	13-28%	R_G1	R_R1
	Notably Low	5-13%	R_G2	R_R2
	Exceptionally Low	0-5%	R_G3	R_R3
	Not on record		R_G4	R_R4

Table 8 Calibration of RS from LTCD control curves

Reservoir Storage Risk Indicator	LTCD Control Curve limits
	800/600 Ml/d
R_S 0	Level 1
R_S 1	Level 2
R_S 2	Level 3

Reservoir Storage Risk Indicator	LTCD Control Curve limits
R_S 3	
R_S 4	Level 4

This methodology is demonstrated in Figure 8, Figure 9 , and Figure 10 below using data from the 2012 drought. For the river flow and groundwater level parameters, the prevailing mode is the observed data set from January 2012 to end of March 2012 and predicted mode (assumes 60% average rainfall) is forecasted from March to September 2012. For the storage level parameter, the prevailing mode is the observed data set for February 2012 and predicted mode (assumes 60% average rainfall) is forecasted from March to September 2012. The forecasts at the end of February or March are critical in determining the potential need for early drought measures as it is at this point that the winter recharge is likely to have ceased and so a prediction of the worst case for the summer can be made on the basis of the groundwater recession. Taking each parameter in turn, the hydrologic risk indicators are derived as follows:

Groundwater level - R_G

With reference to Table 7 above and Figure 8 below, it can be seen that the prevailing mode is predominantly within the 'Exceptionally Low' zone at the start of the year, giving a prevailing groundwater risk indicator of R_G3. The predicted level moves to R_G4 throughout the 6 month period.

Note that in this example only the Gibbets Cottages OBH has been shown, however, in practice several regional OBHs would be used to derive an overall view of groundwater level status throughout the catchment.

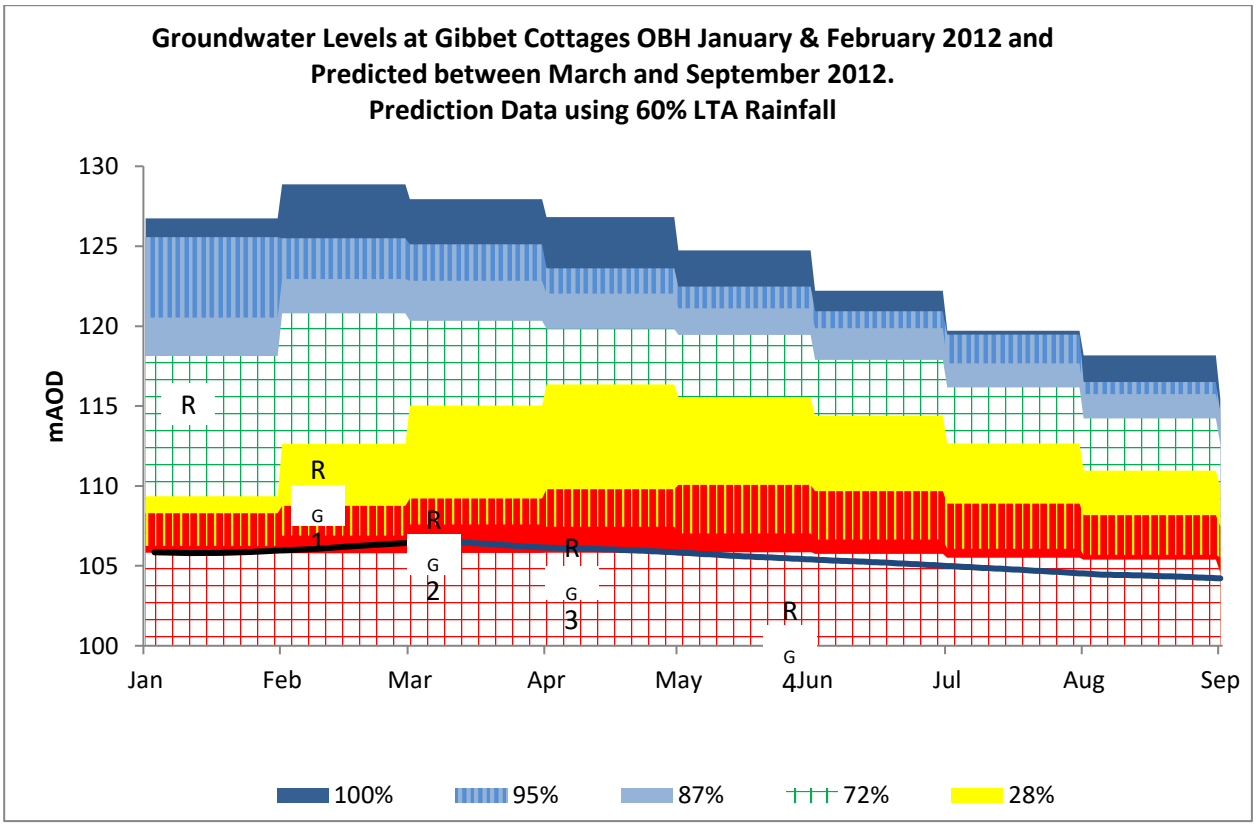


Figure 8 2012 groundwater levels (Gibbet Cottages OBH) - prevailing for January 2012 to end of March 2012, predicted thereafter to September 2012

River flow - RR

With reference toTable 7 above and Figure 9 below, it can be seen that the prevailing mode in March is dominantly within the 'Exceptionally Low' zone, giving a prevailing river flow risk indicator of R_R3. The predicted trend for the 6 month forecast period sits within the 'Not on Record' zone during May giving a predicted river flow risk indicator of R_R4.

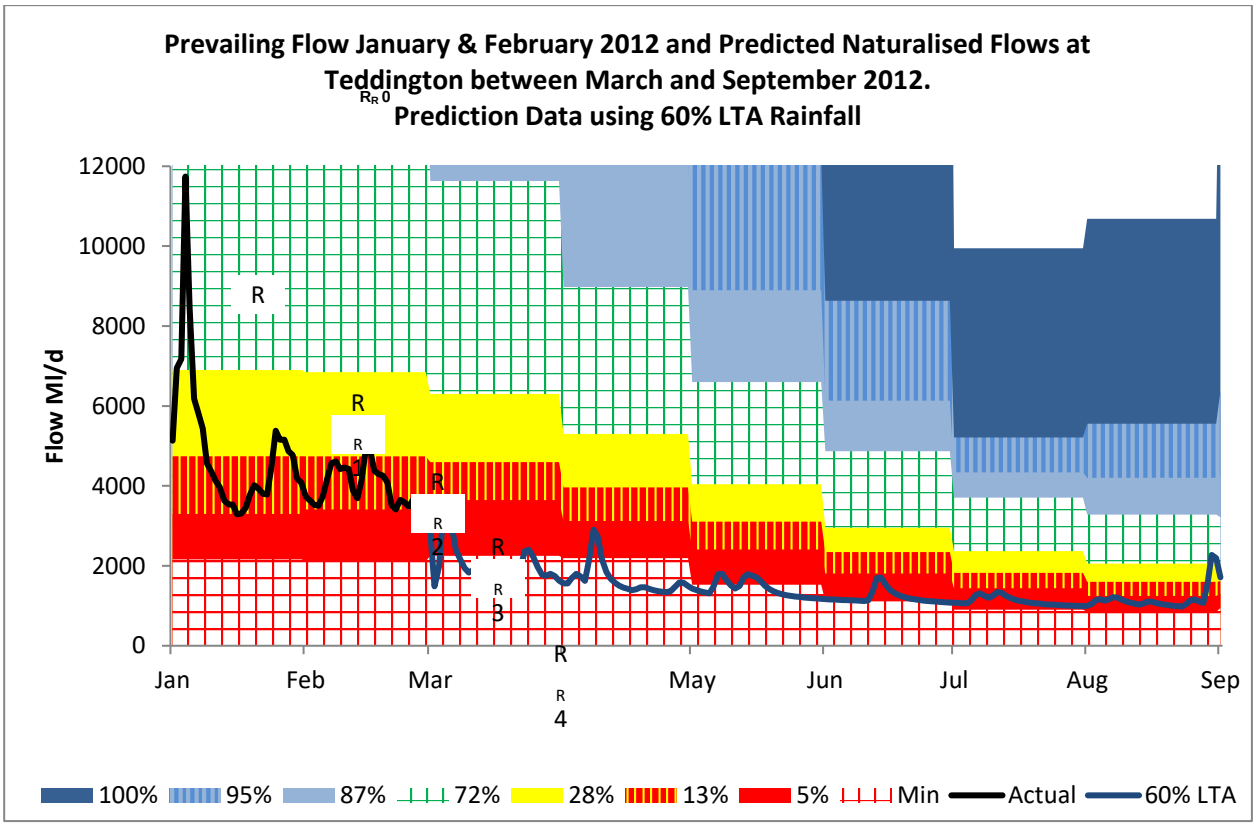


Figure 9 2012 Teddington flows - prevailing from January to end of March, predicted thereafter from March to end of September

Reservoir storage -RS

With reference to Table 8 and Figure 10, the prevailing trend from the start through to the end of February is within the blue 800 Ml/d flow band (RS0). With a 60% predicted long term average rainfall the storage falls into R_S3 in June 2012 then into R_S4 in July 2012.

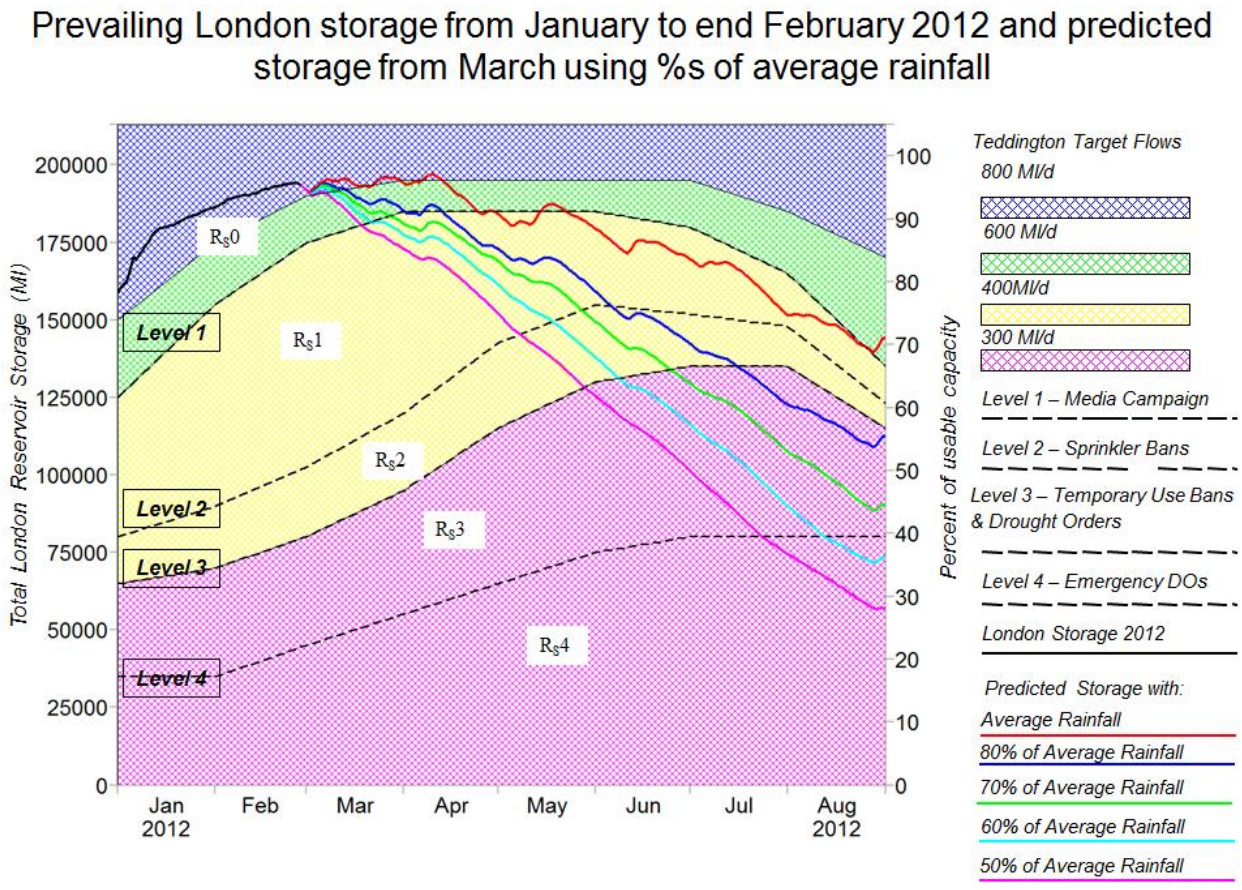


Figure 10 2012 Reservoir storage levels- prevailing to end of February, predicted thereafter (using 2012 LTOA which has since been revised)

4.3.3. Summary

The results of the prevailing and predicted analyses for all three hydrologic variables are summarised below in Table 9.

Table 9 Summary of results for a 6 month forecast from March 2012.

	R_G	R_R	R_S
'Prevailing'	3	3	0
'Predicted'	4	1	4

Step 2b - Combined hydrologic risk indicator

In order to provide a balanced assessment of the overall risk in terms of the hydrologic indicators, the analysis integrates the three individual hydrologic risk indicators relating to groundwater (R_G), river flow (R_R) and reservoir storage (R_S) to provide a combined hydrologic risk indicator (R_C) that is applied to the prevailing situation and predicted scenarios; R_C is given by:

$$R_C = (R_G \times W_G) + (R_R \times W_R) + (R_S \times W_S)$$

Where WG, WR and WS are monthly weighting factors; their formulation is described in detail in Appendix F, Step 2b. The appropriate weighting factors are given in Table 10 below and are shown for all months in Appendix F for London and SWOX respectively. The weighting is used for the relevant month being assessed. Therefore, for the prevailing situation the February weighting is used and for the predicted situation the weighting for August is used.

Table 10 Weighting factors for March and September for London WRZ.

Month	GW - WG	River Flow - WR	Reservoir Storage - WS
March	50%	20%	30%
September	50%	20%	30%

Using the results of the above 2012 example as summarised in Table 9 and the weighting values given in Table 10, R_C values can be calculated for predicted and prevailing conditions in September and March respectively, Table 11. The value is rounded to the nearest whole number to give the combined risk value.

Table 11 Calculation of the combined risk values (R_c) for 'prevailing' March 2012 and 'predicted' August 2012

	R_G * WG	R_R * WR	R_S * WS	R_C
Prevailing	(3 * 0.5) =1.5	(3 * 0.20) =0.6	(0 * 0.3) =0	2
Predicted	(4 * 0.50) =2	(1 * 0.20) =0.2	(4 * 0.3) =1.2	3

Step 2c - Overall risk indicator (ORI)

The risk to security of supply and the appropriate measures to be taken are determined by a consideration of both the prevailing and predicted situation. For example, if groundwater levels are well below average but river flows and reservoir levels are relatively high compared to groundwater levels, then it would be wasteful to switch on strategic schemes prematurely, but it may be prudent to introduce demand management measures such as a TUB. Thus, using prevailing and predicted R_C, the Overall Risk Indicator (ORI) has been developed to provide a balanced assessment of the known short term ('prevailing') risks and potential worst case ('predicted') risks. Table 12 below provides the correlation between the ORI and the prevailing and predicted R_c values.

Table 12 Overall Risk Indicator derived from prevailing and predicted R_c values

Combined Prevailing Risk Indicator	Combined Predicted Risk Indicator	Overall Risk Indicator
R_C0	R_C0	ORI 0/0
	R_C1	ORI 0/1
	R_C2	ORI 0/2
	R_C3	ORI 0/3
R_C1	R_C1	ORI 1/1
	R_C2	ORI 1/2
	R_C3	ORI 1/3
	R_C4	ORI 1/4

Combined Prevailing Risk Indicator	Combined Predicted Risk Indicator	Overall Risk Indicator
R_C2	R_C2	ORI 2/2
	R_C3	ORI 2/3
	R_C4	ORI 2/4
R_C3	R_C3	ORI 3/3
	R_C4	ORI 3/4
R_C4	R_C4	ORI 4/4

Thus, converting the results of the 2012 example as given in Table 12 gives an Overall Risk Indicator of ORI 2/3.

4.3.3.1. Step 3 - Determination of Measures and Drought Event Level (DEL)

The ORI is used as the principal guide for determining the measures to be taken, which in turn is used to set the appropriate Drought Event Level (DEL). Operational aspects, such as outages (when a source of water is not available for use due to reasons such as water quality and maintenance), also need to be considered before appropriate measures are decided upon. The level of DEL (0, 1, 2, 3 and 4) will determine the appropriate level of governance, which ranges from senior management through Director to CEO level. Table 13 below provides the link between the ORI values, DEL, the level of governance and the measures related to the Levels of Service which are largely demand side measures.

The 2012 example giving an ORI level of 2/3 has been highlighted in the table. It shows that the Drought Event is set at DEL3, with governance at Director level and a set of measures consistent with Level 3 of the Levels of Service.

Table 13 Drought Risk Level and Event Level

Overall Risk Indicator Level	TW Drought Event Management Level	Event Controller	Potential Drought Measures	Implied Level of Service
ORI 0/0	DEL 0	No event	No measures introduced.	Not applicable
ORI 0/1	DEL 1	Senior Manager	Media/water efficiency campaign.	Level 1
ORI 0/2	DEL 2	Senior Manager	Enhanced media /water efficiency campaign and TUB.	Level 2
ORI 0/3	DEL 3	Director	Enhanced media /water efficiency, TUB, campaign Non Essential Use Ban (NEUB) and drought permits.	Level 3
ORI 1/1	DEL 1	Senior Manager	Media/water efficiency campaign.	Level 1
ORI 1/2	DEL 2	Director/Senior Manager	Enhanced media campaign and TUB.	Level 2
ORI 1/3	DEL 3	Director	Enhanced media /water efficiency campaign/, TUB, NEUB and drought permits.	Level 3
ORI 2/2	DEL2	Director/Senior Manager	Enhanced media campaign and TUB	Level 2
ORI 2/3	DEL3	Director	Enhanced media/water efficiency campaign/ /Temporary Use Ban; application for NEUB / drought permits.	Level 3
ORI 2/4	DEL3 or DEL 4	Director/ CEO	Enhanced media/water efficiency campaign//Temporary Use Ban; application for NEUB/ drought permits. Preparation for EDO application.	Level 3
ORI 3/3	DEL 3	Director	Enhanced media/water efficiency campaign/ Temporary Use Ban. Introduce NEUB/ drought permits.	Level 3

Overall Risk Indicator Level	TW Drought Event Management Level	Event Controller	Potential Drought Measures	Implied Level of Service
ORI 3/4	DEL 4	CEO	Enhanced media/water efficiency campaign/ Temporary Use Ban Introduce NEUB / drought permits. Preparation for EDO and possible application.	Level 3
ORI 4/4	DEL 4	CEO	Enhanced media/water efficiency campaign/ Temporary Use Ban Introduce NEUB / drought permits. Introduce emergency measures.	Level 4

4.3.3.2. Drought Event-management structure

In accordance with the drought management governance described above in Step 3, our drought management structure is shown below in Figure 11.

The structure reflects the broad supporting discipline base that will be required to support a Drought event. Each business lead will have a team supporting them comprising seconded and supporting staff and external consultants where required. The same structure would be applied for all WRZs.

The resource required and the structure reporting to each lead role will be defined by the severity of Drought and the resource situation in each water supply zone and will continually be reassessed as the severity of the situation changes during a drought.

The stakeholder engagement role is critical in terms of providing a focus for all stakeholder communications and discussions. The stakeholder lead will be responsible for maintaining a close working relationship with critical stakeholders such as the EA and Defra and other key stakeholders such as CCWater, Natural England and the GLA, whilst ensuring appropriate appointed stakeholder contacts for all other stakeholders.

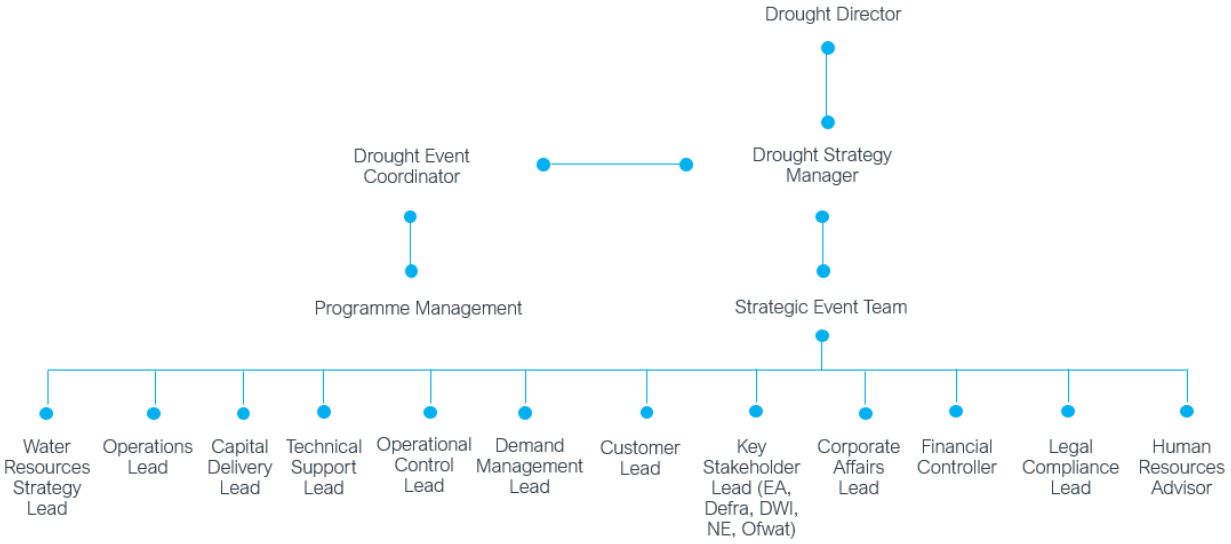


Figure 11 Drought Event Management Structure

4.3.4. Sequencing and timing of measures

For any drought scenario the timing of introduction of the most severe measures that are required is assessed within the protocol. This enables determination of the timing and sequencing of the lesser and, by necessity, earlier measures. Thus, a timeline can then be used to back cast from the point at which it is identified that the most severe predicted measure is required.

It is also necessary to implement water use restrictions in the sequence set out in our Levels of Service, as follows:

- Media campaign must precede a Temporary Use Ban (TUB).
- TUB must precede a NEUB.
- TUB must precede a drought permit.
- NEUB must precede an emergency drought order (EDO).

In order to accommodate the required timeline, there may need to be an overlap in the process due to the time taken to determine NEUB application. For London, the plan assumes the periods of time for the individual actions in the process are as follows:

Level 1 measures

- Media campaign: 2 weeks

Level 2 measures

- TUB: 3 weeks.

Level 3 measures

- NEUB up to 10 weeks from date of the application to granting of order; NB- this time scale allows for a public hearing.
- Drought permit: up to 10 weeks (for the more environmentally sensitive permits) from date of the application to granting of permit; NB - a Category 1 level drought permit may be determined significantly more quickly than 10 weeks.

Level 4 measures

- EDO: up to 10 weeks from date of application to granting of order; NB - this time scale allows for a public hearing.

As shown in Table 14, it can be seen that the elapsed time by which a NEUB could be put in place starting from a point when no preliminary measures had been introduced would be in the order of 15 weeks; for an EDO the equivalent elapsed time is likely to be 25 weeks.

Table 14 Drought Measures Indicative Timescale for London

Measure	Time to Implement (Weeks)			
Media campaign	2			
Temporary Use Ban		3		
NEUB /drought permit			10	
Emergency drought order (EDO)				10
Elapsed time (WEEKS)	2	5	15	25

The elapsed times shown in Table 14 can be used as a guide for planning the timing of the introduction of measures when used in association with the scenarios described above which provide predictions of when certain risk levels will be reached.

4.4. SWOX WRZ

4.4.1. Methodology

The principal and most drought-critical source in the SWOX WRZ is the Farmoor water resources system comprising abstraction from the River Thames transferred to Farmoor reservoir, referred to in the next sub-section. The methodology for the zone has been developed in recognition of the potentially relatively rapid decline in Farmoor reservoir storage compared to London reservoir storage under comparable low flow conditions.

Drought triggers

The Farmoor licence increasingly constrains abstraction from the river as the River Thames recedes under low flow conditions. This, in turn, governs the quantity of river water that can be transferred to Farmoor reservoir. This river/reservoir dependency has been used to define a set of triggers based on critical low flows at Farmoor, the criteria are as follows:

- Trigger for determining the submission date for NEUB and drought permit applications is set at 200 Ml/d flow in the River Thames (5-day running mean) under DEL3 or DEL4 drought event scenarios;
- Trigger for predicting the implementation of NEUB and drought permit options is set at 100 Ml/d (5-day running mean) under DEL3 or DEL4. The latest point of implementing drought permit options will be either by river flow actually receding down to the 100 Ml/d level, or reservoir storage drawing down to 70% in June and July and to 60% in August and September, whichever is the earliest. If NEUB is not already in place company-wide through the London protocol, the above criteria will also be used as the basis for implementing the NEUB.

The 200 Ml/d trigger has been chosen on the basis that it represents the threshold flow after which the maximum licensed abstraction is approximately equal to demand on the Farmoor system and hence thereafter reservoir storage will tend to decline; up to this point Farmoor reservoir will be close to full capacity.

The 100 Ml/d trigger represents the point of significant risk of Farmoor reservoir storage falling to 70% in June and July and 60% in August and September. As all droughts are different, the correspondence of this trigger with the measures being triggered by the London protocol, which will override demand measures in SWOX (see below), will depend on the way the specific drought has developed. Note that a base flow at Farmoor of 200 Ml/d can sometimes be reached towards the end of the summer/autumn recession under normal water situation conditions (best defined by groundwater levels), typically in September or early October. Therefore, a DEL3 or DEL4 criterion is added to the triggers as set out above.

The 1976 drought was used to illustrate and test the effectiveness of the triggers (Section 8 and Appendix F). The 1976 drought was the most uniformly extreme in terms of paucity of rainfall over the Thames catchment and for which a good data set is available. By examining the River Thames flow at Farmoor with London reservoir storage during 1976 a useful guide is provided on the SWOX-London triggers, which show that:

- In the last week of April the flow at Farmoor reached the 200 Ml/d trigger when London reservoir storage reached Level 1 on the LTCD;
- In mid-July flow at Farmoor reached the 100 Ml/d trigger when London reservoir storage reached 70%.

Thus, with reference to the London protocol described above, a helpful conclusion from the above relationships is that for a severe drought (DEL 3 or DEL 4), the enhanced media campaign and Temporary Use Ban measures will already be operating when applications for NEUB and drought permits are submitted for SWOX triggered by the 200 Ml/d flow threshold.

SWOX assessment methodology

There are three basic steps to the SWOX protocol, which is based on the London WRZ, summarised briefly as follows:

- Step 1 consisting of:
- Step 1a -Collation of groundwater, river flow and reservoir storage observed ('prevailing') data.
- Step 1b - Predictions of worst-case scenarios using results from Step 1a as initial conditions, includes new trigger for the application of NEUB and drought permits.
- Step 1c - Estimation of drought severity or frequency of occurrence.
- Step 2 - Risk assessment using the information from Step 1 to derive a composite indicator of risk to security of supply, the Overall Risk Indicator (ORI).
- Step 3 - Guided by output from Step 2, assignment of Drought Event Level (DEL 1,2,3 or 4) and consequent measures to be taken or proposed

Note that within Step 1b, the methodology includes the estimation of the trigger for the submission of NEUB and drought permit applications.

4.4.2. Sequencing and timing

The sequencing of measures and their timing would in the first instance be triggered by the introduction of measures for the London WRZ, see Protocol for London WRZ, Section 4.3.
Given that winter rainfall generally tracks from west to east over the region, it is extremely unlikely that there will be a prolonged period of winter rainfall in which the upper Thames receives below average rainfall while the lower Thames receives normal amounts. However, in the very unlikely event that SWOX WRZ appears to be substantially advanced in terms of drought severity, the SWOX protocol would be followed in its entirety.
As described above, the trigger for applying to Defra for NEUB and to the EA for drought permits is reaching 200 Ml/d naturalised flow on the River Thames at Farmoor under DEL3 or DEL4 drought event scenarios. At this point it is very likely that TUB restrictions would already be in force.

Implementation of NEUB or drought permits would be risk-based, triggered either by consideration of the prevailing reservoir storage approaching 70% or a threshold of naturalised flow of 100 Ml/d or a combination of both.

The trigger for applying to Defra for an Emergency Drought Order would be after the implementation of NEUB measures and would be based on modelling of the likely decline in Farmoor storage taking into account the benefit derived from implementation of Drought Permit options. This assessment would use modelling as a guide to determine the potential time to reach the 33% and the application for an Emergency Drought Order would be based on the expected elapsed time to obtain an EDO. Assessment of conditions at the time of year would also be instrumental in the decision.

The sequencing and timings are given in Table 15 below for a drought of potential severity of at least 1:20 in which the need for drought permits and NEUB and possibly an Emergency Drought Order are predicted. Note that, as the elapsed times are based on the worst-case situation, in practice there is likely to be significantly more time available to implement measures than stated in the table.

Table 15 Drought Measures Indicative Timescale for SWOX

Measure	Triggers	Minimum time to implement (Weeks)			
Media campaign	DEL1 or higher	2			
Temporary Use Ban	DEL2 or higher		3		
NEUB /drought permit	Application to Defra/EA—200 Ml/d rule			10	
Emergency drought order	Application to Defra- implementation of DD11				10
Cumulative Elapsed time		2	5	15	25

4.5. Protocol for Kennet Valley WRZ

The Kennet Valley WRZ is served by a combination of surface water abstraction from the River Kennet in Reading and by several Chalk groundwater sources throughout the zone.
The principal source in the zone and providing the greater part of the supply for the Reading area is the Fobney Advanced Water Treatment Works (AWTW), which derives its raw water from the River Kennet. Work was completed in 2006 to improve the robustness of this source during drought through the Holy Brook flow control structure.

The groundwater sources in the zone have proved to be robust to drought at least since the early 1970s. That is to say, based on current hydrogeological understanding and groundwater remaining above the recorded minimum level (generally the lowest 1976 level), abstraction is expected to be maintained at the assessed deployable output. We have completed an assessment of the potential impacts more severe droughts would have on us; this can be found in section 8.

We have assessed what measures may be needed in a severe drought and threshold values have been developed for the River Kennet below which the Fobney source output may decline. These values are used for determining the need for the introduction of measures in the Kennet Valley zone. Analysis has therefore been undertaken of the flows at Theale to determine a guidance trigger for the introduction of drought measures in the zone.

Holy Brook Control Structure

The Holy Brook is a historic, man-made channel which obtains its flow from the River Kennet/Kennet and Avon canal system approximately 4 kilometres upstream of the Fobney AWTW. At times of low flow the Holy Brook historically took a high and disproportionate amount of flow from the Kennet system. To offset this, a control structure has been installed located on the Holy Brook just downstream of its bifurcation from the River Kennet.

We have agreed an Operating Protocol with the EA, which is based on the principle that as a drought worsens and flows in the River Kennet decline, a progressively higher proportion of flow is diverted from the Holy Brook into the Kennet system that flows past the Fobney AWTW intake. Accordingly, an Operating Schedule has been agreed for the Holy Brook control structure. The schedule is based on a series of triggers requiring closure and opening of the gates on the new control structure as determined by a specified flow in the River Kennet at the Theale Gauging Station, 800m upstream of the Holy Brook control structure. These triggers will be used to aid decision-making when reviewing restrictions for the Kennet Valley WRZ together with reference to the imposition of restrictions in the London WRZ.

Fobney Source Robustness to Drought

The Fobney source is licensed for 72.7 Ml/d with a source deployable output of 63.1 Ml/d average and peak assuming 9.7% process losses. Therefore, the flows available for abstraction at Fobney need to be maintained at least to 72.7 Ml/d in order to ensure the deployable output is maintained.

Figure 12 shows the flows in the River Kennet at Theale for the lowest flow periods experienced within the period of record (commenced October 1961) for the gauging station at Theale. The graph shows the low flow periods of 1965, 1976, 1992 and 1997 and comparison of the drought episodes shows clearly that the worst drought experienced in the record was 1976.

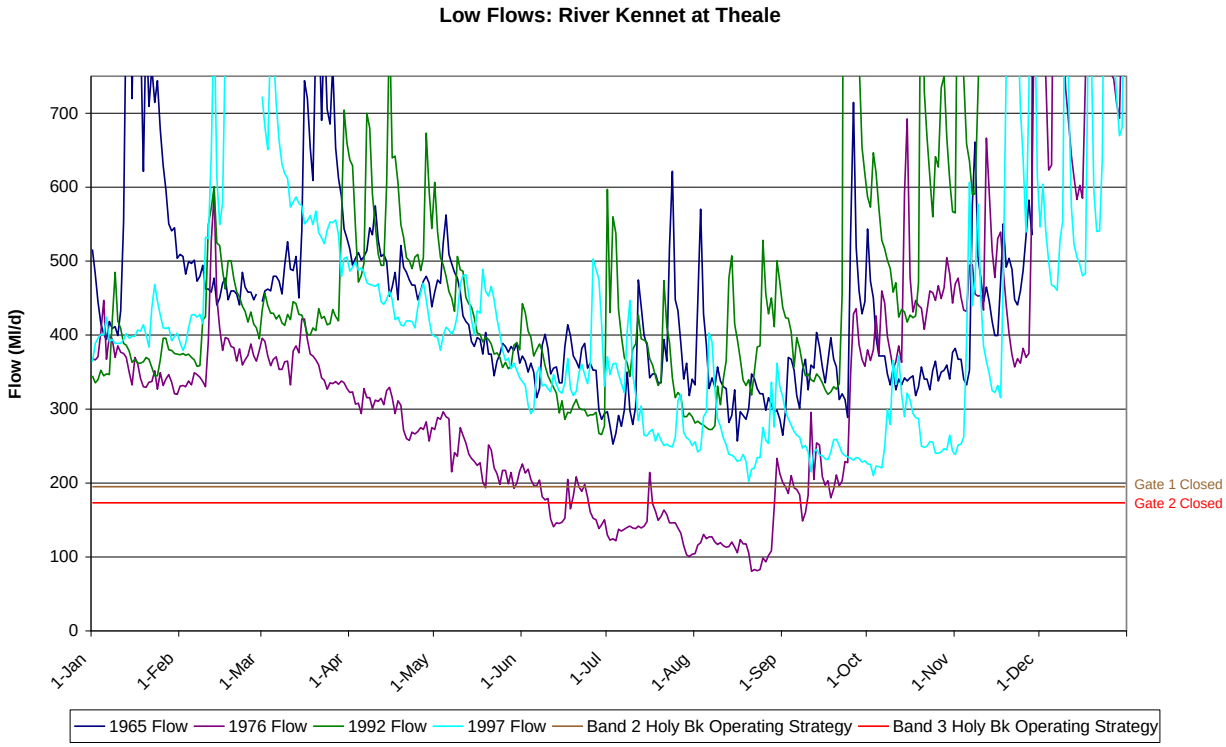


Figure 12 Historic Low Flows for the River Kennet at Theale

Figure 12 and Figure 13 shows the relationship between the flows at Theale and the flows at Fobney, showing the benefit to the flows at Fobney that are provided by the Holy Brook control structure. The diagram shows that as the flow declines at Theale to 195 Ml/d the first gate is shut and so the flow available at Fobney is increased from 75 Ml/d to approximately 90 Ml/d. In a similar way the closure of the second gate at a flow of 173 Ml/d at Theale increases the flow from 75 Ml/d to about 90 Ml/d at Fobney AWTW. It is not until the flow then falls to about 150 Ml/d at Theale that the flow available at Fobney decreases below the licensed abstraction rate of 72.7 Ml/d thereby impacting the source deployable output.

Note that in estimating the flow at Fobney AWTW, apart from the flow diverted down the Holy Brook, account must also be taken of the flow diverted down the fish pass at the Labyrinth weir (approximately 200 metres upstream of the Fobney works intake) as well as leakage through the canal bed. At times of low flow the fish pass diversion can account for up to 44 Ml/d and bed leakage can also be significant due to the increasingly perched nature of the canal bed as the natural water table declines.

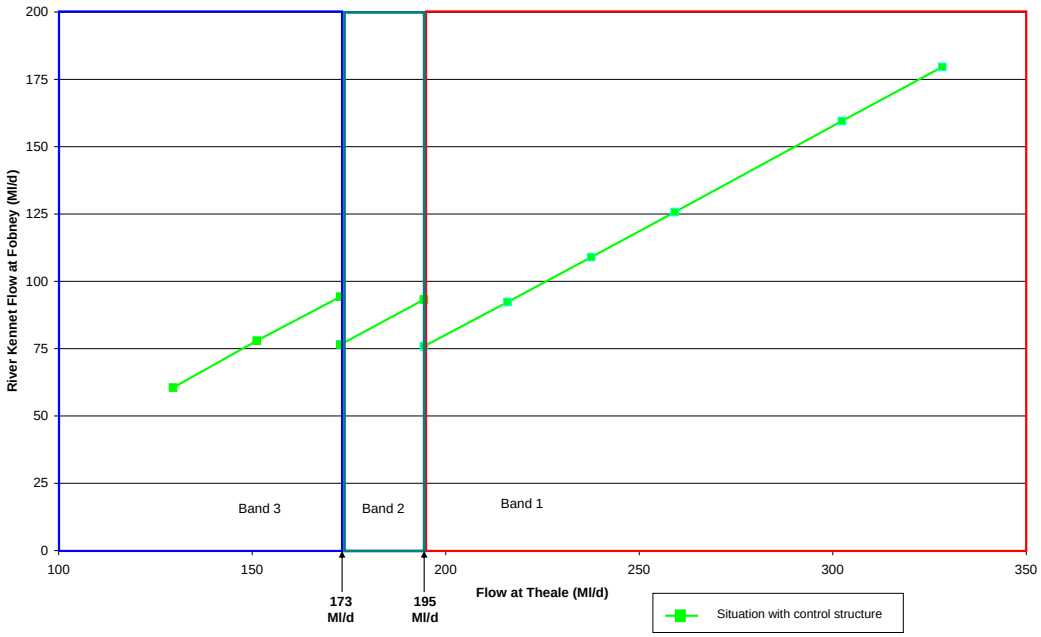


Figure 13 Impact of the flow control structure on the flow in the River Kennet at Fobney

West Berkshire Groundwater Scheme

Figure 14 shows that in order for the flow at Theale to be maintained above 150 Ml/d, the West Berkshire Groundwater Scheme (WBGWS) must be in full operation. When the WBGWS is in operation, the minimum flow at Theale that would have been experienced in 1976 is approximately 150 Ml/d i.e. the flow required to maintain the abstraction at Fobney at 72.7 Ml/d.

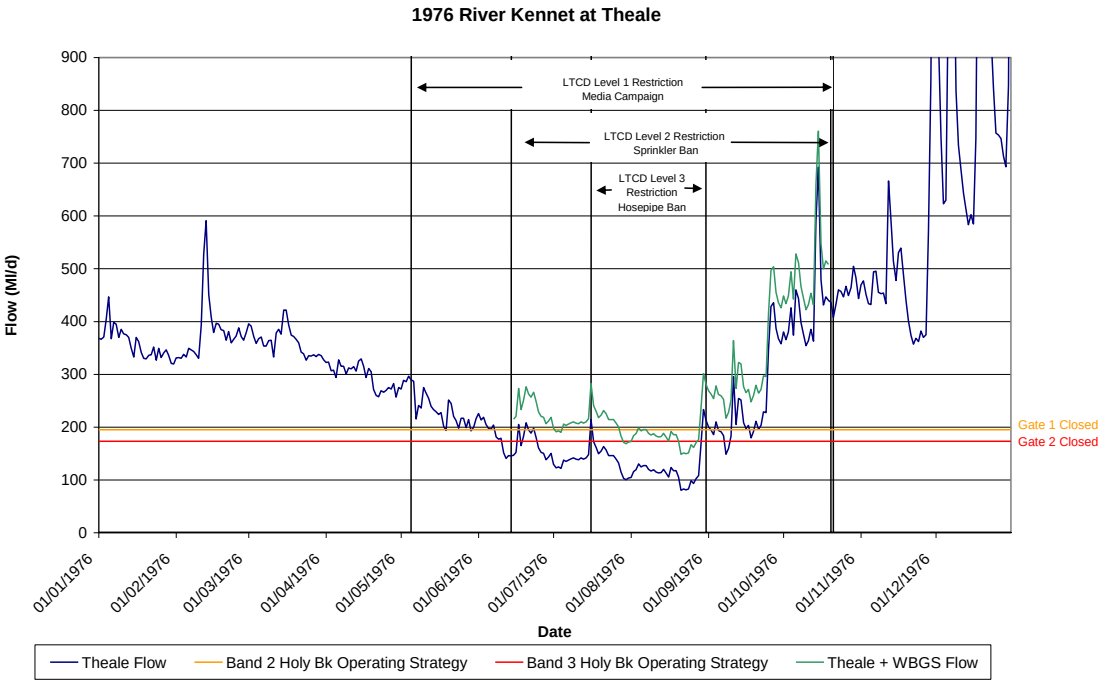


Figure 14 Benefit of West Berkshire Groundwater Scheme augmentation of River Kennet

The adopted trigger levels for guiding decision-making on the introduction of restrictions are set out in Table 16. Normally water use restrictions from the initial media campaign through to Temporary Use Ban and NEUB would be triggered from the London WRZ protocol, see Section 4.3 above.

Table 16 Kennet WRZ Trigger Levels

Critical period	Flow at Theale (Ml/d)	New Flow Split Structure State
Band 1	>195	Gates fully open
Band 2	<195	LoS Level 3 -Temporary Use Ban measures to be introduced prior to Gate 1 closure. Gate 1 closure - triggered 195 Ml/d threshold After Gate1 closure submit: • NEUB application for Kennet Valley WRZ; • Drought Permit applications in priority order as set out in Appendix C.
Band 3	<173	Gate 2 closure - triggered by 173 Ml/d threshold Conditions of Gate 2 closure are that the Temporary Use Ban will be in place and the NEUB application will be underway.
Implementation of Drought Permits		NEUB will be implemented alongside the introduction of Drought Permit options.

An assessment of the potential impact of a severe drought on the flow in the River Kennet and the Kennet and Avon canal and on the water abstraction arrangements at Fobney AWTW, which is fed by abstraction from the Kennet and Avon canal, has been undertaken. The flow down the Holy Brook leaves the River Kennet at the 'Arrowhead' Structure which controls the split of flow along the River Kennet and the Holy Brook. The analysis has determined that the flow along the Holy Brook needs to be restricted during low flow periods because if not controlled it will result in low flows at the Fobney intake, such that abstraction cannot be maintained to the levels required to secure supplies to the Reading area. We have tested the impact of a more severe drought on the Kennet Valley WRZ drought measures and this is described in Section 8.

We have agreed an Operating Protocol with the Environment Agency which sets out the rules governing the timing of the restrictions that would be put in place to ensure that adequate flow is maintained in the River Kennet, whilst ensuring the required environmental minimum flow is provided to the Holy Brook. In a very severe drought we could invoke a drought permit option to allow for a reduction of the flow to the Holy Brook and an Environmental Assessment Report (EAR) has been produced for this option. It is also recognised that during a severe drought the ability to maintain adequate flows for abstraction at the Fobney intake, may require the closure of the fish pass at the Labyrinth weir just downstream of the split of the River Kennet and the Kennet and Avon canal arm from which the abstraction is taken as shown in
Figure 15 . The Environment Agency are not able to close the fish pass, in line with the Salmon and Freshwater Fisheries Act requirements. Therefore, an option would be required to transfer water from the River Kennet below the Labyrinth weir and discharge it into the Kennet and Avon canal just upstream of the Fobney intake. This has been discussed this with the Environment Agency and we have agreed that such an option should be included in our drought plan. The option could be accommodated through a transfer licence, because the water is being transferred between watercourses with no change to the water quality or intervening use of the water. An application for a transfer licence could be completed in a short timescale in the event that it is needed in a drought or included in the operating agreement. This is outlined conceptually in
Figure 15 .

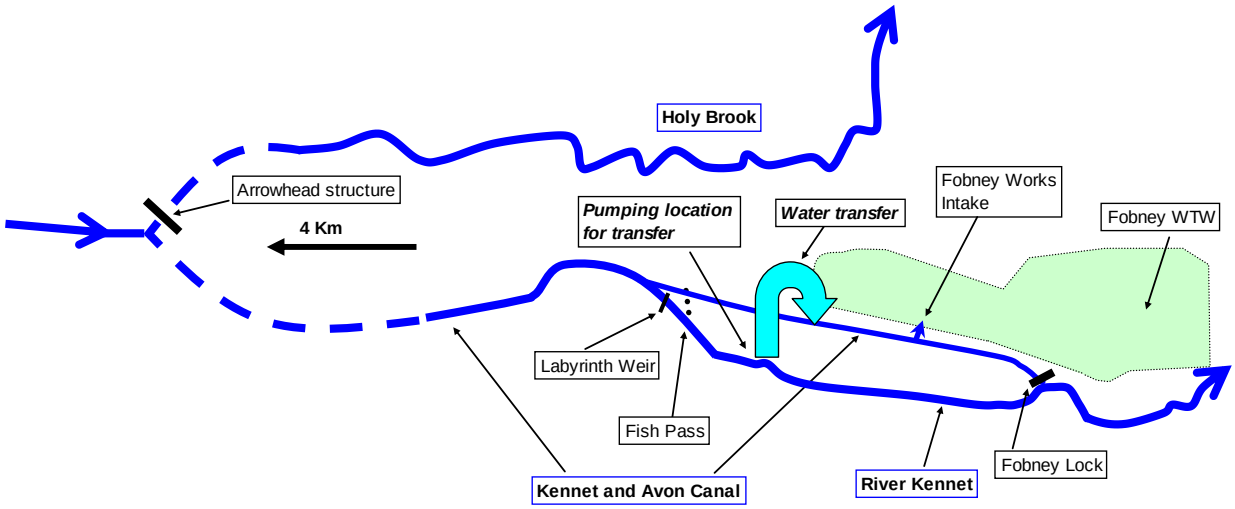


Figure 15 Configuration of pumping arrangements at Fobney intake. Water is pumped from below the Labyrinth Weir into the navigation reach above the Fobney intake channel

Kennet Valley WRZ Resilience

As noted above all the key groundwater sources in the Kennet Valley WRZ are resilient to drought, however Fobney AWTW, by virtue of the flows in the Kennet and Avon Canal that serve the works, is less resilient. The resilience of Fobney is linked to:

- The operation of WBGWS, augmenting natural base flows by the time they have receded down to the critical level of 150 Ml/d at Theale.
- Additional support from drought permits during the critical period
- Supporting the Kennet Valley WRZ and Fobney AWTW by drought permits alone if the WBGWS is not in operation

In this assessment it is assumed that the fish pass at Labyrinth weir will be closed during the extreme low flow critical period for Fobney AWTW. However, if the fish pass cannot be closed, we would require a drought permit to allow for transfer of water from below Labyrinth weir to the canal upstream of our intake.

West Berkshire Groundwater Scheme (WBGWS)

The River Kennet is one of the largest sub-catchments of the River Thames and its base flow can be taken as representative of the base flow at Teddington Weir. It is therefore extremely unlikely that a hydrological situation could exist in which base flows at Teddington Weir could be significantly misaligned with those at Theale.

During periods of very low flow, the WBGWS is triggered when London reservoir storage reaches the Level 2 curve on the LTCD (see Section 6.1.8.4). This trigger is likely to be reached when naturalised flow at Teddington Weir is between 3000 and 2000 Ml/d. At this time flow at Theale is likely to be between 400 and 300 Ml/d. This range is significantly above the point (150 Ml/d) when the flow at Fobney AWTW starts to approach the licensed abstraction limit of 72.7 M/d. The recession of 1976 was the most severe on record for the Theale gauging station. Comparison with the stream hydrographs at Theale and at Teddington Weir for 1976 clearly shows that the WBGWS would have been in operation at least 2 months prior to Fobney requiring support from the scheme, see Figure 16 below.

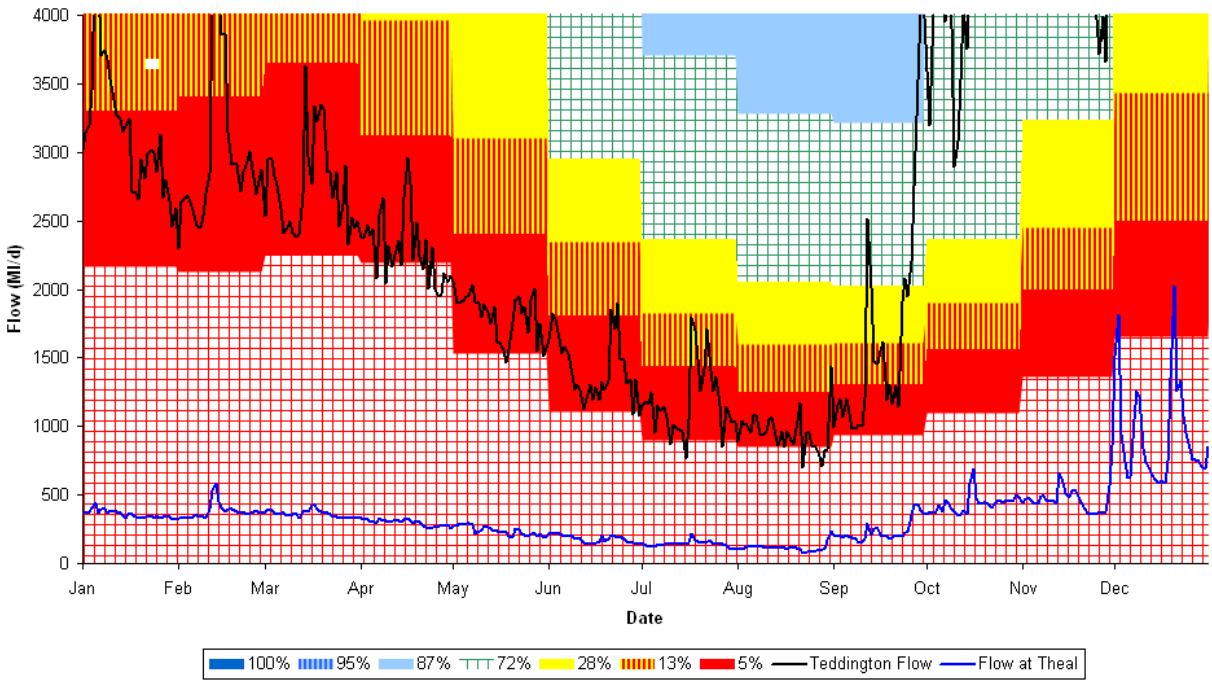


Figure 16 Comparison of River Thames flow at Teddington Weir and River Kennet flow at Theale GS during 1976.

Drought permit support

The drought permit options that can effectively support Fobney AWTW (see Appendix C) are:

- Pangbourne Groundwater source
- Fobney Emergency Boreholes
- Further reduction in residual flow down the Holy Brook

The net contribution from the Pangbourne source drought permit into the Reading area is set at 7 Ml/d. The contribution from the Fobney Emergency boreholes is estimated to range between 12 and 28 Ml/d. Thus, the contribution from the groundwater sources range from 19 to 35 Ml/d. However, with the WBGWS in operation, which provides around 55 Ml/d at Fobney AWTW, it is unlikely that any further support would be needed from reducing residual flow down the Holy Brook.

Supporting Kennet WRZ without the WBGWS in operation

In the event that the WBGWS were not in operation during extremely low flow periods such as experienced in 1976, it is clear that a substantial contribution from the Holy Brook residual flow would need to be made, say in the order of 10 to 30 Ml/d. It is assumed that there will always be some natural flow reaching the Fobney arm of the River Kennet system enabling a degree of raw water abstraction into the works. Under the scenario where the WBGWS is not in operation, a shortfall of 55 Ml/d during critical periods has been estimated.

Trigger for drought permits

With regard to the trigger for implementing drought permits at 173 Ml/d (Gate 2 closure), consistent with the other WRZ lead times, a period of 10 weeks has been calculated back from the point when Gate 2 closure is predicted. This means that, in practice, during the early stages of a severe drought (as given by DEL3 or DEL4), an essential requirement will be the prediction of flow recession in the River Kennet at Theale.

Note that, this drought protocol has not yet been used during a drought period, and so it will be subject to review following any drought period.

4.6. Protocol for Guildford WRZ

The Guildford WRZ is served by a combination of surface and groundwater abstraction. The principal source is at Shalford where water can be abstracted from either the River Wey or the River Tillingbourne, which enters the former at this point. The remainder of the WRZ is served by abstraction from groundwater, either from the Chalk or the Greensand aquifers. The Shalford source is the largest individual source in the zone and so is the key source for use as an indicator of when drought conditions are developing.

The Shalford source is licensed for 30 Ml/d and has no flow constraint. Abstraction can be taken either from the Wey or the Tillingbourne and so the deployable output (DO) is determined through reference to both sources.

The Shalford source has historically been robust through drought periods such that its yield could be maintained during the droughts experienced over the period of record. The robustness of the source arises from the fact that the combined flows in the Wey (as gauged at Tilford) and the Tillingbourne have historically been well in excess of the abstraction requirements at all times since the 1950s. This is demonstrated by the figures below, which show that the combined flow of the Tillingbourne and Wey available to the Shalford intakes is some 38 Ml/d above the Shalford abstraction licence.

Shalford abstraction licence	30 Ml/d
Source DO	26.4 Ml/d (12% process losses)
Minimum flow in Wey plus Tillingbourne	68.4 Ml/d

Based on historical low flows, see Figure 17 , threshold values have been developed for the Wey at Tilford for use in triggering the need for the introduction of measures specifically to address the risk to supplies in the Guildford zone, Table 17.

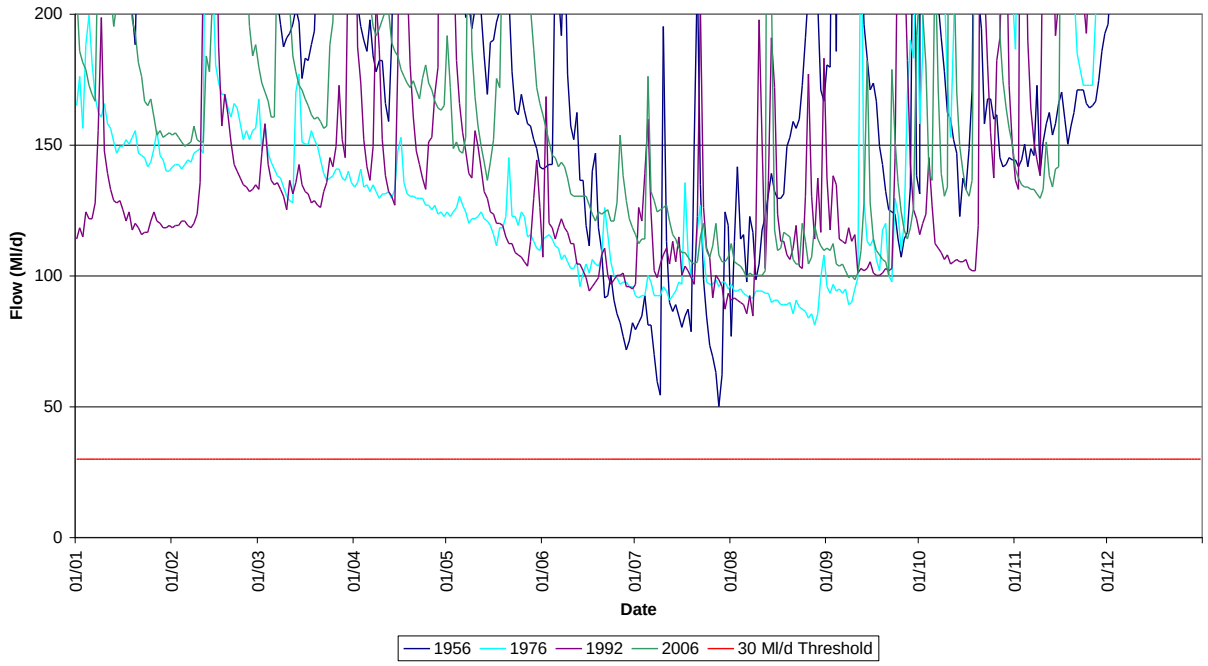


Figure 17 Historic low flow on the River Wey

Table 17 Indicative Flow Triggers for Guildford WRZ

Measure	Flow rate
Temporary Use Ban	90 Ml/d (on average for 5 days)
NEUB	75 Ml/d (on average for 5 days)
Drought permit	75 Ml/d (on average for 5 days)

The thresholds are based on the minimum flows experienced in 1976. A safety margin of 20 Ml/d has been allowed for (difference between the minimum recorded flow at Tilford and maximum abstraction rate). The trigger points are chosen to allow for an appropriate period to prepare for a drought order or drought permit applications.

In practice, a minimum period of 10 weeks has been allocated for the lead time from submission to granting of drought permit. The preparation time needed for a given permit will vary depending on the information needed for each drought permit. It is therefore important that the appropriate hydrologic tools are available for predicting flows in the Wey and Tillingbourne.

The resilience of the Guildford WRZ to more severe droughts has been assessed and is described in more detail in Section 8.

4.7. Protocols for Slough, Wycombe, Aylesbury and Henley WRZs

Both Slough, Wycombe, Aylesbury (SWA) and Henley WRZs are entirely served by groundwater sources abstracting predominantly from the unconfined Chalk aquifer of the Chiltern Hills. These groundwater sources have proved to be robust to drought, for the period of record since the 1976 drought, but this is not to say that the supply situation should not be monitored and a protocol put in place to safeguard security of supply. This protocol is important for these zones, but is also of relevance to the London WRZ, as the Chilterns can also provide significant baseflow contribution to the River Thames, directly or via its tributaries. The background to the development of the protocol for the SWA and Henley WRZs is outlined in Appendix G. We recognise that during a drought a lot of rivers will be suffering from low flows and this is of particular importance in the SWA WRZ which covers the area of some of the Chilterns Chalk streams. We have reduced our reliance on abstractions that may affect chalk streams over recent years with the closure of our groundwater sources at Mill End on the River Wye and New Ground on the River Bulbourne and reduction at Pann Mill on the River Wye. We also plan to close our source at Hawridge in the Chess catchment at the end of 2024. We have been able to make these reductions through improving our supply network to enable more water to be transferred from our sources close to the River Thames such as Taplow and Medmenham northwards to meet demand in areas previously served by these sources. This has also served to improve the resilience of our water supply in this zone because the Thames-side sources are more resilient to severe drought than those further up the catchment. This means that we are in a better position to maintain supplies through a drought without having a significant adverse impact on chalk streams.

The specific situation in the SWA and Henley WRZs will be monitored through the tracking of key catchment groundwater levels, as well as tracking the abstraction performance of selected groundwater sources in relation to their DO.

Stonor Park OBH has been chosen for tracking groundwater levels in the Chilterns and forms the basis for defining drought management control levels for both the SWA and Henley zones. The rationale adopted is as follows:

- Groundwater levels in the Chalk at Stonor Park broadly reflect groundwater behaviour across the Chilterns in both the SWA and Henley WRZs;
- When groundwater recession continues below levels normally expected, enhanced tracking of groundwater levels and abstraction source performance will commence;
- If groundwater recession continues further, reaching low levels at times of high demand, then a TUB may be triggered;
- At groundwater levels down to the minimum recorded in the catchment, the groundwater sources are robust, being able to produce their deployable output;
- Below the minimum recorded groundwater levels, drought permits may be required to supplement normal supply capability;
- Drought management actions would be triggered assuming company-wide actions were not already in place triggered by the management protocol for the London WRZ.

These are pragmatic principles, but in practice the timing of implementation of such measures is difficult to define with confidence. This is because, historically, no demand management actions have been triggered specifically by drought conditions in the SWA or Henley zones, rather actions have been driven initially by supply demand conditions in London. Therefore, the protocol for these WRZs

remains provisional and would be reviewed following a drought of sufficient severity to warrant measures being implemented on the basis of these zonal triggers. This partly reflects the relative robustness of the SWA and Henley groundwater sources, with robustness of SWA having been improved in recent years with reduction in the number of groundwater sources in the upper parts of the catchment resulting in more reliance on Thames side sources, and with more reductions planned with the closure of Hawridge in 2024. However, there is significant uncertainty in assigning drought management measures to specific hydrogeological conditions and control levels. Clearly, however, when establishing the need to trigger drought management actions when crossing any defined control levels it is necessary to consider the source performance and demand situation at that time.

Within the context outlined above, Figure 18 illustrates the drought management control curves and tracking approach for the SWA and Henley WRZs. This approach is based on tracking the Stonor Park groundwater hydrograph against its historical record, as defined by a series of control curves based in part on monthly statistics developed by the EA, e.g. "Notably Low", "Exceptionally Low". It can be seen from Figure 18 that, for example, the minimum historic groundwater level is defined by groundwater level conditions that occurred in 1976. The key features of tracking groundwater levels against the control curves are as follows:

- Enhanced Tracking - When groundwater levels decline below the RG1 (Below Normal) control level, enhanced tracking of groundwater levels and abstraction source performance will commence. In around 90% of years when levels have been below this interface, groundwater levels have continued to decline to be Notably Low.

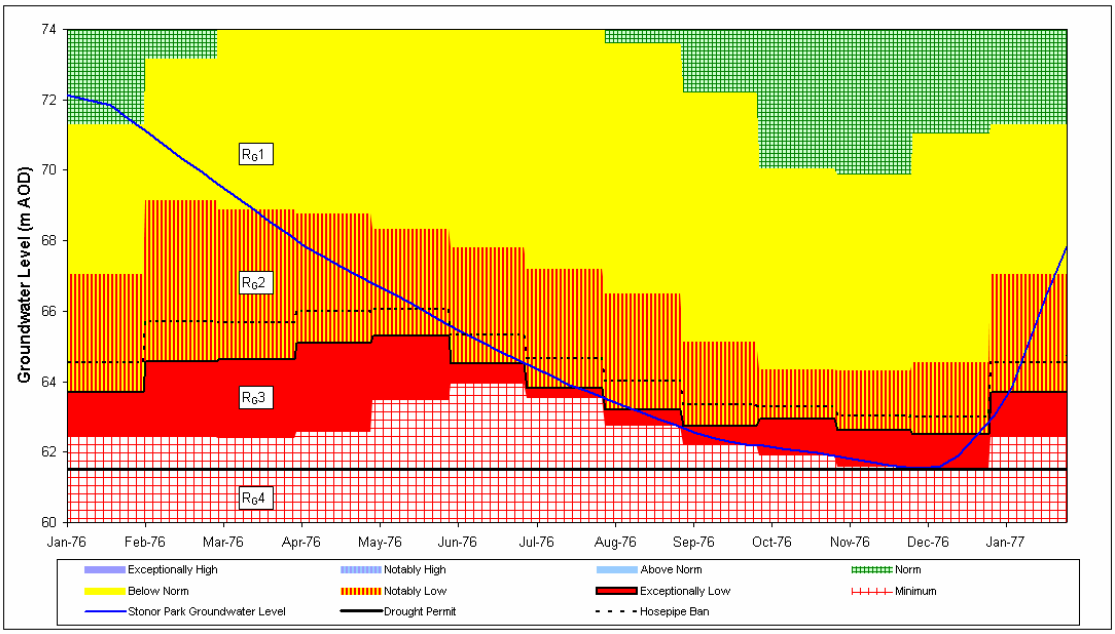


Figure 18 Groundwater Control Curves for Stonor Park OBH for 1976

- Temporary Use Ban Implementation – The groundwater level at which a TUB might be implemented has been set as a seasonally variable level, at 75% below the RG2 interface. A TUB is more likely to be implemented if the control level is crossed at or shortly after the groundwater maximum in May and recession continues towards the minimum recorded groundwater levels. Such action would be taken assuming a company-wide TUB was not already in place.
- This control level has been set by attempting to "calibrate" the timing of historical drought actions, as inferred from the London WRZ protocol, with the Stonor Park historic

groundwater hydrograph. Using this approach, the occurrence or absence of drought actions in SWA and Henley in 1976 and 2006 is consistent with those inferred from the London WRZ protocol. However, from the 1997 Stonor Park hydrograph, the protocol indicates that a TUB should be triggered rather earlier than the start of April, as indicated by the London WRZ protocol. In practice, a TUB could likely be deferred to springtime to maximize savings.

- Drought Permit Application – As groundwater levels decline below the RG3 (Exceptionally Low) control level, an application for a drought permit may be made, depending on the time of year and demand. An application is more likely to be made if the control level is crossed shortly after the RG3 groundwater maximum in May and recession continues towards the minimum recorded groundwater levels, e.g. 1976, 1997. In years such as 1991 and 2006, the RG3 control level was crossed several months before the May maximum, just as groundwater levels started to recover and, as such it is unlikely that a drought permit application would not be required.
- Drought Permit Implementation – The implementation of increased abstraction under a drought permit may be triggered once groundwater levels fell below the historic minimum, RG4 control level, depending on source performance. This control level is currently defined as 61.5 m AOD and, historically, has been approached and reached during the months of November and December significantly after the normal peak demand periods.
- Using these control curves, the historic groundwater hydrograph recession rates observed in 1976 and 1997 would have provided the necessary 10 week period between applying for and, if required, implementing an appropriate drought permit. However, the recession rates in these same years also produce an 8 to 10 week period between introducing a TUB and applying for a drought permit; this is rather more than the 3 weeks assumed to be required. This potentially conservative outcome demonstrates some of the uncertainty in generating groundwater control curves for SWA and Henley, but an appreciation of this uncertainty will drive a pragmatic decision-making process. This process may be supported by making predictions for groundwater level recession at Stonor Park.
- As for some other WRZs, e.g. Kennet Valley, the drought protocol for SWA and Henley has not yet been used in practice leading up to or during a drought because we have not experienced a severe drought since development of this protocol. Consequently, the protocol will be subject to review during and following future droughts, as well as following any significant change in the supply demand balance in the SWA and/or Henley WRZs.

4.8. Return to normal conditions - process

In the same way that the protocols provide an assessment of the escalation of risk to security of supply, so do they provide an assessment of the diminution of risk to security of supply. The information provided enables us to appraise customers and stakeholders of the reduced risk and relaxation of restrictions.

Regular discussions will be held with the EA to ensure a common position is formed on the improving water situation, as assessed for each WRZ by using the full range of hydrological data (see Section 4.3.3, Step 1a). Before declaring an end to a drought event and the consequent lifting of all drought management measures, we will seek confirmation that these actions are consistent with the EA's position on the water resources situation.

The Drought Management Methodology will be used as a guide to decide when measures will be lifted in accordance with the improving Drought Event Levels (DEL1 to 4) associated with a return to wetter conditions.

4.9. Post Drought Review

Each drought is different and provides an opportunity for reviewing and improving the Drought Plan, therefore we would carry out a review after a significant event. This review would establish the proper closedown of an event and captures the learning gained from it. Such a review should be undertaken as soon as practicable once the event has closed down, and once all the learning and facts can be fully assimilated. A meeting or series of meetings would be held with the full event team, assessing the factors that worked well, and those that could be improved to prevent or better manage a similar event in the future. The meetings would be minuted and actions assigned and followed up.

A drought, whilst different from some of the fast-moving events such as a serious burst water main, is subject to the same scrutiny. A single season drought event would be subject to 'Review' at the end of the water resources stress period and again once the event had been closed down. A longer drought would be subject to annual reviews after each water resources stress period and again once the event had been closed down.

Operations Management Procedures are reviewed on an annual basis and updated in the light of new information, knowledge and experience.

Post - drought review assessment activities:

Review the effectiveness and efficiency of:

- Drought Management Methodology
- Drought Management Event procedures
- Communications with:
    - Customers
    - EA
    - Other stakeholders
    - Water companies and Water UK
- Demand-side measures, including review of actual savings and update of predicted savings
- TUB - notification and representation process
- NEUB application process
- Supply-side measures, including operational aspects and water resource benefit
- Drought permit application and implementation process, environmental impacts and impacts on other abstractors

We would endeavour to produce our post drought report 6 months after the cessation of the drought, for example 6 months from the point that the TUB is lifted. We will also endeavour to produce a post drought review of drought permits/orders 1 year after the drought permits have been lifted. This would be repeated for 3 years or until agreed with the EA.

a) On the basis of results from the post drought review, carry out the following actions:

- Prepare draft and final Lessons Learnt Report.
- Review and, if necessary, update existing Drought Plan.

We undertook a review of the 2012 drought, the last significant drought to occur in the Thames region, and included the lessons learnt in our revised plan produced in 2013.

4.10. Summary

London and SWOX WRZs are known as conjunctive use zones as the water resources are derived from a combination of river abstraction, raw water reservoir storage and groundwater sources. For both zones, the critical element in the system is the level of reservoir storage, which in turn is dependent upon river flow. The drought management measures for the London zone consist of:

- Demand-side measures in which water use restrictions associated with Thames Water's Levels of Service play a major role and are triggered by the prevailing / predicted protocol;
- Supply-side measures in which several strategic drought schemes play a major role in augmenting the London zone's supply capability.

Both the supply and demand-side measures form an integral part of London's deployable output. Because of the dominant nature of the London WRZ, it will generally be the case that the water use restrictions introduced in the London WRZ will also be applied to the rest of our supply area. Nonetheless, the Drought Plan recognises that there may be situations in which more local measures may need to be introduced for the other WRZs; consequently, protocols have also been developed for these zones.

The SWOX methodology is similar to that for London and so is based on the prevailing/predicted assessment. The introduction of water use restrictions is determined, in the first instance, by the London protocol. However, it is supplemented with a trigger for submitting NEUB and drought permit applications based on the level of natural flow (200 Ml/d) in the River Thames at Farmoor. Unlike the London WRZ, there are no supply-side strategic drought schemes built into the zone's deployable output; the major supply-side augmentation comes mainly in the form of increased abstraction from existing sources introduced at Level 3 through the drought permit mechanism.

The protocols for the Kennet Valley and Guildford WRZs are based on critical low flows in the River Kennet and River Wey respectively, which act as the trigger mechanism for the introduction of drought measures.

SWA and Henley WRZs are entirely supplied by groundwater sources, which historically have remained robust during drought. The protocol for these zones is based on tracking key regional observation boreholes together with the performance of selected groundwater sources in relation to their deployable output.

Section 5. Demand-side measures

The full range of demand-side options available during the course of a drought is detailed below. The drought interventions are planned to mitigate the need for emergency restrictions under the Level 4 level of service.

The demand-side drought interventions are a sub-set of the baseline demand management activities that are set out in our Water Resource Management Plan. During the course of a drought, leakage reduction, principally find and fix, and water efficiency can to some extent be enhanced. However, enhancement of meter installation over and above the on-going programme is not regarded as effective or efficient during the relatively short duration of a drought event because it would not be possible to install enough meters in the timescale to make a difference to the drought situation.

As noted in Section 1, we have incorporated the legislation on water use restrictions introduced in 2011 into our plan. Our policy is that Temporary Use Ban restrictions would be introduced at Level 2.

In accordance with our stated Levels of Service (Table 4 Levels of Service), unless there are good reasons for doing so, we will not impose water use restrictions. Therefore, the sequencing of the drought interventions is commensurate with increasing risk to security of supply. The full range of demand-side measures are detailed in Table 18 along with the respective drought event risk level (DEL), see Section 4, Table 12.

Table 18 Demand-side measures

Measure	Description of measure	Drought Event Risk Level	Level of service	Additional comments
Media /water efficiency campaign	Wide-scale communications activity to encourage voluntary reduction in water usage	DEL1	Level 1	
Enhanced media /water efficiency campaign	Enhancement of above activity	DEL2	Level 2	
Leakage reduction	Increased leakage activity / Network pressure management	DEL1-DEL2	Not applicable	
Temporary Use Ban	11 categories of use (largely domestic), banning the use of a hosepipe.	DEL2	Level 2	Would normally be introduced at same time as the enhanced media/water efficiency campaign. Net effect is to reduce peak demand for water.
Non Essential Use Bans	Application to Defra to grant 10 categories of non-essential use restrictions affecting commercial businesses.	DEL 3	Level 3	
Emergency Drought Order	Application to Defra to grant an emergency drought order, including rota cuts and standpipes.	DEL 4	Level 4	

5.1. Savings from demand-side measures

Savings from demand-side measures are based on our previous experience of implementing demand side restrictions. These are underpinned by the same methodology as employed since the Drought Plan 2010. The impact of an Ordinary Drought Order was combined with the observed impact of the 2006 hosepipe ban to produce the net impact of restrictions from levels 1 to 3 given the prevailing conditions in 2008. The 2008 estimates were revised to produce updated figures for 2012 and are now adopted for 2021.

The savings are given below for London and Thames Valley WRZs and represent the maximum savings that can be expected during the peak month of July when pressure on water resources is likely to be greatest.

Level of service London WRZ- Peak month saving as a percentage of total demand

- Level 1: Providing a 2.2% maximum reduction in Unrestricted Demand.
- Level 2: Additional 7.9% (cumulative 10.1%) maximum reduction in Unrestricted Demand.
- Level 3: Additional 4.4% (cumulative 14.5%) maximum reduction in Unrestricted Demand.
- Level 4: Additional 18% (cumulative 32.5%) maximum reduction in Unrestricted Demand;

Level of service Thames Valley WRZs- Peak month saving as a percentage of total demand

- Level 1: Providing a 3.8% maximum reduction in Unrestricted Demand.
- Level 2: Additional 10.5% (cumulative 14.3%) maximum reduction in Unrestricted Demand.
- Level 3: Additional 4.8% (cumulative 19.1%) maximum reduction in Unrestricted Demand.
- Level 4: Additional 18% (cumulative 37.1%) maximum reduction in Unrestricted Demand;

The detailed breakdown of the assumed demand-side savings, including monthly profiles, and how the previous imposition of demand side measures has been used to estimate the maximum demand savings that could be achieved is detailed in Appendix L.

In summary, it is estimated that the demand-side measures for the London WRZ, will provide cumulative savings up to and including Level 3 of 14.5%. For the Thames Valley WRZs the revised cumulative savings are 19.1%. We have been working with WRSE to review the savings assumed for levels 1-3 and we will consider updating these on the conclusion of that work.

5.2. Water Efficiency

5.2.1. Baseline Water Efficiency Activity

We have promoted the wise use of water for over two decades. In recognition of the pressure on water resources, higher expectations of our regulators and the wider stakeholder community, our water efficiency baseline programme has grown significantly in breadth and scale since 2005. The programme has included a large-scale audit programme with household and commercial customers, activities in schools, promotion of technological developments and activities aiming to raise awareness of the need to use water wisely. We have developed our understanding of water use and

how to most effectively encourage customers to save water, and promoted knowledge sharing across the industry.

Our baseline programme, from 2010 onwards, is built on lessons and experience as demonstrated by achievement of regulatory targets.

We continue to look for opportunities to improve our performance, and in line with stakeholder and regulator expectations, we aspire to a comprehensive integrated model of demand management and are proposing an enhanced programme for the period 2020-2025.

For more information about our long-term plans for the ongoing water efficiency programme, please refer to Thames Water's Final Water Resources Management Plan 2019[8].

5.2.2. Activities during Drought

In addition to our ongoing water efficiency campaign activities, increased activity will be carried out in the event of a drought. A drought situation would require a response aiming to achieve an immediate step-change in customer water use behaviour and would be run alongside the activities of the on-going water efficiency programme.

We will use the experiences of our long running water efficiency programme to target our drought campaign most effectively, using information about our customer's habits and opinions related to water use and water saving from the historic and current domestic audit trials and per capita consumption (pcc) data investigation study, as well as previous drought activities. Along with the Communication Strategy, the following points describe what we would consider in developing our campaign:

- Learning from activities that were effective during previous droughts including 2006 and 2012, subsequently identified potential activities to be carried out in a future drought, and wider regional activities such as stakeholder consultation responses.
- Learning from water efficiency customer research and customer engagement trials will be used to inform communication and engagement methods.
- Targeted communication and distribution of literature to domestic customers to raise awareness of the water resource situation and to encourage a reduction in non-essential water use such as that used for garden watering or car washing.
- Geographically targeted activities in drought areas, i.e. areas where the potential supply / demand deficit is greatest, and targeted activities in a manner that most affects the characteristics of the risk in that specific area (e.g. peak day concerns in areas of Thames Valley where there are fewer raw water reservoirs would be better addressed by gardening campaigns, and peak week concerns in London by more general daily-water-use messages).
- Identification of key partners that would be effective to work with during a drought situation (e.g. Local Authorities, GLA, gardening groups) and ensure that we have an

[8] https://www.thameswater.co.uk/about-us/regulation/water-resources#current

established relationship with these organisations that we can build on should the need arise.

- Identification of key events to target during a drought and with a consideration of how we could most effectively and logistically participate in these events to raise the profile of the water conservation message.

- Joined-up integrated messages across all drought communications / advertising (with appropriate and consistent messages) with timing of activities sensitive to other Company messages. Each level of the drought should have key messaging, activities and required resources.

- During a drought event the work of the water efficiency team will be augmented by individuals and teams from across Thames Water, e.g. media/press office, key account managers, community liaison executives and customer centre staff, ensuring that existing channels of communication are fully utilised to distribute a Company message.

Specific measures undertaken by the water efficiency team would include:

- An increase in the promotion of water efficient devices and technologies. An enhanced response to severe localised resource issues would be the offer of household audits where cistern devices would be installed, internal leaks detected and repaired, and water efficient showerheads/spray taps installed.

- A strong partnership approach - collaboration with other water companies and key stakeholders in the region to ensure the provision of up to date information and to encourage sensible water use.

- An increase in contact with major commercial water users including gyms, leisure centres, golf courses providing advice, free water audits and resources for commercial customers to undertake their own in-house water efficiency campaign.

- A targeted gardening campaign to promote water efficient gardening delivered in partnership with respected external organisations such as gardening groups and environmental groups and societies.

5.3. Leakage reduction

5.3.1. Non-drought activities

Leakage reduction remains a fundamental component of our plans to manage the balance between supply and demand.

During the last AMP period (2015/16 to 2019/20) we had a target to deliver a reduction in our leakage level of 9%, dropping leakage from 665 Ml/d to 606 Ml/d, with most of the reduction in London. By 2019/20 we outperformed those reduction targets.

Over the next AMP period (2020/21 to 2024/25) we have agreed to deliver leakage reductions totalling 20% (as measured using Ofwat's 3 year rolling average measure). These reductions are very large and are beyond that needed to ensure the balance of supply and demand in each water resource zone.

We have also been working to bring our leakage reporting in line with Ofwat's latest reporting guidance which was introduced to improve consistency of reporting between water companies. As a result, we have reassessed our measure of leakage level, further lowering our reported leakage. This "accounting" change is not part of the 20% reduction.

Our pipes remain old, and many are in relatively poor condition. Where possible we are looking to extend the life of these pipes and have a programme of work in place to identify and remove peak pressures on the network. This is targeting the smoothing of significant daily variations in pressure, either through installation of better controls on our pumps and control valves, installing surge management devices, or collaborating with our largest customers to smooth out how they take water from our pipe network.

Despite this work we still have high breakout rates of leaks and are therefore dependent on identifying, locating and repairing leaks as quickly as possible. We continue to refine our ability to spot leaks as they occur. We are investing in smaller district meter areas to better identify leaks with greater geographic granularity. We are also improving our data to more accurately determine leakage at this local level. This used alongside our fleet of permanently installed acoustic loggers, and our increasing coverage of smart customer meters, means our ability to identify leaks as they occur is improving. With the increase in sensors on the pipe network we are investing in more intelligent systems to improve the use of this data. We are also investing in systems that are used in the field, first to direct the technicians to the best location, and then to better capture information to more accurately, efficiently and speedily pass on to the repair gangs. We are also looking at new ways to repair leaks to speed up the process and minimise interruption to our customers.

We also continue to support our customers with repairs to leaks on their own pipework, offering free leakage detection and, in most cases, free repair.

We are also learning from the information that is now available from our smart meters. From this we are discovering that leakage on our pipe network is lower, but the losses from plumbing systems inside houses and commercial premises is higher. We are therefore using the data from the smart meters to target "smart home visits" and "smart business visits" to provide advice and assistance to our customers to help them use less water.

We have also invested in monitoring of our strategic mains network, with flow, pressure and acoustic sensors to monitor these key assets in close to real time to identify problems and fix them before major failure.

5.3.2. Activities during drought

During drought all the activities that are part of our long-term leakage reduction programme will continue as before with every effort made to speed up their delivery. It is acknowledged that during drought it would be beneficial in the short term to divert resources from other activities on to find and fix activities in order to make shorter term, though probably less sustainable, gains in leakage reduction. This would include discussions with highways authorities and councils to allow us to prioritise our street works. In particular, experience has shown that customers expect and appreciate the speedy repair of visible leaks during drought events when they are being asked to use water wisely.

5.4. Temporary Use Ban restrictions

As part of our Levels of Service, see Table 4, a TUB could be imposed at Level 2. This drought intervention is aimed at reducing peak demand for water, which in turn, will gradually reduce the total amount of water used.

A TUB includes eleven categories of use, which are specified within section 76(2) of the WIA 1991 (as amended by section 36 of the FWMA 2010); the categories of water use that are prohibited are:

a) watering a 'garden' using a hosepipe;

b) cleaning a private motor-vehicle using a hosepipe;

c) watering plants on domestic or other non-commercial premises using a hosepipe;

d) cleaning a private leisure boat using a hosepipe;

e) filling or maintaining a domestic swimming or paddling pool

f) drawing water, using a hosepipe, for domestic recreational use;

g) filling or maintaining a domestic pond using a hosepipe;

h) filling or maintaining an ornamental fountain;

i) cleaning walls, or windows, of domestic premises using a hosepipe;

j) cleaning paths or patios using a hosepipe;

k) cleaning other artificial outdoor surfaces using a hosepipe.

Most of the uses of water which may be prohibited only apply to the use of water drawn through a hosepipe or similar apparatus. The exception to this is filling or maintaining a domestic swimming or paddling pool and filling or maintaining an ornamental fountain in which the use of water which may be prohibited extends to all means of filling, including fixed or permanent plumbing (but excluding handheld containers in the case of domestic swimming or paddling pools).

It is important to note that the definition of a garden within the TUB legislation includes:

a) a park;

b) gardens open to the public;

c) a lawn;

d) a grass verge;

e) an area of grass used for sport or recreation;

f) an allotment garden;

g) any area of an allotment used for non-commercial purposes;

h) any other green space.

However, the definition of a “garden” does not include the following:

a) agricultural land;

b) other land used in the course of a business for the purposes of growing, for sale or commercial use, any crops, fruit, vegetables or other plants;

c) land used for the purposes of a National Plant Collection;

d) a temporary garden or flower display;

e) plants (including plant organs, seeds, crops and trees) which are in an outdoor pot or in the ground, under cover.

Statutory health or safety exemptions apply to some of the categories of water use, see Appendix L1.

5.4.1. Implementation Policy

5.4.1.1. Formal notice

In regard to implementing TUB measures, the legislation sets out specific requirements for notifying the public prior to the introduction of these measures. We have selected a 3 week period for imposing TUB restrictions. Within the formal notice we will explain how representations about proposed prohibitions may be made and will ensure that representations are given appropriate consideration, particularly where stakeholders raise issues that have not been previously considered.

The public notice will be published on our website as well as in two national newspapers and a local newspaper. The notice will provide details of why the TUB is being introduced and describe the activities that are being banned and the exemptions being granted. An example of the public notice for the 2012 TUB for London WRZ is shown below in Box 1.

Representations received will be considered by an internal panel and our response will be published on our website within the 3 week period.

Important information for all Thames Water customers

We are in drought.

What it means for you.

After an exceptionally dry two years, with below average rainfall for 19 of the past 24 months, the Thames Water region, like much of the South East, is in drought.

As a result, as of 5 April 2012, it will be prohibited to draw water through a hosepipe or similar equipment, or fill or maintain a domestic swimming pool, paddling pool or ornamental fountain.

Details of the restrictions are provided below.

PLEASE USE WATER WISELY

Variation of Temporary Use Ban Section 76 Water Industry Act 1991

The prohibition on the use of potable* water supplied by Thames Water for a number of specified purposes will come into effect on 5 April 2012.

Following consideration of responses received to the advertisement of the ban, some changes have now been made. Thames Water Utilities Limited therefore gives notice that the prohibition will be varied with effect from midnight on 18 April 2012. The effect of the variation is that the potable* water Thames Water supplies throughout its entire area must NOT be used for the following purposes:

1. watering a 'garden' using a hosepipe;
2. cleaning a private motor-vehicle using a hosepipe;
3. watering plants on domestic or other non-commercial premises using a hosepipe;
4. cleaning a private leisure boat using a hosepipe;
5. filling or maintaining a domestic swimming or paddling pool (except when using hand held containers filled directly from a tap);
6. drawing water, using a hosepipe, for domestic recreational use;
7. filling or maintaining a domestic pond (excluding fish ponds) using a hosepipe;
8. filling or maintaining an ornamental fountain;
9. cleaning walls, or windows, of domestic premises using a hosepipe;
10. cleaning paths or patios using a hosepipe;
11. cleaning other artificial outdoor surfaces using a hosepipe.

Definition of a garden

A "garden" includes all of the following: a park; gardens open to the public; a lawn; a grass verge; an area of grass used for sport or recreation; an allotment garden, as defined in section 22 of the Allotments Act 1922; any area of an allotment used for non-commercial purposes; and any other green space.

Exemptions

The following will be exempted from the restriction:

i) using a hosepipe in a garden or for cleaning walls or windows of domestic premises, paths or patios, a private leisure boat or an artificial outdoor surface, where such use is necessary for health and safety reasons.

ii) people with severe mobility problems who hold a current Blue Badge as issued by their local authority will not be prohibited from using a hosepipe to water a garden attached to a domestic dwelling, plants on domestic premises, or allotments where the Blue Badge holder is the tenant.

iii) using a hosepipe to clean a private motor vehicle, walls and windows of domestic premises, or paths, patios and other outdoor surfaces where this is done as a service to customers in the course of a business.

iv) using a hosepipe to water an area of grass or artificial outdoor surfaces used for sport or recreation, where this is required in connection with a national or international sports event. A list of qualifying events will be published on the company's web-site and updated as and when required.

v) drip or trickle irrigation watering systems, fitted with a pressure reducing valve and a timer, that are not handheld, that place water drip by drip directly onto the soil surface or beneath the soil surface, without any surface run off or dispersion of water through the air using a jet or mist.

Please visit our website at www.thameswater.co.uk/drought for further useful information and explanation relating to the above.

Representations

Representations about these variations to the Temporary Use Ban may be made in writing to the Public Consultations team, 2nd East, Thames Water, Clearwater Court, Vastern Road, Reading RG1 8DB, or by email to consultations@thameswater.co.uk Representations must be received before the end of 5 April 2012.

If, as a result of such representations, any further terms of the prohibition are varied, a further notice will be published.

**Water treated to drinkable standards*

To find out more about how drought will affect you, please visit **www.thameswater.co.uk/drought**

5.4.1.2. Phasing and Exemptions

Our implementation policy on phasing and exemptions is based on the following factors:

- Defra/EA guidance.
- UKWIR Code of Practice generally and in particular adherence to the 2nd principle of proportionality, see Appendix L2.
- Findings from customer research survey, see Appendix L3.
- Clarity of message - consistent with our experience with past droughts, Defra and the EA, Ofwat and CCWater have emphasised the need for clear and straightforward customer communication to facilitate an effective response to the new measures.
- The requirement for a consistent approach by water companies in the South East of England, see Appendix L4.

- Consultee representations from the December 2011 consultation process and ongoing stakeholder dialogue.
- Experience of implementing a TUB in 2012

Phasing

The TUB legislation includes an option for phased implementation of the possible prohibitions.

We would not propose any phasing of the imposition of the eleven categories of use, as set out in the TUB if we faced a potentially severe drought situation, however we may adopt a flexible approach through implementing measures in one or more phases if the specific drought risk warranted it. However, dependent upon the prevailing Drought Event Level assigned, we may not prohibit all of the categories of use in a drought event.

As part of a Drought Event Level 2, DEL2 (see Table 10) a TUB is likely to be enforced (see Table 15). This level of water use restriction would be consistent with Level 2 of our Levels of Service. A single implementation phase would help to maximise water savings as well as send out a strong simple message that the drought situation is worsening.

The DEL is calculated based on the prevailing and potential water situation (Section 4.3.2) and generally this can be set at the end of the winter recharge season in March, when the final status of groundwater levels is known (Section 2.2). It is most likely that the DEL set at this point will apply until the beginning of the next recharge period, thereby determining whether all of the categories of use should be prohibited for the summer period.

Exemptions

We have worked alongside Water Resources in the South East water companies to align our exemptions for TUBs. The TUB restrictions exemptions are listed in Table 19:

Table 19 TUB exemptions

TUB Category	Statutory exception	Discretionary Universal Exception (granted by all water companies)	Suggested Discretionary Concessional Exception (granted by individual water companies)
1. Watering a garden using a hosepipe	Using a hosepipe to water a garden for health or safety reasons. NB In this category, the definition of "a garden" includes "an area of grass used for sport or recreation". Therefore, it should be noted that watering areas of grass, which are used for sport or recreation, is covered by a Statutory Exception for health & safety only in relation to the active strip/playing area, not the entire ground.	• To Blue Badge holders on the grounds of disability • Use of an approved drip or trickle irrigation system fitted with a pressure reducing valve (PRV) and timer	• To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge • To water newly laid turf for first 28 days
2 Cleaning a private motor-vehicle using a hosepipe	A "private motor-vehicle" does not included (1) a public service vehicle, as defined in section 1 of the Public Passenger Vehicles Act 1981 (c), and (2) a goods vehicle, as defined in section 192 of the Road Traffic Act 1988 (d)	• To Blue Badge holders on the grounds of disability • Use of a hosepipe in the course of a business to clean private motor vehicles where this is done as a service to customers	• To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge
3. Watering plants on domestic or other non-commercial premises using a hosepipe	Does not include watering plants that are (1) grown or kept for sale or commercial use, or (2) that are part of a National Plant Collection or temporary garden or flower display.	• To Blue Badge holders on the grounds of disability • Use of an approved drip or trickle irrigation system fitted with a PRV and timer	• To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge • To water newly laid turf for first 28 days
4. Cleaning a private leisure boat using a hosepipe	(1) cleaning any area of a private leisure boat which, except for doors or windows, is enclosed by a roof and walls. (2) Using a hosepipe to clean a private leisure boat for health or safety reasons	• Commercial cleaning • Vessels of primary residence • Cases where fouling is causing increased fuel consumption • Engines designed to be cleaned with a hosepipe	• To prevent or control the spread of non-native and/or invasive species
5. Filling or maintaining a domestic swimming or paddling pool	(1) filling or maintaining a pool where necessary in the course of its construction (2) filling or maintaining a pool using a hand-held container which is filled with water drawn directly from a tap (3) filling or maintaining a pool that is designed, constructed or adapted for use in the course of a programme of medical treatment (4) filling or maintaining a pool that is used for the purpose of decontaminating animals from infection or disease (5) filling or maintaining a pool used in the course of a programme of veterinary treatment (6) filling or maintaining a pool in which fish or other aquatic animals are being reared or kept in captivity	None	

TUB Category	Statutory exception	Discretionary Universal Exception (granted by all water companies)	Suggested Discretionary Concessional Exception (granted by individual water companies)
6. Drawing water, using a hosepipe, for domestic recreational use	None	None	
7. Filling or maintaining a domestic pond using a hosepipe	Filling or maintaining a domestic pond in which fish or other aquatic animals are being reared or kept in captivity	• Blue Badge holders on the grounds of disability	• To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge
8. Filling or maintaining an ornamental fountain	Filling or maintaining an ornamental fountain which is in or near a fish-pond and whose purpose is to supply sufficient oxygen to the water in the pond in order to keep the fish healthy	None	• To operate water features with religious significance
9. Cleaning walls, or windows, of domestic premises using a hosepipe	Using a hosepipe to clean the walls or windows of domestic premises for health or safety reasons	• To Blue Badge holders on the grounds of disability • Commercial cleaning	• To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge
10. Cleaning paths or patios using a hosepipe	Using a hosepipe to clean paths or patios for health or safety reasons	• To Blue Badge holders on the grounds of disability • Commercial cleaning	• To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge
11. Cleaning other artificial surfaces using a hosepipe	Using a hosepipe to clean an artificial outdoor surface for health or safety reasons	• To Blue Badge holders on the grounds of disability • Commercial cleaning	• To customers on the company's Vulnerable Customers List who have mobility issues but are not in possession of a Blue Badge

NEUB Legislation

The Drought Direction 2011 (DD11), which replaced the Drought Direction 1991, sets out the categories of use that can be prohibited in a NEUB. The relevant categories are as follows:

1) Watering outdoor plants on commercial premises;
2) Filling or maintaining a non-domestic swimming or paddling pool;
3) Filling or maintaining a pond;
4) Operating a mechanical vehicle-washer;
5) Cleaning any vehicle, boat, aircraft or railway rolling stock;
6) Cleaning non-domestic premises;
7) Cleaning a window of a non-domestic building;
8) Cleaning industrial plant;
9) Suppressing dust; and
10) Operating cisterns.

Exemptions

We have worked alongside Water Resources in the South East water companies to align our exemptions for NEUBs. Table 20 lists the exemptions from the NEUB restrictions.

Table 20 NEUB exemptions

	Drought Order Category	Statutory Exemptions	Universal Exception	Discretionary Exception	UKWIR Suggested Discretionary Exceptions
1	Watering outdoor plants on commercial premises	This includes plants which are in a pot or container that is outdoors or under cover and plants which are in the ground under cover. This does not include plants grown (i.e. cultivated or propagated) or kept for sale or commercial use or plants part of a National Plant Collection or temporary garden or flower display.	None	Use of an approved drip or trickle irrigation system fitted with a PRV and timer is set for use in the evening or night.	Use of an approved drip or trickle irrigation system fitted with a PRV and timer
				Water newly bought plants for the first 28 days after the implementation of the ban.	Watering newly-bought plants
2	Filling or maintaining a non-domestic swimming or paddling pool	This restriction shall not apply to: • Pools open to the public (a pool is not open to the public if it may only be used by paying members of an affiliated club or organisation). • Filling or maintain a pool that is used by pupils of a school for swimming lessons. • filling or maintaining a pool where necessary in the course of construction. • filling or maintaining a pool using a hand-held container which is filled with water drawn directly from the tap. • filling or maintaining a pool designed, constructed or adapted for use in the course of a programme of medical treatment. • filling or maintaining a pool that is used to decontaminate animals from infections or disease.	None	None.	Swimming pools serving industrial training if considered justified
					Swimming pools with covers
					Pools with religious significance
					Pools fitted with approved water conservation or recycling systems
					Pools that are subject to significant repair and innovation

	Drought Order Category	Statutory Exemptions	Universal Exception	Discretionary Exception	UKWIR Suggested Discretionary Exceptions
		• filling or maintaining a pool used in the course of veterinary treatment. • filling or maintaining a pool in which fish or other aquatic animals are being reared or kept in captivity.			
3	Filling or maintaining a pond	This restriction shall not apply to ponds in which fish or other aquatic animals are being reared or kept in captivity or to filling or maintaining the pond with a hand-held container which is filled with water directly from the tap.	Blue Badge holders on grounds of disability	None	Customers on the company's Vulnerable Customer List who have mobility issues but are not in possession of a Blue Badge
4	Operating a mechanical vehicle washer	None	None	On biosecurity grounds	Washers which recycle water and thus use less than 23 litres per wash
					On biosecurity grounds
5	Cleaning any vehicle, boat, aircraft or railway rolling stock	Cleaning any vehicle, boat, aircraft or railway rolling stock for health and safety reasons	None	On biosecurity grounds	Low water use technologies
					Small businesses whose sole operations are cleaning of vehicles using hosepipes
					Those using vessels as a primary residence
					Cases where fouling of hulls causes fuel consumption
					To remove graffiti
					To prevent of control the spread of non-native and/or invasive species

	Drought Order Category	Statutory Exemptions	Universal Exception	Discretionary Exception	UKWIR Suggested Discretionary Exceptions
6	Cleaning any exterior part of a non-domestic building or non-domestic wall	Cleaning any exterior part of a non-domestic building or non-domestic wall for health and safety reasons	None	To remove graffiti by applying to the wholesale supplier	Small businesses whose sole operations are cleaning of buildings using hosepipes
					Low water use technologies
					To remove graffiti
7	Cleaning a window of non-domestic building	Cleaning a window of non-domestic building using a hosepipe for health and safety reasons	None	Small businesses whose sole operations are cleaning of windows using hosepipes.	Small businesses whose sole operations are cleaning of windows using hosepipes
8	Cleaning industrial plant	Cleaning industrial plant using a hosepipe for health and safety reasons	None	Biosecurity	To remove graffiti
9	Suppressing dust	Suppressing dust using a hosepipe for health and safety reasons	None	None	None
10	Operating cisterns on unoccupied buildings	None	None	None	None

The Drought Direction 2011 sets out the restrictions that can be applied under a NEUB. The restrictions are for commercial and industrial water use, that can be imposed under an ordinary drought order. A water undertaker may apply to Defra for an ordinary drought order under Section 73(1) and 74(2) (b) of the Water Resources Act 1991 if it can be shown that the 'exceptional shortage of rain' will lead to a serious deficiency of supplies of water.

5.4.1.3. Implementation policy

The measures included in a NEUB are significant and as such we would not introduce them unless the water situation was not becoming very serious.
Prior to a NEUB application, we would discuss the need for such a measure with Defra as well as the EA to ensure that they were fully appraised of the situation and aware of the reasons why such a measure is necessary.

We have included an allowance for a minimum of a 10 week period to allow for the submission to granting, or otherwise, of the drought order application.

Within the application process, the principal document submitted to Defra is the 'Statement of Reasons'. In the statement of reasons, we would set out the case for seeking authorisation to implement NEUB restrictions. The report would explain in detail why and how the exceptional

shortage of rainfall is likely to lead to a serious deficiency in water supply and set out , in the meantime, all of the necessary drought interventions that we would be carrying out to avoid the need for Emergency Drought Orders.
Before we would consider applying and implementing a NEUB the DEL would have been escalated to Level 3. However, we would need to be clear that such an action would significantly help to avoid Level 4 emergency water use restrictions.

Because of the serious conditions of drought severity under which we would consider a NEUB, all ten measures would be applied for simultaneously.

5.5. In extremis options, more before Level 4 Demand side measures

The demand-side measures that might be considered to further avert Level 4 emergency restrictions are:

- Further reduction of bulk supplies to other companies where possible
- Reductions in water pressure
- Restricting supplies to large commercial users
- Enhanced leakage reduction
- Heightened, widespread communications campaign to request customers to use less water.

Further reduction of Bulk Supplies

The potential for reduction in provision of bulk supplies beyond what is already agreed with neighbouring water companies would be explored and measures would be implemented if feasible and agreed with neighbouring water companies.

Reductions in water pressure

The potential for significant reductions in water pressure would be implemented. This would need to be implemented without posing a risk to human health and so may be restricted to certain sections of the water network.

Restricting supplies to large commercial users

The potential reduction in supplies to large commercial users would be explored working closely with Retailers.

Communications campaign to request customers to use less water

A campaign to request customers to make significant reductions down to very low levels of household use would be implemented if there was serious threat of reaching Level 4. This has been developed jointly with the WRSE water companies, taking into account international experience from, for example, Cape Town, and would involve a campaign that outlined ways that customers could reduce their demand to approximately 80 l/p/day and a further, more stringent set of reductions to reduce demand to 50 l/p/d. The campaign would provide indicative daily volumes for certain uses, e.g.

showers, dish washing, toilet flushes, food preparation, drinking, cooking, house cleaning, laundry, pets, teeth and hands.

Further details of the measures that could be used to avoid Level 4 emergency drought order restrictions are included in Appendix L.

5.6. Emergency Plan - Level 4

5.6.1. Emergency Drought Order

Our Levels of Service stipulate that Level 4 emergency restrictions should never be applied; in reality this currently equates to a frequency of approximately 1 year in 100 years on average. The aim of all preceding supply and demand-side measures is to mitigate the need to resort to Level 4 emergency restrictions. It would only be in the most extreme situations (not yet experienced in the hydrologic record from 1920 to 2020) that such extreme actions may be needed.
In the event that emergency measures are necessary, authority to carry them out can only be obtained through the grant of an emergency drought order (EDO), under sections 73 and 75 of the Water Resources Act 1991, through application to Defra. The procedure for this is similar to that of applying for an ordinary drought order (ODO). Thus, within our Statement of Reasons, it would have to be demonstrated that:

- By reason of an exceptional shortage of rain, a serious deficiency of supplies of water in any area exists or is threatened; and
- That the deficiency is such as to be likely to impair the economic or social well-being of persons in the area.

An EDO allows a water undertaker to do the following:

(a) To limit the use of water for such purposes as it thinks fit (i.e. not merely those specified in the Drought Direction 2011).

(b) To set up, and supply water by means of standpipes, rota cuts or water tanks.

EDOs will only be used as a last resort to reduce demand, when all other demand management and supply enhancement possibilities have been exhausted. An EDO may last for up to three months, with provision for extension up to five months.

The introduction of an EDO would require consultation prior to it being introduced. Particular consideration would be given to the Fire Emergency Planning Authorities and Fire and Rescue Services within the Thames Water supply area to ensure that water supply for essential firefighting could be maintained. A full consultation process would be undertaken with the fire services prior to implementation of EDOs. This is in line Part 5 of the 2004 Fire and Rescue Services Act.

5.7. Summary of demand-side measures and activities

Table 21 shows the range of demand-side measures that fall within the four DEL levels.

Table 21 Demand-side measures and activities

Drought Event Level					
		DEL 1	DEL 3		DEL 4
		Media Water efficiency (L1)	TUB (L2)	NEUB (L3)	EDO (L4)
TW activities	Media campaign and Water Efficiency Activities				
	Enhanced media campaign and Water Efficiency Activities				
	Leakage reduction				
Garden	Using a sprinkler or an unattended hosepipe				
	Watering a 'garden' using a hosepipe* (Garden includes: parks, gardens open to the public, lawns, grass verges, areas of grass used for sport of recreation, allotment gardens, any areas of an allotment used for non-commercial purposes, any other green space)				
	Watering plants on domestic or other non-commercial premises using a hosepipe				

Watering an allotment or garden that is connected to domestic premises and watering plants on domestic premises using a hosepipe, by people with severe mobility problems who hold a current Blue Badge as issued by their local authority		TUB/NEUB Exemption	TUB/NEUB Exemption	
Watering an area of grass or artificial outdoor surfaces used for sport or recreation, where this is required in connection with a specific national or international sporting event		TUB/NEUB Exemption	TUB/NEUB Exemption	
Using a hosepipe to clean domestic paths or patios, where this is done as a service to customers in the course of a business		TUB Exemption		
Using drip or trickle irrigation watering systems that are not handheld, that place water drip by drip directly onto the soil surface or beneath the soil surface, without any surface run off or dispersion of water through the air using a jet or mist		TUB Exemption		
Using a hosepipe to water a garden or to water plants where such watering is restricted to newly laid turf, newly sown lawns, newly planted trees, shrubs and plants when the laying, sowing or planting has been carried out as service to customers in the course of a business. This exemption only applies for a period of 28 days from the day of planting, sowing or turf laying.		TUB		
		Exemption		
Drawing water, using a hosepipe, for domestic recreational use				
Filling or maintaining an ornamental fountain				
Cleaning paths or patios using a hosepipe				

	Cleaning other artificial outdoor surfaces using a hosepipe.				
	Watering outdoor plants on commercial premises				
Ponds/pools	Filling or maintaining a domestic swimming or paddling pool (except when using hand held containers filled directly from a tap)				
	Filling or maintaining a non-domestic swimming or paddling pool (except when using hand held containers filled directly from a tap)				
	Filling or maintaining a domestic pond using a hosepipe (excluding fish ponds)				
	Filling or maintaining a pond (excluding fish ponds)				
Vehicles	Cleaning a private motor-vehicle using a hosepipe				
	Using a hosepipe to clean a private motor vehicle, where this is done as a service to customers in the course of a business		TUB Exemption		
	Cleaning a private leisure boat using a hosepipe				
	Operating a mechanical vehicle-washer				
	Cleaning any vehicle, boat, aircraft or railway rolling stock				
Buildings	Cleaning walls, or windows, of domestic premises using a hosepipe				
	Using a hosepipe to clean walls and windows of domestic premises, where this is done as a service to customers in the course of a business		TUB Exemption		
	Cleaning non-domestic premises				
	Cleaning a window of a non-domestic building				
Industry	Cleaning industrial plant				

	Suppressing dust				
	Operating cisterns.				

	Activity permitted
	Activity exempt from legislation; permitted
	Activity prohibited

Levels of Service	
L1	Level 1
L2	Level 2
L3	Level 3
L4	Level 4

* Using a hosepipe to water a 'garden' for health and safety reasons is not to be treated as a category of use prohibited under The Act. We would expect that any organisation seeking to rely on the health and safety exemption would carry out and document their assessment of risk, prior to carrying out any watering with a hosepipe during the period of the TUB or NEUB, and will robustly challenge any organisation watering excessively for this purpose

Section 6. Supply-side measures

6.1. Introduction

This section discusses supply-side measures in detail for each Water Resource Zone. With the notable exception of drought permits/orders, (see Appendices B and C) supply-side measures are not part of our stated Levels of Service but rather are measures that are introduced during the course of a drought to increase the amount of water available for supply.

Supply-side measures can be categorised into:

- Optimisation of existing sources
- Strategic schemes
- Bulk supplies
- Drought Permits or Orders
- Recommissioning of disused sources
- In extremis options

The benefits from each drought option including strategic supply schemes and drought permit options are set out in detail in Appendix B. Table 23 shows the benefit in Ml/d of the strategic supply-side schemes and groundwater drought/peak load schemes available for London.
Our operating policies on each of the supply-side options are outlined in sections 6.1.1 to 6.8.

6.1.1. Optimisation of Existing sources

The assessment of water availability assumes that all existing sources are operating at their expected capacity. Our policy is to optimise the use of existing sources such that those that are most drought resistant are used in preference to those sources which are more vulnerable. In general, this means that in the conjunctive use WRZs of London and SWOX, full use of groundwater sources should be made in order to conserve reservoir storage.

The assessment of water availability assumes that all existing sources are operating at their expected capacity but, an allowance for outage due to factors such as mechanical failure and pollution events is used for planning purposes. It is also prudent to plan for a level of outage to occur during drought periods. The outage allowances for London and SWOX reported in the Annual Review 2020 are 97.15Ml/d and 17.14Ml/d, respectively, these are based on analysis of recent historical outages. An allowance for outage has been made in the examples to show historic impact of drought episodes described in Section 9.

6.1.2. Strategic schemes

Strategic drought water resources schemes are mostly only relevant to London's WRZ, see below, and generally devised only to be operated at the onset of a serious drought. However strategic schemes can also be deployed during periods of high demand or to help with periods of outage. The TGWTW Operating Agreement allows for the use of the scheme to meet high demands or other emergencies and the NLARS Operating Agreement has a similar condition. In 2018 when outage was experienced of the Thames-Lee tunnel it was necessary to deploy NLARS and this was implemented in order to preserve London storage.

6.1.3. Bulk supplies

Bulk supplies are transfers of either raw or treated water exported or imported between neighbouring water company areas. Thames Water's policy is to honour its existing bulk supply agreements, see respective sub-sections for each WRZ below.

6.1.4. Drought Permits or Orders

Drought permits are concerned with abstraction from our existing sources that is outside of the conditions stated in the licence. The drought permit option represents an important supply-side resource relevant to all WRZs; full details are given in Appendices B and C. Drought permits are prioritised based on the proposed implementation order (with 1 being the most likely to be implemented).This prioritisation is based on magnitude of environmental impact, water resources benefit and ease of implementation. In an actual drought, other factors will also be taken into account in determining which drought permits should be applied for, such as ease of implementation and water resources contribution to areas of need. Therefore, the actual order of implementation of drought permit options in a drought may vary slightly from this prioritisation although the priority order given in this Appendix (C) would form the basis of the order in which options are used in a drought.

The EA is responsible for granting drought permits and, in so doing, it must be satisfied that the benefits to supply outweigh the potential environmental impacts.

The Secretary of State is responsible for granting drought orders and, in so doing, must be satisfied that the benefits outweigh the potential environmental, economic and other impacts.

Strictly speaking, there is no single criterion for specifying the lead time for preparing and submitting drought permit or order applications. The lead time required will depend upon the environmental sensitivity of the option being considered along with the preparatory monitoring needed to satisfy EA requirements. As a working rule our plan assumes a 3 month preparation period prior to the need for implementation of drought permits. After a drought permit application has been submitted to the EA it has been assumed that a decision would be forthcoming within 4 to 8 weeks of submission, provided the preliminary monitoring and environmental assessment have been completed beforehand.

Drought permits would generally be implemented at Level 3 of Thames Water's Levels of Service, with the trigger of DEL 3. Full Environmental Assessment Reports (EARs) have been prepared for all our drought permit options. A programme of baseline monitoring has been undertaken to inform the completion of the environmental assessment reports.

The Drought Plan guidance 2020 requires that ideally all the drought permit / order options that are included in water company plans should have EARs that are well developed such that they are "application-ready" i.e. they are prepared to a level of detail such that if a drought occurred at any time the EARs could be used to support a Drought Permit application with very little update required. In practice is not possible to maintain EARs as application ready at all times because updates will be required to bring the reports up to date with the most recent baseline information available and to set out the details related to the drought for which they are proposed to be implemented. Therefore, it is likely that a certain amount of work will always be required on "application-ready" EARs before they can be used in practice.

All EARs have been updated for the 2022 Drought Plan to take into account further data collected since 2017 and any revisions to the assessed impact of the DP options. The updated EARs have been prepared in accordance with Government regulations and good practice guidance, including the EA Drought Plan Guideline updated in 2020. We have liaised closely with the EA to ensure it is satisfied with the approach adopted for the drought permit assessment methodology and outcomes of the EARs reports.

In preparation for and during a drought we will work closely with the EA in the process of drought permit applications. A list of potential venues for Drought Permit hearings and local newspapers in which each Drought Permit could be advertised has been included in Appendix C. This is a provisional list and would require confirmation and update before a Drought Permit application.

Drought Orders

Where a Drought Order has been made, no compensation is payable except in the limited circumstances set out in Schedule 9 of the Water Resources Act 1991 and Condition Q of Thames Water's Instrument of Appointment.

Where any Drought Order authorises the use and occupation of land, the owners and occupiers of the land and any person interested in it, or injuriously affected by entry onto it, or its use or occupation, may claim for any loss or damage caused as a result of that entry as a result of that occupation or use.

Any claim for compensation must be made within the time limits set out in Schedule 9 by serving notice on Thames Water setting out the grounds of the claim and the amount claimed. Compensation disputes may be referred to the Upper Tribunal.

Additional compensation may be available in respect of an ordinary Drought Order (but not an Emergency Drought Order) by those affected by its particular provisions. For example, if the order prohibits or limits the taking of water from a specific source, the persons to whom that restriction applied may claim for loss or damage sustained as result.
No compensation is payable for prohibitions on the use of water. However, where an order provides for supplies to be interrupted or cut off then daily payments must be made (£10 for domestic customers subject to a maximum equal to the previous years' charges and £50 for business customers, subject to a maximum of £500) if the cut off or interruption of supply could not reasonably have been avoided. This is set out in Condition Q of Thames Water's Instrument of Appointment.

We will look to support any abstractors who may be adversely affected by supply side drought measures by working with them to look at ways of improving their water efficiency and facilitating finding of alternative sources of raw water.

Assessment of any potential derogation resulting from our Drought Permit (DP) options has been undertaken to determine the impact on downstream abstraction licence holders. This is required to understand the potential for the DP options to result in claims for compensation.

The only third-party licence holder identified that is likely to be materially derogated is RWE Generation UK in respect of the abstraction for cooling water at Didcot Power Station. In view of this potential impact we have undertaken an assessment of the likelihood of this occurring and have determined from an initial review that in the severe drought of 1976 it is likely that the abstraction by RWE Generation UK would have been reduced from the 2nd lowest abstraction tier on its licence to the lowest tier for a total of 4 days more than would have been the case if the drought permit were not implemented. Since undertaking this review RWE Generation UK has closed Didcot A power station and so has reduced its abstraction requirement which means the likely reduction in flows to the lowest tier will have less impact on RWE Generation UK's ability to abstract the water it requires in a drought. We have discussed the potential drought permit impact with RWE Generation UK to agree a position in relation to the potential impact on its abstraction. RWE Generation UK has indicated that derogation of its licence would be likely to result in significant commercial impact on the power generation activities at Didcot. Together we have agreed that the impact could be addressed through the provision of insurance against the derogation impact in the event of a severe drought and that we will pursue the option of insurance against the potential for compensation in liaison with RWE Generation UK. This requirement will be reviewed now that Didcot A has been closed and their abstraction requirement has been reduced.

Through the environmental assessment process, we have identified potential impacts on other licensed abstractors as a result of drought permit implementation. The impact on their abstraction capability has been determined by assessing if the drought permit will have a low, medium, high or no risk to the ability of the abstractor to continue abstraction. These are not considered to be material but will be reviewed with the third parties to determine the significance of impact. Appropriate mitigation and/or compensation measures will be agreed if necessary. This will be conducted during the process of drought permit/order application. Mitigation and/or compensation will only be provided if it is clearly demonstrated that the 3rd party abstraction is compromised as a result of the Drought Permit implementation and not as a result the natural effect of drought.

In the event that the Drought Permits were implemented we would contact the abstractor at least 2 weeks before the Drought Permit application to discuss the risk to the abstractor and would agree any measures to mitigate the impact of the Drought Permit option and to address the potential issue of compensation should it arise.

This applies to the following drought options:

Table 22 Abstractors potentially requiring compensation/mitigation

Drought permit or order option	Abstractor/ Licence Holder	Risk to licence
Lower Thames	Private abstraction – Shepperton Marina	Low

	Private abstraction – Kingston upon Thames	Low
Sundridge (options) (London WRZ)	Sevenoaks District Council (Wildfowl Reserve) (surface water transfer between sources)	Uncertain
Latton (SWOX WRZ)	Hanson Quarry Products Europe Ltd (GW abstraction) Moreton C Cullimore (Gravels) Ltd (GW abstraction) Farmcare Trading Ltd (GW abstraction)	Low Low Low
Meysey Hampton (SWOX WRZ)	The Cooperative Wholesale Society Ltd (GW abstraction) Hanson Quarry Products Europe Ltd (GW abstraction) Moreton C Cullimore (Gravels) Ltd (GW abstraction with flow constraint)	Low Low Low
Eynsford (London WRZ)	Sandfields Farms Limited (surface water, spray irrigation**)	Low
Pangbourne	Enfield Estate Trust Corp Ltd (Surface water, Spray irrigation**)	High
Childrey Warren	Elms Farm Partnership (surface water, agriculture/spray irrigation**) Hallidays Developments Ltd (surface water, production of Energy) with a constraint.	Low High

** Abstraction licences for spray irrigation can be restricted during drought conditions under Section 57, it is therefore possible that these licences could be restricted before the implementation of drought permits.

6.1.5. Exceptional Shortage of rainfall

In order to obtain a Drought Permit it is a legal requirement to justify an exceptional shortage of rainfall such that a serious deficiency of supplies of water in any area exists or is threatened. Our Drought Management methodology sets out how reservoir storage, groundwater levels and river flows are all used to determine the onset of drought and how droughts are managed in each water resource zone.

This information together with rainfall data will be used to demonstrate an exceptional shortage of rainfall and a serious deficiency of supplies.
The water situation reports we produce each month during average weather conditions include information on monthly rainfall, deficit over the preceding year, annual summaries of rainfall as a percentage of long term average and a map to show the variation across our supply area, see Appendix D. During a drought this assessment would be completed more frequently.

When the water resource situation reaches the point where drought permits or orders are required an exceptional shortage of rainfall assessment would be completed at either a Thames regional scale and/or for each Water Resource Zone depending on the extent of the drought.

The need to demonstrate an exceptional shortage of rainfall could apply across the whole Thames catchment if drought permits or orders are required for London and so the rainfall pattern over the whole catchment would be used to demonstrate the exceptional shortage. It may also be necessary to demonstrate the exceptional shortage of rainfall over one or more of the other WRZs. In either case it is more appropriate to use areal rainfall which is indicative of the whole area rather than at individual points where gauges are located. Areal rainfall is calculated using a network of rain gauges to determine rainfall for the Thames catchment and its sub-catchments which enables the effect of the rainfall deficit to be used to more comprehensively demonstrate the impact on water resources than if isolated rain gauges are used. The areal rainfall pattern may also be supplemented by individual rain gauge records if this is useful in indicating the exceptional shortage at the time of the drought.

Areal rainfall data covers the following areas-

- Cotswold West
- Cotswold East
- Berkshire Downs
- Chiltern West
- Upper Thames
- Cherwell
- Ock
- Thame
- North Downs – Hants
- Wey – Greensand
- North Downs – South London
- Loddon
- Lower Wey
- Upper Mole
- South London
- Chiltern East Colne
- Lee Chalk
- North London
- Lower Lee
- Roding
- Enbourne
- Cut

The period assessed to determine the exceptional shortage of rainfall would be defined during each drought event as each drought is different, and so the period assessed would be applicable to the

specific drought and the time that it has taken to result in a potential shortfall in supplies. Typically, this could include assessments over periods of 6, 12, 18 months or longer. The appropriate techniques for demonstrating an extreme shortage of rainfall would vary according to the nature of the drought event in terms of its duration and the severity of the deficit. A combination of the following techniques would be used along with other measures if appropriate:

- Monthly and cumulative rainfall deficits
- Monthly and cumulative percentage of long-term average rainfall
- Geographical extent of rainfall deficit
- Comparison of rainfall deficit with other drought events within the Thames Region, for example 1976.

The assessments of rainfall deficit would be used to place the drought within the context of the long term record of droughts and an approximate return period would be calculated which would be used to demonstrate that the measures proposed to manage the drought were consistent with Thames Water's levels of service.

This information for rainfall shortage would be used alongside the drought protocol for each Water Resource Zone, which includes assessment of reservoir storage, groundwater levels and river flows to demonstrate the severity of the water resource situation arising from the rainfall deficit. In the same way as the rainfall deficit is used to calculate a level of severity and approximate return period the river flow and ground water levels would also be analysed to determine their severity when compared to the historic record and an approximate return period would be determined.

It is not possible to set out exactly what information would be used and how it would be presented prior to the drought event occurring because each drought is different and therefore a certain amount of flexibility is required to make the case for an exceptional shortage of rainfall.

6.1.6. Recommissioning and Maintenance

With only a few exceptions, all of our licensed sources are fully utilised. There are a small number of sources that are not in regular use, due either to not being cost-effective to operate or having water quality issues. This is not to the detriment of normal year supply although is under review due to the required resilience duty within the 2014 Water Act.

We have an ongoing programme of review of source outage and availability to ensure security of supply beyond a normal year. This determines the requirements to undertake work to ensure sites are in a state of suitable readiness as a drought situation develops.

6.1.7. In extremis options, More before Level 4 - Supply side measures

More before Level 4 or in extremis options would be considered in situations more severe than Level 3 of Thames Water's Levels of Service hierarchy. These include: tankering, emergency raw water pipeline transfers, reduction in bulk supplies, temporary desalination units and alternative sources for non-potable use. In addition, a drought permit option for the lower Thames may include an allowance for the back-pumping of water over Molesey and Teddington weirs in order to ensure that the water available in the Lower Thames can be taken at the existing intakes. We are undertaking further

assessment of these options to develop more detailed plans for what would be required in the event of a severe drought that required these options to be implemented.

Further reduction of Bulk Supplies

The potential for reduction in provision of bulk supplies beyond what is already agreed with neighbouring companies would be explored and measures would be implemented if feasible and agreed with neighbouring companies.

Tankering of raw water to the Lower Thames Estuary

This could include tankering of fresh water from overseas to a terminal on the Thames Tideway, which would require a pipeline to transfer the raw water from a Terminal on the Thames Tideway. We recognise that certain external measures would need to be put in place before the option can be considered to be available. This option has been further developed through the WRSE group in order to consider benefits for the wider South East and so, if necessary, this option would be implemented through close working with WRSE and also potentially Essex and Suffolk Water. Further work is planned on this option through WRSE, in particular, to determine whether the lead time for the scheme could be reduced.

Tankering of potable supplies

Tankering of supplies would be considered and undertaken to meet demand in hotspots where necessary although this option is likely to be available on a small scale only because of the limited number of tankers available.

Installation of temporary desalination units

The potential to install temporary desalination units would be considered and where feasible may be implemented. The feasibility of this option would be determined by the ability to feed the treated water into the network and the need to satisfy drinking water quality standards. Mobile desalination units have been developed for use overseas, for example in Cyprus, and the units are available in various volumes.

Utilisation of alternative sources of supply for non-potable use

Potential options to use dewatering discharges as a replacement for non-potable use would be explored. For example, quarry or excavation dewatering discharges could potentially be used to provide irrigation water for high value recreational uses where restrictions on use would have significant economic impact. We would also explore the setting up of non-potable water refill points for businesses on a community scale e.g. for councils for parks watering, this could potentially be provided through the re-use of treated STW effluent.

Deephams Reuse

Potential options also include reuse of Deephams effluent which was considered / tested in the 1976 drought. This option would effectively bring forward the longer-term option for reuse of Deephams effluent but on a temporary basis for extreme drought. The option would involve the transfer of a proportion of the Deephams effluent to a point further up the River Lee system for discharge upstream of our Lee intakes to allow for increased abstraction into the Lee Valley reservoirs.

Back, pumping over Lower Thames Weirs

As mentioned in Section 6.1.7 a drought permit option for the Lower Thames may include an allowance for the back-pumping of water over Molesey and Teddington weirs in order to ensure that the water available in the Lower Thames can be taken at the existing intakes.

London WRZ

Central to London's drought management are the strategic water resource schemes, which provide a major augmentation to its supply capability. On the other hand, bulk supplies represent a significant export to other neighbouring companies. Whilst the zone currently does have drought permit options, they represent a secondary back-up to supply. There are two disused sources that could be recommissioned. Our Merton and Honor Oak sources are currently out of service and the deployable output is declared as zero. Significant investment is required to return the sources to operation. Recommissioning of Merton groundwater source is in WRMP19 preferred plan for delivery in AMP9 in 2030/31.

Over time we have seen changes in the algal blooms contributing to the detriment of the water quality in our storage reservoirs under certain conditions (EG In the Spring under blue skies). At this time, across our total storage reservoir asset base, we are unaware of the effect this would cause under drought conditions and any resilience changes. We will continue to improve our understanding of the resilience of our water system.

6.1.8. Strategic schemes

As outlined in Section 4.2.1, London's deployable output is heavily dependent upon the timely introduction of certain supply-side measures. In total these options add approximately 310 Ml/d to London's supply capability thereby greatly helping to off-set the depletion of surface water resources during drought. The strategic drought schemes built into London's deployable output are listed in Table 23, which gives the schemes' contribution to London WRZ's supply capability. We have made two significant changes to our strategic schemes for London since the last plan with the reduction in the scheme benefit for Hoddesdon to 0 Ml/d and reduction of benefit from TGWTW from 150 to 100 Mld.

Table 23 Benefit provided by Strategic Schemes

Scheme	Benefit Ml/d
North London Artificial Recharge Scheme (NLARS)	220 to 156
Hoddesden Transfer scheme	0Mld Scheme under review
Thames Gateway Water Treatment Works (TGWTW)	Up to 100 (see section 6.2.1.3)
West Berkshire Groundwater Scheme (WBGWS)	126 to 67

Small scale groundwater schemes	
ELRED, Stratford Box and Old Ford	26.7
Chingford Artificial Recharge Scheme (CHARS)	15.1 to 10.6

The operation of NLARS, TGWTW and WBGWS is subject to separate operating agreements with the EA.

6.1.8.1. Triggers

With the exception of NLARS and the WBGWS, the trigger for switching on all the strategic schemes (see Table 24 below) is based on the earliest point in time at which the London reservoirs start to lose storage at the beginning of a potentially serious drought (at least DEL1 event level). Two operational surrogates are employed for this purpose, these are:

The recession of the River Thames at Teddington Weir reaching a naturalised flow of 3000 Ml/d for 10 days on average; and

the drawing down of reservoir storage to the 800/700/600 Ml/d curve on the LTCD.

Table 24 Triggers for Strategic Schemes

Scheme	Trigger
NLARS	NLARS Operating Agreement: Teddington target flow reduces down to 600/400Mld curve (Level 1 curve on LTCD)
TGWTW	TGWTW Operating Agreement: Drought Event Level (DEL) is at least DEL1, Naturalised Teddington flow remains at or below 3000 Ml/d for 10 or more days and the drawing down of reservoir storage to the 800/700/600 Ml/d curve on the LTCD or earlier if the drought severity warrants it.
ELRED	Internal operating rule: as per TGWTW
Stratford Box	Internal operating rule: as per TGWTW
CHARS	Internal operating rule: as per NLARS
WBGWS	Level 2 curve on LTCD

The 3000 Ml/d trigger is based on past experience that when naturalised baseflow recedes down to 3000 Ml/d the permitted abstraction level is insufficient to maintain London's reservoir storage. Consequently, the reservoir storage level starts to decline. The trigger represents a well-tried operational expedient for estimating the threshold between maintaining and losing reservoir storage. The 3000 Ml/d trigger criterion is sometimes reached in non-drought years towards the end of a normal summer/autumn recession as is the drawing down of reservoir storage to the 800/700/600 Ml/d curve on the LTCD, hence the additional criterion of specifying Drought Event Level 1, which relates to the water situation that generally exists at the start of a drought.

Details of the strategic schemes are as follows.

6.1.8.2. North London Artificial Recharge Scheme (NLARS)

NLARS is a strategic resource scheme that enables beneficial use of the confined Chalk aquifer in North London by a technique known as artificial recharge. In this case, treated water is recharged into the aquifer via purpose-built boreholes. The aquifer is kept as full as possible in 'normal' operational periods, when water resources are plentiful, in preparation for drought conditions.

From switch on to the full operation of NLARS takes an elapsed time of 7- 30 days. It is likely that we would have a phased switch on depending on the potential severity of the drought and taking into consideration the operation of those NLARS boreholes whose initial abstraction output would be less sustainable during extended droughts.

NLARS is operated in accordance with the North London Artificial Recharge Scheme Operating Agreement between Thames Water and the EA.

6.1.8.3. Thames Gateway Water Treatment Works (TGWTW)

TGWTW is a desalination plant that uses brackish water abstracted from the Thames Tideway and treats the water to potable standard. The source has an abstraction licence for 200 Ml/d peak and 200 Ml/d average and the water treatment plant has a maximum output of 100 Ml/d. The output of the plant is lower than the licensed abstraction volume because there are significant treatment losses incurred as a result of the desalination process. Prior to 2017 our Drought Plan included the assumption that the TGWWTW could provide a sustained output of 150 Ml/d for the duration of a sustained drought. We undertook a review of the TGWWTW in 2017/18 and identified that the works needed a substantial mid-life upgrade and so a programme of work was implemented, commencing in AMP7 to undertake significant remedial upgrade works to the plant such that its output could be maintained reliably at 100Ml/d. The use of the TGWTW is governed by an Operating Agreement as part of a Water Resource Management Agreement under Section 20 of the Water Resources Act 1991.

The Operating Strategy contained within the Operating Agreement states that:

"The Undertaker may operate the Abstraction if any of the following criteria are satisfied and the Undertaker is of the reasonable opinion that if the Abstraction is not used, there will be a significant risk to the Undertaker's ability to fulfil its statutory duty in respect of water supply:

i) whenever:

a) Reference to event level in the Undertaker's Drought Plan; and

b) the naturalised Teddington Flow has remained at or below 3000 Ml/d for ten or more consecutive days. Once the naturalised Teddington Flow reverts to 3000 Ml/d or above, the abstraction will continue to operate until the Undertaker, in consultation with the EA, is satisfied that there is no further imminent risk to its ability to fulfil its statutory duty in respect of water supply.

ii) during operational emergencies caused by peak demands or other extreme events beyond the Undertaker's control, which threaten the reliable provision of public water supplies

The Undertaker may also operate the Abstraction to take whatever minimum flows may be necessary to keep the Works in acceptable operating condition."

Thus the relevant clauses for a drought event are ia) and ib), which essentially say that before the plant is used, firstly a drought event has to be declared and thereafter the actual trigger for switch-on is the recession of the lower Thames down to 3000 Ml/d, as measured upstream of Teddington Weir and corrected for a non-abstraction [naturalised] regime.

On the basis of experience gained during the commissioning process, subsequently operating the site in 2012 and more recently, it is expected that the 'ramping up' time to implement the plant at full output will take between 4-6 weeks. This estimate is based on our current protocol of running the plant in the early part of the year to ensure it is in state of readiness so that the ramping up to close to maximum output is from a status of water into supply of approximately 50 Ml/d. Because of the proactive approach taken in the revised drought protocol this procedure can be commenced well in advance of the likely need to implement the scheme.

In 2019 Defra requested that we review the triggers used for TGWTW to ensure that they were appropriate for maximising the beneficial output from the plant. We undertook this review at the time and confirmed that we consider that the trigger continues to be appropriate. Its operational use at the current trigger point maximises its deployable output contribution by switching it on sufficiently early to support London reservoir storage as it begins to decline in any year which could develop into a significant drought.

We can confirm that Thames Gateway has the capability to achieve 100Ml/d. The plant is run annually for a period at lower volumes of at least 25Ml/d, as per the licence agreement, to maintain operating capability. The designed intermittent use of the plant means we need to replace perishable equipment once used, such as costly membranes. To manage these replacement costs, and also high operating costs, we will only utilise the full capacity of the plant when required.

Since commissioning and testing and following further subsequent periods of use of the plant, we have had the opportunity to learn about the operation of the plant on an estuary with changing salinity. This has led to working improvements that have optimised the operational practice, and also awareness of the required maintenance to maintain the intermittently used equipment.

The plant was designed to achieve 150Ml/d against historic droughts, and not to deal with more extreme droughts that are expected to be of greater intensity and less water availability. Following a comprehensive review of the plants component elements we have revised down the plant reliable output to 100 Ml/d as described above. It should also be noted that salinity levels in the upper and middle Thames Tideway are forecast to show greater variability, impacting the current running of the plant. To improve resilience to these conditions we are undertaking a works upgrade to improve the resilience of the plant so that it will be capable of 100Ml/d sustained output in future drought periods.

Hoddesdon Transfer Scheme. The Hoddesdon transfer scheme is current undergoing an engineering review and therefore the current DO attributable to the scheme is zero, pending the outcome of the review.

6.1.8.4. West Berkshire Groundwater Scheme (WBGWS)

The WBGWS is a strategic drought scheme under which untreated groundwater is discharged into the Kennet and Pang tributaries of the River Thames in order to increase the flow to the London reservoir abstraction points, as well as our water treatment works at Fobney in the Kennet Valley WRZ. The WBGWS is owned and operated by the EA in accordance with the West Berkshire Groundwater Scheme Agreement (1989) between Thames Water and the EA. We may request the EA to switch on and operate the scheme once reservoir storage has drawn down to the Level 2 control curve on the LTCD. An important pre-requisite to use of the scheme is the timely introduction of Level 2 demand management measures of Thames Water's Levels of Service (enhanced media

campaign and Temporary Use Ban). Under the existing protocol a TUB would be in place in a severe drought well before this trigger was reached.

A benefit of some 126 Ml/d reducing to 67 Ml/d in a prolonged drought is provided by the scheme. This benefit is provided to the river system downstream of the WBGWS wellfields, principally the River Kennet and is then passed into the River Thames. The deployable output for London amounts to 88 Ml/d however the DO is currently under review and will be updated for the final Drought Plan.

The implementation time for full operation is between 2 - 21 days. The scheme Operating Agreement states that The Environment Agency shall ensure that the scheme is delivering its maximum output within 48 hours of a request from Thames Water to operate the scheme in a drought.

6.1.8.5. Groundwater sources

ELRED

ELRED is the East London Resource Development Scheme and is licensed for 20.6 Ml/d peak and 18 Ml/d average.

This source is normally operated at a low base load level when required but its output can be increased during peak demand and drought periods, giving a benefit of13.2 Ml/d and this contributes to the provision of 25.7 Ml/d when operated in conjunction with Stratford Box and Old Ford. The implementation time for this supply-side measure from a low base load level to 12 Ml/d is 7-14 days and time to produce maximum output would be longer, up to 28 days or more.

Stratford Box

Stratford Box is a groundwater abstraction source and is licensed for 8 Ml/d peak and 8 Ml/d average. This source is only operated during drought periods in conjunction with the Old Ford licence. The implementation time for this supply-side measure is a minimum of 7-14 days but may take longer depending on water quality testing.

Old Ford

Old Ford is a ground water source and is licensed for 4.5 Ml/d peak and 4.5 Ml/d average. This source is operated in conjunction with Stratford Box. The implementation time is a minimum of 7-14 days but may take longer depending on water quality testing.

Chingford Artificial Recharge Scheme (CHARS)

CHARS is a similar scheme to NLARS but on a smaller scale. The scheme is licensed for 18 Ml/d maximum abstraction from four boreholes in the Lee Valley. The normal operating strategy for CHARS is to support meeting peak demands in non-drought periods, but it is also a source that would be used in the event of drought, providing a net benefit of 15.1 Ml/d reducing to 10.6 Ml/d in a prolonged drought.

The implementation time for this supply-side measure is 7-14 days.

6.1.9. Bulk supplies

Within our supply area, London has the majority of the bulk supply options. Whilst developing our Water Resources Plan, we have explored with our neighbouring water companies on several occasions the possibility of terminating, or at least reducing, our exports.

Table 25 below gives the current position on bulk exports. It can be seen that there is a maximum commitment during drought to export approximately 73 Ml/d of raw water and 12 Ml/d of treated water. This commitment was reduced from 101 Ml/d in 2014/15, as a result of an agreement with Essex and Suffolk Water to reduce the bulk supply provision. Therefore, the provision to Essex and Suffolk Water is reduced to 71 Ml/d on average through the year, arising from a profile of no less than 60 Ml/d for Jan-Mar each year and 75 Ml/d during the remainder of the year. We will however endeavour to assist other water companies in the situation where our supplies are not at serious risk but neighbouring companies may be at risk, for example, in the case of a one-year drought in which security of supply in neighbouring water companies may be at greater risk.

Table 25 London WRZ- Current Bulk Supply Agreements

Imports	Exports
None	Essex and Suffolk Water - 91 M/ld average and 118.2 Ml/d peak raw water transfer from Lee Valley to Chingford area. Thames Water and Essex and Suffolk Water agreed a reduction to this bulk supply provision in 2014 such that the provision to Essex and Suffolk Water is reduced 71 Ml/d on average through the year arising from a profile of no less than 60 Ml/d for Jan-Mar each year and 75 Ml/d during the remainder of the year. There is agreement to reduce export by 25% where Thames Water has implemented a TUB and Essex and Suffolk Water have not.
	Affinity Water - 2 Ml/d raw water to Sunnymeads WTW; 12.2 Ml/d treated water via Fortis Green, with a peak capability of 16Ml/d and up to a maximum of 27Ml/d under the agreement and 0.2 Ml/d at Hampstead Lane;
	SES Water - agreement exists to supply up to 13.6 Ml/d. SES Water have only required 5 Ml/d in recent years. This would be reduced from 5 Ml/d to 0 Ml/d during drought.

Essex and Suffolk Water

The largest export is to Essex and Suffolk Water from North London, 91 M/ld average and 118.2 Ml/d peak. Thames Water and Essex and Suffolk Water agreed a reduction to this bulk supply provision in 2014 such that the provision to Essex and Suffolk Water is reduced to no less than 60 Ml/d for Jan-Mar each year and 75 Ml/d during the remainder of the year. The bulk supply agreement has a variation clause relevant for drought conditions as shown in Table 26. Under a drought situation in which Thames Water has implemented a TUB and Essex & Suffolk Water has not, the agreement states that the export will be reduced by 25%. If both companies have implemented TUBs and there is a shortfall in supply due to the impact of drought on available resources, then the reduction is determined by fair apportionment.

Table 26 Bulk Transfer to Essex and Suffolk Water

	Average daily Ml/d	Maximum daily Ml/d
Provision during non-drought periods	90.92	118.2
Provision during drought	71	

Provision during drought periods (25% reduction) if TUB is imposed in Thames Waters supply area but not Essex and Suffolk's	53	88.65

The process for implementation of this provision involves dialogue between both companies in the period running up to the implementation of a TUB by Thames Water. When the potential for the imposition of a TUB by Thames Water is identified, we will inform Essex and Suffolk Water. We will then continue to keep them informed of the likely date of imposition of the ban and confirm that the bulk supply will be reduced by 25% from this date if Essex and Suffolk Water have not imposed a TUB. We will also keep Essex and Suffolk Water appraised of the likely date of lifting of the TUB and will confirm that the reduction in the bulk supply can be lifted as soon as the TUB has been lifted. If Essex and Suffolk Water has not imposed a TUB but we have, then Essex and Suffolk Water will keep us informed on the likely date of its imposition of a TUB.

In times of extreme drought affecting both companies (described as 'unusual drought' in the Agreement) and where both water companies have put on TUBs, there is a further provision that provides for a 'fair apportionment' of available water between the two companies where we are unable to provide the full bulk supply.

The terms "unusual drought" and "fair apportionment" are not defined in the Agreement, however, unusual drought is seen as a situation where measures more extreme than the requirement for a TUB would be required such as the need to introduce a NEUB. If this situation occured the companies would discuss the measures that would be appropriate at the time to provide for a fair apportionment. Both companies have agreed that under these circumstances a pragmatic approach would need to be adopted to take account of the differing water resource situations and consequent supply capabilities of each water company.

Thames Water and Essex and Suffolk Water have discussed the options to provide mutual aid in situations where the respective supply/demand situations may require it. This can apply to drought situations but also to other circumstances such as during periods of outage where it is prudent to provide mutual aid to each other. This provision therefore enables us to allow for a reduction of up to 20 Ml/d to the bulk supply provided to Essex and Suffolk Water. Conversely there is also the potential for us to increase the provision up to 118 Ml/d where Essex and Suffolk Water may require it and we are able to make the transfer without compromising the supply to our own customers.

SES Water

The bulk supply agreement between Thames Water and SES Water provides for a supply of up to 13.6 Ml/d via Thames Water's pumping station at Merton. We have agreed to maintain the supply during drought, if required by SESW, as long as there is no risk to supply to our customers. The provision of the bulk supply would be likely to be unavailable if we had implemented a NEUB. SESW has not required the full 13.6 Ml/d in recent years. If provided the bulk supply received by SESW would be via their pumping station at Merton which is currently disused and would need a period of rehabilitation before it was recommissioned. Therefore, it is clear that SES Water consider that limited reliance should be placed on the availability of this supply during a drought period and it should be considered as an option in severe drought to mitigate the risk of Level 4 measures being required.

Affinity Water

Fortis Green

This bulk supply is for a maximum of 27 Ml/d under the agreement although Affinity Water has an average requirement of 12.2 Ml/d and can take a peak of 16Ml/d. This supply would be maintained during a drought unless continued supply was prevented by unusual drought. Therefore, the supply would be maintained if we have implemented a NEUB but would potentially suspended if we were approaching Level 4.

Iver Water Treatment Works

This bulk supply agreement is for 2 Ml/d and would be maintained during a drought unless subject to failure due to drought. Therefore, the supply would be maintained if we implement a NEUB but would potentially be suspended if we were approaching Level 4.

- We also have two bulk supply provisions to Affinity Water linked to the construction of HS2 and so these are of limited duration but would commence in 2021. Affinity Water do not currently include the volumetric benefit of these connections in their supply demand balance modelling as they are related to HS2 construction. Therefore, for the duration of HS2 construction these two connections cannot be used for supply demand balance calculations. Affinity Water is exploring the potential to include these connections in their longer-term supply demand balance planning (post HS2 construction phase) as part of the WRSE modelling under the various drought modelling scenarios (beyond AMP8). Affinity Water expect to be able to provide an update on the feasibility of operating these connections on a longer-term basis under drought conditions later in 2021, once the WRSE modelling has progressed to a point where they can clarify further how they might be operated in the future.

Perivale

This bulk supply agreement is for treated water up to 10 Ml/d and is on a best endeavours basis and would be maintained if we imposed a TUB, but may be suspended in a severe drought (approximately 1:200 year) or if a NEUB was imposed. The Perivale connection is designed to provide water during peak conditions only and is supported by an agreement for the loss of Affinity Water peak supply capability in the event of HS2 construction phase activities impacting on their existing supply base.

Cockfosters

This bulk supply agreement is for treated water up to 5 Ml/d and is on a best endeavours basis and would be maintained if we imposed a TUB, but would be suspended in a severe drought (approximately 1:200 year) or if a NEUB was imposed. The Cockfosters connection is designed for both average and peak demand conditions and covers exclusively the HS2 water demand for the construction of the Chilterns tunnel as an indirect supply.

We will also continue to discuss bulk supply possibilities with other neighbouring water companies.

6.1.10. Drought permits

As outlined below, there are several potential drought permit options available for the London WRZ. The trigger for the application of a drought permit is the risk of London's reservoir storage reaching the Level 3 control curve, see Section 4 above.

Options

- Reduction of Teddington Weir flow below licensed minimum of 200 Ml/d.
- Increase of abstraction above annual average for M2 licence.
- Darent Valley groundwater
- Increase abstraction above licensed limit at Sundridge and Eynsford wellfield.
- South London groundwater
- Relaxation of annual limit at Waddon

6.2. SWOX WRZ

6.2.1. Optimisation of existing sources

We upgraded the GATOX pipeline (Gatehampton to Oxford pipeline) several years ago and this has improved the robustness of our supply capability by improving the connectivity from our groundwater sources in the Goring Gap to the demand centres supplied by the Farmoor system. During the course of a drought maximum use of this enhanced connectivity will be made.

6.2.2. Strategic resources

SWOX has no strategic drought water resource options built into our deployable output.

6.2.3. Bulk supplies

The provision for a bulk supply to Severn Trent Water of 2.3 Ml/d exists from the North Cotswolds area. This supply has not been required in recent years and no formal agreement exists. This supply would be maintained during a drought unless the continued supply resulted in risk to supply to our customers.

6.2.4. Drought permits

Drought permit options form an important part of our plan for the SWOX WRZ. All the possible options and their suggested order of priority are given in Appendix C. The principal option is to make fuller use of the Farmoor system by increasing the availability of raw water for abstraction from the River Thames during periods of low flow and low storage levels at Farmoor reservoir.

RWE Generation UK is the major abstractor from the River Thames immediately downstream of Farmoor. Thames Water will liaise with RWE Generation UK well in advance of implementing the Farmoor drought permit option.

Other options in the SWOX resource zone include increased abstraction from Gatehampton under conditions when the flow constraints are in force.

The remainder of options available are abstractions from groundwater with the preferred initial option being the introduction of Latton and the disused Meysey Hampton summer boreholes. This would be followed by Ogbourne, Axford and Baunton.

Potential options to benefit the Banbury area include a drought permit to abstract from the Oxford Canal. However, this option is dependent upon the water being made available by the Canal and River Trust. The Canal and River Trust has indicated that up to 5 Ml/d could be made available without the requirement for further investment depending on the severity of the drought situation. We have discussed the requirement for a Drought Permit with the Canal and River Trust and further discussions would take place to agree in principle commercial terms in advance of an application for a Drought Permit. It should be noted that the Oxford Canal option will only be available if the water is available from the Canal and River Trust at the time of the drought.

The potential for increased abstraction at the Bibury source would be dependent upon the provision of sufficient treatment capability to increase the output from the source. It may also require increased network capability to enable transfer of the water to areas where it will provide benefit in reducing the impact of drought on other sources e.g. Farmoor.

We have also introduced a Drought Permit option at Childrey Warren following the closure of the source due to adverse impact on the Letcombe Brook. This option would only be used if there was local supply risk in the area around Wantage.

There is also potential for drought permits at Axford and Ogbourne, but these would be of lower priority than the options above because of the potential adverse impact on the River Kennet.

6.2.5. Recommissioning

The re-commissioning of Compton is included as an option for potential use in a very severe drought i.e. if we were at risk of reaching Level 4 in SWOX. This option was previously included as a drought permit option, but due to the substantial re-commissioning required in order for the source to be used, we no longer include it as a drought permit option for level 3. However, we have retained the EAR for Compton prepared for previous drought plan updates and this would be used if we needed to use this option in a severe drought. The source would also require nitrate treatment.

Similarly in a very severe drought we would consider the recommissioning of Blewbury, which could be used to reduce the amount of water from Gatehampton that is used locally and thereby enable greater benefit from the transfer of water from Gatehampton northwards to Oxford. This option could only be pursued if the current high nitrate levels are addressed. We no longer hold an abstraction licence for the Blewbury groundwater source following its transfer to the Gatehampton licence and the source has not been used in recent years due to high nitrate levels. Any use of the Blewbury source, in a very severe drought would mean we would need a drought permit and so we have retained the EAR previously prepared for Blewbury. This option would also require the temporary installation of nitrate treatment equipment.

6.3. Kennet Valley WRZ

6.3.1. Existing sources

During low flow conditions Pangbourne groundwater source is subject to a reduction in abstraction due to the flow constraint on the licence which stipulates that boreholes 5 & 6 cannot be used when flow in the River Pang fall below a specified level. This places more importance on the Fobney AWTW.

6.3.2. Strategic Schemes

There are no strategic schemes within this zone.

6.3.3. Bulk supplies

There are no currently available bulk supply options within this zone.

6.3.4. Drought Permit Options

The principal option identified in the Kennet Valley is the option to vary the flow constraint condition on the Pangbourne licence so that the use of boreholes 5 and 6 is permitted after the flow constraint has come into force. This option would be required when the supply/demand balance in the Kennet Valley is at risk due to reduced output at this and other sources.

Other options identified in the Kennet Valley are to abstract from the Fobney emergency boreholes. The option of increased abstraction at Playhatch has also been identified in the event of severe drought.

In more severe drought conditions using Fobney AWTW up to its full licensed rate is a potential option but would require a further reduction of the residual flow down the Holy Brook. However, this may be possible through agreement with the EA rather than through a drought permit, although an EAR has been prepared for this option.

For a given drought event, the trigger for starting to prepare for drought permit applications would be when the recession at Theale gauging station on the River Kennet is likely to fall to 195Ml/d (closure level for Gate 1 on Holy Brook control structure). This rule should always give a lead time of at least 3 months.

6.4. Guildford WRZ

6.4.1. Existing sources

The principal source at risk in this WRZ during a drought is Albury. There is a condition on the Albury licence which requires abstraction to cease when flow falls below a prescribed level. This level would only be reached in a very severe drought and a Drought Permit option is included to cater for a drought of this extreme severity.

6.4.2. Strategic Schemes

There are no strategic schemes within this zone.

6.4.3. Bulk supplies

Table 24 Bulk Transfer to Affinity Water

	Average daily Ml/d	Maximum daily Ml/d
Bulk transfer agreement Ladymead via Park Barn	2.27Ml/d	2.27Ml/d

There are also two possible new transfers to Affinity Water, 'MILH Reservoir Connection' and 'WALT Treatment Works connection'. The current assumptions are that these would be resilience transfers and only required when we are not experiencing a drought. We will continue to discuss these potential options with Affinity Water.

6.4.4. Drought Permit Options

The options considered for the Guildford zone are a variation to the abstraction licence at Albury and additional abstraction from the Shalford source. Both sources have been proven to be robust to drought, see Section 5.6 for Shalford. Environmental Assessment Reports have been prepared for these options.

6.5. Slough, Wycombe and Aylesbury WRZ

6.5.1. Existing sources

The yields of our sources are not vulnerable to droughts in the historic record during drought and can operate normally under these conditions experienced historically. However, work to assess the potential impact of more severe droughts than have been experienced in the historic record shows that there might be a slight reduction in yield at some of our sources and this is discussed in Section 8.

6.5.2. Strategic Schemes

There are no strategic schemes within this zone.

6.5.3. Bulk supplies

There are no currently available bulk supply options within this zone.

6.5.4. Drought Permit Options

The option considered for the SWA zone is a drought permit option to allow abstraction at Pann Mill following the reduction in licence at Pann Mill and this option would be to return to the previous deployable output volume. Environmental Assessment Reports have been prepared for this option. The potential drought permit option at New Ground is a more before Level 4 option due to the infrastructure that would be required for water treatment if it was re-commissioned.

6.6. Henley WRZ

6.6.1. Existing sources

There are no vulnerable sources in this zone and all sources can operate normally.

6.6.2. Strategic Schemes

There are no strategic schemes within this zone.

6.6.3. Bulk supplies

There are no currently available bulk supply options within this zone.

6.6.4. Drought Permit Options

The only option considered for the Henley zone is the increase of abstraction from the Harpsden and Sheeplands sources which are licensed in aggregate. An Environmental Assessment Report has been prepared for this option.

6.7. Permits and approvals required for drought options implementation.

We have reviewed requirements for permits and approvals arising from drought option implementation. These are shown in

Table 27 below.

Table 27 Permits and approvals likely to be required prior to implementing drought options.

Option	Action	Consents that may be required
Lower Thames	Backpumping over Molesey Weir (as assessed in EAR) – installation and operation of pumps, pipework and associated infrastructure. If backpumping over Teddington weir was also required, this would need similar consents and PLA consent. We recognise that in the event of severe drought with very low flows over Teddington weir then the PLA has to apply to the Secretary of State for Transport if the level upstream of the Richmond sluices is to fall below that required. This may require an assessment of the impact of a lower level upstream of Richmond sluices to support the PLA's application.	• Flood Defence Consent from Environment Agency • Planning Permission from Local Planning Authority • Consent from SoS for reduced levels u/s Richmond sluices
Farmoor	Backpumping – installation and operation of pumps, pipework and associated infrastructure	• Flood Defence Consent from Environment Agency • Planning Permission from Local Planning Authority
Horton Kirby ASR	Pumps and pipeline required	• May require Planning Permission from Local Planning Authority depending on scale and location of works
Bibury	Minor construction works, temporary water treatment facility would be required. Modifications to the distribution network may be required.	• May require Planning Permission from Local Planning Authority depending on scale and location of works
Ogbourne emergency boreholes2	Works to connect emergency boreholes to the WTW and network. Minor construction works; connection of mobile generators and starters to each borehole pump. Refurbishment or replacement works on the pipeline may be required	• May require Planning Permission from Local Planning Authority depending on scale and location of works
Oxford Canal	Installation of pumps and temporary pipe connection between the Oxford Canal and Grimsbury Reservoir	• May require Planning Permission from Local Planning Authority depending on scale and location of works • May require Flood Defence Consent from Environment Agency

Option	Action	Consents that may be required
Fobney	Over-pumping from River Kennet to K&A canal. Minor construction works. Construction of a temporary WTW plant within the existing site boundary	• Transfer licence. May require Planning Permission from Local Planning Authority depending on scale and location of works

6.8. Provision of supplies to other water users during drought

We would consider requests from other water users such as private water suppliers or other sectors such as agriculture, for example where there are needs for livestock during a drought and we will make best endeavours to provide supplies in these circumstances. However, we are only able to do this where it does not adversely affect the security of supply for our own customers, and we will give priority to supply to our own customers.

Section 7. Communications Strategy

7.1. Introduction

Communication before, during and after a drought event is of paramount importance to ensure that our customers and stakeholders understand where we are in the drought plan protocol and the rationale for the steps we are implementing and also that the different steps in the drought plan can be implemented in a timely way, given the dependence that exists on third parties. In the context of the drought protocols, this section sets out our communications strategy. When a significant drought develops across the south east of England it usually affects the whole region. Therefore, we have discussed with the other water companies in the south east how we can adopt a consistent approach to drought communications and, where possible, implementation of drought measures and this is described below in this section.

7.2. Objectives

An important factor in developing our communications plan is the requirement to keep customers and stakeholders well informed during a drought or supply/demand event. With this in mind, the overall objectives of our drought communication plan are:

- To keep the public, stakeholders and regulators fully aware of how the drought is developing, the potential for drought measures to be required and the impacts of planned measures.
- To simply and clearly provide customer education on how to prepare for, adapt to and mitigate water use restrictions, such as water saving tips/advice.
- To promote and enhance ongoing water-efficiency messages through a multi-channel approach, thereby optimising the reach to our customers.

To achieve these objectives, and as all droughts are different, the communication plan will be adapted to suit the challenges for a given drought year. This plan will:

- Define the nature, timing and targeting of our external and internal communications
- Identify key stakeholder groups with individual communication needs according to the impact of drought measures
- Ensure that Thames Water engages all relevant stakeholders early and proactively. This will include Local Resilience Forums as appropriate
- Describe all external communications activities and how they will be integrated with the overall Drought Plan

7.3. Key Messages

Timely and clear messages are vital for a successful communications plan. The messages must be consistent, appropriate and effective, reflecting accurately the escalation or de-escalation of the drought and its impacts.

Drought messages will cover three main dimensions:

- Evidence-based information about the water resource situation (rainfall, reservoir levels) and the probability of further restrictions if necessary
- Proactive information about what customers and the public can do to reduce water usage and mitigate the impacts of the drought (dealing with restrictions, water usage efficiency measures)
- Evidence-based information about the water resource situation (rainfall, reservoir levels) and the probability of further restrictions if necessary
- Full information about Thames Water's contribution to reduce the impacts of the drought (leakage reductions, information around how we're helping etc)

7.4. Stakeholders

The key stakeholders with respect to drought in our area are:

7.5. Environment Agency (EA)

Throughout the drought event we will work closely with the EA. During a drought event the EA will fulfil technical, advisory and regulatory roles. As discussed in Section 2, we depend on the EA for the provision of important hydrological data and its view on drought severity. In the case of a potentially serious drought (greater than DEL2), we will discuss with the EA the possibility of drought order/drought permit applications, see Appendix C. Central to the EA's regulatory function is the operation of the Lower Thames Operating Agreement and the regular interaction of its operational staff with Thames Water's operational staff. We are also required to consult with the EA regarding the operation of our strategic water resource schemes, for NLARS or the TGWTW desalination scheme. We are also reliant on the EA for operation of the West Berkshire Groundwater Scheme (WBGWS) and we provide advance notice of when we would want the scheme switched on based on our drought risk assessment. A detailed description of the interactions with the EA is included Appendix J.

7.5.1. Other key stakeholders for the water industry

Other key stakeholders include Defra, Ofwat, DWI, Natural England, CCWater, Port of London Authority (PLA), and New Appointments and Variations (NAVs). Where necessary these organisations will be consulted and informed on the development of the drought situation and proposed measures. To this end, we will arrange a liaison protocol with each of these organisations.

We recognise that in the event of severe drought, with very low flows over Teddington weir, that the level upstream of Richmond sluices may fall below the level required. In this situation the PLA may require an additional assessment in support of an application to the Secretary of State for Transport.

7.5.2. Water companies and Water Resources in the South East (WRSE)

We recognise the importance that demand-side restrictions should be implemented in a clear and consistent way across the South East. We have participated jointly with other water companies in the south east through the WRSE Drought Group. Through participation in this group, we have been able to agree a joint broadly consistent approach to the implementation of TUBs and NEUBs. We also participate in the WRSE Dry Weather Group which is set up to provide a consistent approach

during droughts particularly in relation to drought communications. We have agreed the following joint statement with the other water companies in the south east.

Box 1 South East companies - Joint Statement

Water Companies in the South East Regional Drought Collaboration

The water companies of the south east of England recognise that as an industry we need to work collaboratively to share knowledge and best practice, co-ordinate and align communication to customers and stakeholders, and promote the efficient use of water resources. Therefore, we work closely with other water companies in our region as part of the WRSE and WRE groups. For example, we participate in the regular WRSE "dry weather" meetings which focus the risk of any potential future water shortages. In these meetings all water companies share information about their available water resources, weather forecasts, and any communication needed with customers about any emerging drought situation. These meetings are held all year round and stepped up in frequency when a risk of water shortages across the south east starts to emerge. The meetings facilitate collaboration between water companies and actions to ensure an effective regional response to a developing drought. By working together and following a joined-up approach to communication, we aim to reduce confusion so our customers clearly understand the pressure on water supplies and the environment during water shortages, what we are doing, how they can use water wisely, and what water restrictions may need to be, or are being, imposed. The basis for the variability of responses to water use restrictions from water companies in South East England.

In the South East region water companies source their supplies of raw water in the following ways:

1. River abstraction;
2. Reservoirs filled by river abstraction or impoundment of river water;
3. Groundwater abstraction from boreholes and springs.

The percentage balance of these varies from company to company, and even within company areas and this causes variability in drought resilience and response.

The impact of drought is felt in different areas and over different timescales. An agricultural drought affecting crop growth, for example, can occur after a few weeks of dry and sunny weather over the growing season causing unseasonably dry soil. In contrast, a water resources drought affecting the availability of water for potable supplies, take much longer to develop, after several months of below average rainfall, particularly winter rainfall which is critical for replenishing most water resources. The low groundwater levels, reservoir levels, and river flows that result from this type of dry period reduce the water available and poses a risk to a water company's ability to supply its customers.

To manage this risk, water use restrictions are an important measure that water companies can use to reduce demand during drought. They not only enable companies to maintain essential supplies but also help to conserve water resources in periods of water shortages and reduce the environmental impacts of abstraction.

Water companies will only impose water use restrictions upon their customers if they are absolutely necessary, and in accordance with their Levels of Service for water supply. Water companies fully appreciate the confusion that can be caused when one company introduces restrictions but a neighbouring company does not. One of the reasons for this is the spatial extent of the drought: it may be very localised and not extend beyond the area served by an individual water company. Clearly from a customer point of view, if water use restrictions need to be imposed then a simple and consistent approach should be adopted across the South East.

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At the regional level, one water company may need to impose water use restrictions earlier in a drought than its neighbours, while another water company is able to withhold the imposition of restrictions until much later or not at all.

The reasons why companies may have to react differently in terms of restrictions and their timing are explained below:

Differing levels of drought severity across the region: Whilst droughts across the South East will generally be caused by a regional trend of several months of below average rainfall, sub-regional differences in rainfall amount may cause differing levels of water shortage across the region. In other words, the need to impose restrictions for one company may not equally apply to another. Differing vulnerabilities at Water Resource Zone level: Due to the way the water supply system has developed over time, many water company supply areas are sub-divided into Water Resources Zones (WRZs). These are defined as the largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which customers experience the same risk of supply failure from a resource shortfall. WRZs can be divided into those dependent upon:

- River abstraction only;
- Groundwater abstraction only;
- Reservoirs filled by abstracting local river water or by impounding river water;
- Various combinations of the above.

This mix of WRZ types means that even if there were not a significant difference in drought severity across the region, WRZs will tend to react differently to the same drought, with certain zones experiencing higher levels of risk to potable supplies than others. That means in similar drought conditions, rivers, groundwater sources and reservoirs across the region can respond differently in terms of risk to supply. For example, a WRZ dependent on combined river abstraction and reservoir storage for supply may have a different level of risk to one based on groundwater abstraction. This difference in WRZ vulnerability has an impact both at the company level and regional level. A water company may need to introduce water use restrictions in its more vulnerable WRZs but not need to extend the ban to the remaining zones in its area of supply. The introduction of the new powers in the form of the Temporary Use Ban in 2011 provided an opportunity for the water companies in the South East to review their Drought Plans with a view to finding a clearer, more consistent and more unified approach to introducing water use restrictions across the region than in the past.

The water companies in the South East have had formal meetings to discuss the development of their plans and ensure that they are implementing the powers as consistently as possible. The companies are committed to working collaboratively during periods of water shortages. In this context they have worked together to align the drought levels in their plans and to align as closely as possible the restrictions and exemptions that would be imposed when a TUB and a NEUB are implemented. However, due to the local differences highlighted above, the timing of drought plans and actions will vary across the region.

7.5.3. Support services

We will be proactive in our approach to liaison with specific stakeholder groups involved in the implementation of the drought measures, including the emergency services (police and fire), health authorities and local authorities.

7.5.4. Retailer communications

In April 2017 the water industry was changed to introduce competition in the retail market for non-household customers. This means that there are multiple retail providers to non-household customers throughout England. We remain the wholesale provider for water supply in the Thames supply area and have developed Service Definition Documents covering the dealings between Thames Water Wholesale and the retailers operating in our supply area. A Service Definition Document has been developed for droughts or dry weather conditions management and includes the following sections governing implementation of Temporary Use Bans and Implementation of Drought Orders. We would start regular communications with retailers when we reach drought risk level 2 (DEL2) and would alert retailers as early as possible when there is the risk of requiring a TUB or more severe drought measures.

Implementation of Temporary Use Bans

During a drought we will determine when measures are required to reduce demand and will inform Retailers operating within TWUL Wholesale Operational Area of when a Temporary Use Ban (TUB) is planned.

Implementation of Drought Orders

We will inform retailers operating within the TWUL Wholesale Operational Area of when a Drought Order to ban non-essential use or an Emergency Drought order is proposed. Thames Water will follow the legal requirements in applying for or implementing a Drought Order to ban non-essential use or an Emergency Drought Order.

Revision or change of TUBS or other Drought Measures

We will inform retailers when the conditions of a TUB or Drought Order to ban non-essential use or Emergency Drought Order are changed or terminated.

7.5.5. Communications for Environmental Drought

Under certain drought conditions there could be a situation under which there is adverse impact on the environment due to drought, but the drought has not developed to be severe enough to be a threat to public water supply. Under these conditions there may be benefit from reductions in customer demand. Therefore, in such circumstances we may work with the Environment Agency and other stakeholders to communicate with our customers to request that they take steps to reduce their water consumption. We would use the same means of communication as in situations where reduced consumption is required to reduce the impacts on water supply, but the message would be different with the focus being on the potential to benefit the environment. In these circumstances we would seek to highlight local watercourses where customers may see a benefit from reducing their demand in order to give the message a more local resonance.

7.5.6. Communications for High Demand or Outage

There may be a requirement to communicate with our customers to request that they take steps to reduce demand in circumstances where there is not a drought or a threat of drought. This could arise due to a period of high demand that puts stress on the water treatment or water distribution infrastructure, or it could be due to a period of outage at a water treatment works or a failure of a strategic main. Under such circumstances it would not be appropriate to implement drought measures to restrict demand such as implementation of a TUB as the situation would not have arisen due to an exceptional shortage of rain. Therefore, the implementation of a tailored communications campaign is the best means of trying to achieve a reduction in customer demand in such circumstances and a short lived and targeted campaign using the most appropriate means of communications would be used in these circumstances. It is likely that the use of social media and methods such as text messaging could be used during a campaign of this type. This type of communication was used in the high demand situations experienced in 2018, 2019 and 2020. This approach would also be used in a situation where unforeseen circumstances may occur such as in 2020 as a result of Covid19 which led to high demand in parts of our supply area which when coupled with very hot weather, and in some cases, outage led to stress on our operational network. In these circumstances it is necessary to mobilise a communications campaign quickly, this process is known as 'agile comms'.

7.6. Means of Communication

To gain maximum coverage, communication throughout the drought event will be primarily based on public information through our media relations, including social media channels. Newspapers, radio and TV will reach a wide range of stakeholders and raise general awareness about the status of the drought and the need to reduce water demand. To maximise our coverage, we'll present our media communications in the form of eye-catching news stories with fresh new angles that excite journalists.

Our website is particularly useful for regularly updating drought-related information and water efficiency advice as well as featuring special events or publicity as and when required. Links to other sites of interest also leads to a greater recognition of partnership working initiatives with key stakeholders and regulatory bodies.

We'll use social media, including Twitter, LinkedIn and Facebook, alongside media and web communications channels to reinforce drought messages to customers familiar with digital media.

We will also aim to integrate drought messages where possible with other communications material, for example on water efficiency.

These communication methods will need to be supplemented by proactive advertising, moving from a broadcast marketing plan to one more targeted to local areas that might be more at risk as the drought develops.

Direct one-to-one communication through individual meetings, briefings, workshops and letters to individual stakeholders will become more important as the drought escalates. Participation in high-profile public events will provide opportunities to engage directly, and on an individual basis, with a wide range of stakeholders.

7.7. When to Communicate

The timing and nature of the specific communication activities will be closely aligned with the potential escalation or de-escalation of the drought according to the overall Drought Plan. As a general rule, basic public communication through internet and media will continue throughout the drought. During a drought, campaigns and individual communication with key stakeholders will be specifically planned according to the escalation or de-escalation of the drought.

The implementation of specific drought measures (drought triggers) will be key milestones for review and adaptation of specific communication measures, namely:

- The crossing of enhanced media campaign triggers on the relevant control diagrams
- The announcement and implementation of a TUB, including their formal notification and allowance for and consideration of representations
- The application for and implementation of a NEUB
- The applications for drought permits (if required)
- The preparation, application and implementation of Emergency Drought Orders (if required)
- The relaxation of the above restrictions as the situation improves

The protocol, which is based on early identification of the risk of a severe drought being experienced later in the year, will greatly facilitate proactive communication of the above milestones and measures

7.8. Consultation, feedback and effectiveness of communications

Communication is a two-way process. We will therefore put a process in place for consultation and feedback with stakeholders and the wider public.

The Drought Plan will be available on our website, at our main office in Reading and in the Customer Centre in Swindon.

Effectiveness of communications will be monitored throughout the drought event. We will consult with key stakeholders, particularly the EA, on the ongoing environmental impact assessments of drought measures and will inform them about upcoming public consultations.

Other opportunities to provide feedback on a daily basis will include our website, our Customer Centre and our social media sites.

Periodic surveys using a range of research techniques will be conducted during a drought event. These will be designed to gauge the effectiveness of communications and we will use this information to help improve subsequent communications.

We will keep a record and analyse all drought-related media coverage, including news items resulting from proactive activity, evaluating metrics such as ‘reach’ (how many people had opportunities to view or hear the coverage) and ‘sentiment’ (whether positive, balanced or negative).

In addition, we will record and analyse the results of our paid-for advertising, social media and online activities - for example measuring hits to relevant pages of our website, related take-up of our free water-saving devices and the number of people who use our online water-use calculator to assess their usage and in so doing get tips on how to reduce it.

We will monitor the effectiveness of campaigns by tracking changes in overall demand for water as demand management measures are introduced.

There are several confounding factors that make it difficult to directly assess the impact of demand management measures by simply measuring changes in demand itself. For example, school holidays, bank holidays and prevailing weather conditions can significantly change demand in the same timescales as any campaigns.

Because demand naturally rises and falls throughout the year, the impact of demand management measures must be contextualised against what would be expected if those measures were not in place. Hence, we will need to estimate what would have been expected without the demand management measures.

We have developed models that explain how demand normally varies as a function of weather and "special days" such as school and bank holidays. These models will be used as an estimate of unconstrained demand (the demand which we would have expected to see without the restrictions in place). We will compare demand observed during the restrictions against these unconstrained estimates. The difference shall be our metric on the effectiveness of the campaigns.

Thames Water's supply area is divided into a hierarchy of systems and sub-systems called Regions, Water Resource Zones (WRZs) etc. At the time of writing we have the capability to track the impact of drought measures regionally (London and the Thames Valley) on a weekly basis.

We may extend the analysis into the WRZs and smaller subsystems as / when necessary.

7.9. Learning points from previous droughts and customer research

Our customers responded well to communications in the 2012 drought.

Learning points included:

- It is important to demonstrate and communicate our own activities to reduce water use; for example, leakage reduction, particularly rapidly fixing visible leaks.
- It is important to work closely and consistently with other water companies in implementing and communicating TUB measures.
- Provision of early information on the water resources situation to stakeholders in the period leading up to, during and after a drought.
- The need to ensure that all messages reaching customers are closely aligned in messages, language and timing. This required weekly, and sometimes daily, coordination with communications teams in the EA, Defra, CCWater, Ofwat, Natural England, NFU etc.
- The value of using a customer research panel to obtain representative views on drought issues before, during and after a drought.
- Earlier 'workshop' sessions with key stakeholders to update them on actions and seek feedback.
- The need to improve lead times for customer centre staff when briefing them on the effect of restrictions.
- Greater clarity regarding those uses of water covered by actual and potential restrictions.
- The need for consistent key messages throughout all drought-themed advertising, and wider communications.
- Better liaison with contractors, suppliers and associated third parties to ensure a joint approach to using water wisely.

In recent years we have also taken into account where communication with our customers can be used to help supress demand for water, in certain situations. In the future we expect to continue this work, predominantly for drought communications however this approach could also be used for other high demand situations if appropriate.

Customer research conducted in June and July 2011 (see Appendix L), sought views and attitudes on the water restriction measures within the TUB and DD11 legislation (NEUB), with particular emphasis on phasing of restrictions and possible exemptions. The research also sought to elicit views and attitudes on how a media campaign should be conducted. These findings are considered to remain relevant for the Drought Plan 2022 and so are retained as key features informing the communications plan. We are also undertaking some joint customer research with WRSE in parallel with the consultation on this Drought Plan. The research will focus on customers views on drought communications such as timings of communications and means of communication.

7.10. Communications Plan

An outline of our communication plan is set out below.

7.10.1. Objectives

- Reduce demand, lessening the likelihood of further restrictions
- Explain why there is a need to save water, and what we are doing to help in order to encourage customers to 'do their bit' – building on our ongoing water-efficiency activities urging people to value water and use less of it.
- Explain how restrictions (if in place) affect customers' use of water.

7.10.2. Main Messages

- Customers can do a lot to help by taking simple steps, which together can save significant volumes of water. For example, taking four-minute showers is far more water efficient than having a deep bath. Also, watering gardens by hand using a watering can saves more water than an unattended hosepipe/sprinkler.
- The drought has been caused by a lack of rainfall, which has depleted local water resources.
- We note that there is a particular onus on us to reduce wastage – for example, by fixing leaks – in order to encourage customers to help conserve supplies. In 2020, we communicated the fact we achieved our leakage target to try and encourage customers to change behaviour.

7.10.3. Target Audiences

- Staff by utilising our internal communications
- Domestic customers
- School pupils – this is through always-on water efficiency education
- Local authorities
- Groups particularly affected by restrictions, e.g. allotment owners, turf growers
- Business customers – for example, golf courses or swimming pools
- Retailers and Insets
- Environmental NGOs

7.10.4. Escalation of communication

The information and customer messages will be renewed and updated as appropriate to the escalation of the level of water use restriction. Various methods of communication are likely to be considered at particular levels of any drought event. The tables set out in Appendix H provide a detailed description of the sequential escalation of the main activities and messages appropriate for each stage of the drought event.

Section 8. Effectiveness of Plan

The Drought Plan guidelines ask companies to test plans against a range of droughts to demonstrate their Drought Plan's flexibility and robustness. The purpose of this section is not only to provide tests to demonstrate these aspects but also to show the effectiveness of the protocol against the full range of criteria specified within the Defra Directions and EA guidelines.

In addition, the guidelines also suggest that our drought plan should be tested against droughts that are more severe than those in the current historical record. This has been done using different approaches for different WRZs, taking into account the balance of surface to groundwater resources and the water resource resilience of the WRZs to drought. This approach enables the testing of the plan against more severe droughts to be undertaken using a risk-based approach with more in-depth analysis used for the more complex water resources systems that serve London and SWOX whilst a simpler approach can be taken for the less complex water resources systems for the remaining Thames Valley WRZs. The guidance also requires us to assess the impacts of high demands, heatwaves and outage. The test against more severe drought includes an allowance for outage. The impacts of high demand and heatwaves are addressed through the measures to require customers to reduce their demand and these would all be in place under the severe drought scenarios included in the assessments described below.

We have used a stochastic approach to develop a longer time series of river flows. This assessment is based on analysis of and the breakdown of the weather systems that drive the water resources in the South East. The analysis has generated a very long time-series of data, built up from a combination of the underlying weather systems together with the random element that provides the uncertainty in the weather. The use of this approach enables a simulated time series to be produced which is of much greater length than the historical record.

We have made use of two stochastic weather generators in our assessment of the impact of severe drought. For London, and for the assessment of the robustness of surface water sources in other zones (including the Farmoor system), we have used stochastic data which was developed to support WRMP19. For the assessment of the robustness of groundwater sources, a newer stochastic dataset has been used which has been generated to support the WRSE regional plan and WRMP24. The reason for employing different stochastic datasets for these assessments is that modelling carried out using these datasets provides the best available data for each type of source at the time of writing. More specifically, assessment of flows and conjunctive use simulations have not been completed using the newer (WRMP24) stochastic dataset, but modelling to determine groundwater levels under more severe droughts has been carried out using the new stochastic data (this modelling had not been carried out using the older, WRMP19, stochastic dataset). It is important to note that the two datasets employ similar methods, but assessments which have been carried out using the WRMP19 data will be updated for flows and conjunctive use simulations when results using the newer stochastic data are available.

The stochastic weather and flow generators that have been developed to enable the stochastic approach to drought assessment for WRMP19 are based on the rainfall and potential evapotranspiration (PET) properties that were demonstrated within the 20th Century (1920-1997 for the WRMP19 stochastics and 1950-1997 for the WRMP24 stochastics), and specifically for the drought periods contained within the 20th Century. It uses a multi-site analysis process (based on the historic records for sub-catchment rainfall and PET) to evaluate the influences of random variability, regional climatic factors (such as the North Atlantic Oscillation and Mean Sea Surface

Temperature) and observable drought anomalies to produce a plausible emulation of the 20th Century climate. The newer stochastic dataset uses a shorter baseline period in order to make use of more detailed climate driver data which is only available from 1950 onwards, which results in less bias correction being required. This model has the ability to be run multiple times in order to produce 'what if' analyses of drought conditions that could have occurred within the 20th Century. This has been carried out in such a way to provide a quantified analysis of the modelled return period that is associated with each generated drought (because the generator provides spatially coherent data, return periods can be analysed using a variety of indices, from aridity indices through to estimates of system yield). All of the droughts are temporally and spatially coherent. This means that they provide data in a climatically accurate time series format that covers multiple years (77 years of coherent data per run for WRMP19 data, 48 years for WRMP24). This data is then run through existing rainfall-runoff, groundwater and behavioural models (WARMS2), or used to examine the probability of meteorological conditions associated with events that are tested in the Drought Plan.

8.1. Effectiveness criteria

For our drought plan to be considered effective, or fit for purpose, it must meet the following criteria:

1) Forecasting the impact of drought - the methodology must be capable of predicting the risk to security of supply.
2) Planning ahead - protocols should facilitate:

- The full sequencing of measures to be taken to avoid or minimise the need for Emergency Drought Orders (EDOs).
- Timely introduction of measures to maximise demand and supply-side benefits and allow for their implementation.
- Proactive communication to customers on their participation.
- A reliable assessment to show that the measures being either considered or actually implemented are consistent with Thames Water's Levels of Service. NB Because of its dominance this is a test that currently is only applied to the London WRZ.

8.2. Testing our Drought Plan - London and SWOX WRZs

8.2.1. Worked Examples of extreme scenarios

The worked examples shown below demonstrate the benefit of the methodologies in meeting the effectiveness criteria described above.

A number of techniques have been used for this analysis to test our drought plan against droughts of greater severity with return periods estimated for differing levels of severity. This includes methods that rely on the outputs from the stochastic water resources modelling programme, as mentioned above, that was undertaken for our WRMP19. It should be noted that these assessments do not include expected forecast increases in population or the effects of climate change on water availability because these longer-term issues are dealt with in our WRMP.

For the London and SWOX WRZs the drought risk is dominated by surface water vulnerability, so the following two sections concentrate exclusively on the two major surface water systems; the London reservoirs and the SWOX Farmoor reservoir. Unlike the other WRZs, no analysis of groundwater drought vulnerability was therefore necessary.

8.2.2. London

Impact of stochastically generated droughts

The analysis of stochastically generated droughts is based on the large data set generated from the stochastic analysis for WRMP19. From this large data set, 'libraries' of droughts of known relative severity were selected to represent a wide range of return periods. For our last drought plan, 40 droughts with a wide range of return periods (1 in 10 years to 1 in 1000 years) were run through WARMS2 and results for the events closest to specified return periods were more closely investigated. This time, drought libraries specifically focussed on droughts of a severity of approximately 1 in 200-years and 1 in 500-years were developed in order to give a more detailed view of the impact of droughts of severities required by the planning guidelines, and to demonstrate the uncertainties involved in determining events with large return periods. An 'emulator' model of the London system (known as IRAS) was used to determine the return period for drought events within the stochastic record. Use of this emulator introduces some uncertainty, as the hydrological and systems modelling in this emulator is more simplified than in WARMS2.
The stochastic analysis demonstrated that the 20th century record incorporates two events that are just worse than a 1 in 100 year event in terms of yield (1921 and 1933/34). As previously described, two even increments of drought severity beyond this historic baseline were tested; 'severe' droughts with a return period of approximately 1 in 200 years, and 'extreme' droughts with a return period of approximately 1 in 500 years. For each return period 10 droughts were stitched together into a 100 year record which was run through WARMS2 as a sequence. Both the full libraries and the median drought of each severity provide useful insight, but it should be noted that there is significant uncertainty when assigning a return period to stochastic droughts, and so it is likely that the droughts selected have a range of return periods associated with them (i.e. the extreme drought library may have droughts with severities of > 1 in 1000 years).
The drought sequences were analysed by running them through WARMS2 with simulated demand conditions that would occur during a 'current day' drought, the following demands were placed on the London system:

1. Distribution input equal to the 2020 demand uplifted by the dry year factor quoted in the Annual Review submitted to the Environment Agency.
2. An allowance for 'outage' equal to the figure quoted in the 2020 Annual Review to the EA.
3. An allowance for Bulk Supply quantities supplied to other water companies is also included.

No allowance was made for Target Headroom or the influence of climate change that might have occurred since the end of the 20th Century.

The impact of the median drought of each set of 10 for a 1 in 200 year return period and 1 in 500 year return period on the aggregated London reservoir storage under the Lower Thames Operating Agreement, with and without Drought Permits, is shown in Figure 19 and Figure 17.Where drought permits are included, it is assumed in modelling that they would be implemented whenever we are below the 'Level 3' line. Results for the full libraries can be seen in Appendix N, although care must be taken when interpreting the results in this Appendix, noting in particular the uncertainty associated with selecting events to form these libraries.

It should be noted that a number of modelling assumptions and simplifications are implicit within the results which are shown below. Key examples of assumptions and simplifications include:

- Modelled abstractions will meet the Teddington Target Flow (TTF) perfectly (i.e. on any day when the modelled Teddington Target flow is 300Ml/d, abstractions will be made to ensure a

TTF of 300Ml/d exactly). In practice, hitting the target flow involves a certain degree of error and can be difficult due to the required management of levels in the lower River Thames.

- All strategic schemes are assumed to operate in line with their operating strategy (noting that an outage allowance of c.100Ml/d is included in the level of demand applied). For example the Thames Gateway desalination plant is assumed to operate at 100Ml/d 10 days after crossing the 800/700 line (crossing from blue band to green band) on the LTOA and will continue operating at this volume for the whole duration that it is triggered.
- All 'baseline' groundwater sources are assumed to operate at their deployable outputs every day (again, noting the outage allowance of around 100Ml/d).
- Drought permits in London come in two forms – a reduction in the TTF (allowing more abstraction into our Lower Thames Reservoirs) and additional output from groundwater sources
    - A modelling simplification was required to represent the TTF drought permit, whereby extra water is put into the river, rather than lowering the TTF (as our water resources model is not capable of representing back-pumping over Teddington Weir, which would occur during a severe drought).
    - The additional water abstracted from TTF reductions and drought permits compared to a 'DO' run totals 200Ml/d for three months (100Ml/d from moving to a TTF of 200Mld (not requiring a drought permit), as per our licence, but not following the LTOA, and a 100Ml/d permit, meaning a TTF of 100Ml/d), followed by 300Ml/d for three months (an additional 100Ml/d permit on top of that assumed for the first three months, meaning a TTF of 0Ml/d), and 250Ml/d thereafter (representing reduced water available in the Thames during a very severe event).
    - The additional output assumed from groundwater sources is 40Ml/d for 6 months, and then 25Ml/d thereafter to allow for potential reduction in yield of groundwater sources in a severe drought.

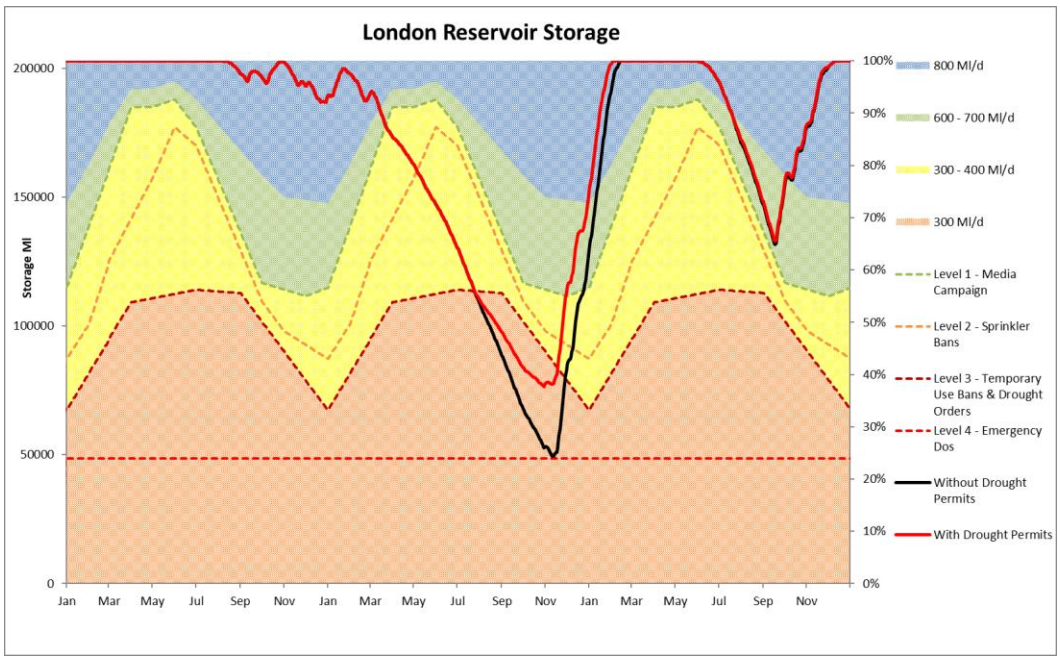

Figure 19 Impact of the Median Generated 'Severe' Drought Event (modelled 1 in 200 Return Period) on Aggregated London Reservoir Storage

As with droughts included in the historical record the drought measures would be implemented as per the Drought Plan methodology and within the indicative timescales required for implementation in London (Table 15). In the examples shown the drought severity becomes more extreme in the winter months and represents only one possible manifestation of how a more extreme drought may develop and therefore the timing of measures required in a more extreme drought as set out below are only an indicative example.

In the 'severe' example shown, it can be seen that without drought permits the 'median' 1 in 200-year event would come very near (but not quite) to requiring emergency drought orders to be triggered. With drought permits in place, while TUBs and NEUBs would be needed for several months, we would not be approaching the implementation of emergency orders, however it is likely that preparations for their use would be made as it is not possible to determine when a drought will end whilst it is being experienced. This event would, however, imply a significant (c. 6 month) period during which drought permits, TUBs, and NEUBs would be implemented, the impacts of which should not be discounted.

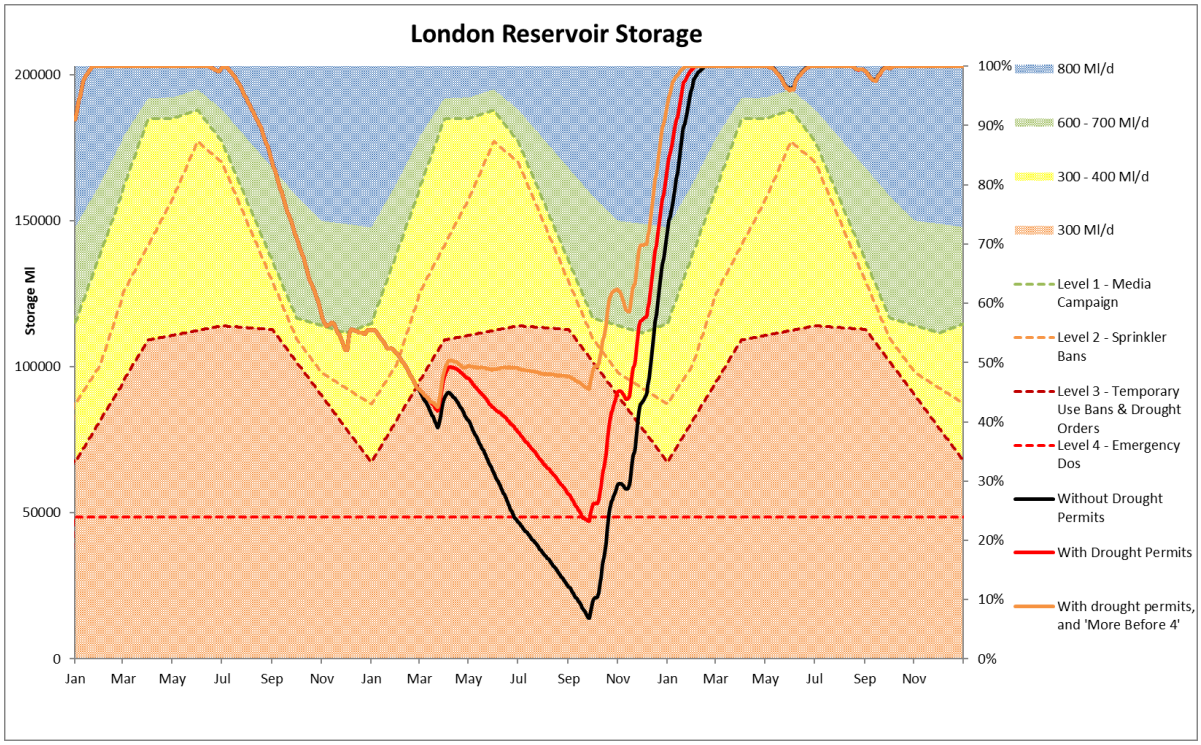

Figure 20 Impact of the Generated 'Extreme' Drought Event (modelled 1 in 500 Return Period) on Aggregated London Reservoir Storage

In the 'extreme' example shown, the picture is slightly different. Without the implementation of drought permits or any demand savings beyond those assumed to be brought by TUBs and NEUBs, a significant period (4 months) of emergency drought order implementation would be required. With drought permits in place, but without any additional measures, emergency restrictions would be implemented for a very brief (< 2 weeks) period of time, although the disruption that this would cause should not be discounted. In order to avert any need for emergency restrictions, additional intervention would be required; in this example we have assumed 10% additional total demand savings from 'More Before level 4' demand measures on top of those brought by TUBs and NEUBs, which would be intended to reduce PCC below 100l/h/d eight weeks after crossing the Level 3 line. Other 'More Before Level 4' supply side interventions could be brought in to bring a similar effect and therefore constitute a further level of resilience in the event of a severe drought.

As shown, whilst these droughts were selected to represent different patterns, they are geared towards the 'medium' term, 12 to 24 month, drought conditions described within the Drought Plan guidance, and do not focus on the 'long term droughts typically lasting more than two years' also described in the guidance. This was because the stochastic modelling demonstrated that the nature of the Thames basin drought behaviour and the controls on the water resource system for London mean that all droughts must include a 'core' very dry winter and extended spring-autumn event if they are to become critical events that might threaten Level 4 restrictions. The most significant droughts are accompanied by dry summer/autumn conditions in the previous year, and possibly a relatively dry winter before or after the core event, meaning that London is most vulnerable to 18 to 24 month type drought events. Although it is theoretically possible that two 'core' events could occur back to back (i.e. resulting in an extremely severe event >24 months), the probability of this is very small (greater than 1 in 1000 return period), so was not considered here.

This analysis demonstrates that the Drought Permits and more before Level 4 measures contained within the Drought Plan are potentially sufficient to address risks from droughts up to and including the modelled 1 in 500 event, although for this analysis no allowances were made for climate change or uncertainty. It is noted that the benefits of the Drought Permits are variable and depend upon the nature and pattern of the drought. These graphs also indicate that, although the permits are potentially effective (alongside the More Before Level 4 actions for droughts of a severity of a 1 in 500 year return period), they can require early triggering within the season, potentially as early as February, in order to provide that effective response, and could be required for extended periods of time (up to 9 months or more). The More Before Level 4 actions would also have a significant impact on customers and are in some cases required for a number of months.

Conclusions

The stochastic test scenarios illustrate the hydrological robustness of London's water resources system as operated within the London protocol with prompt implementation of drought permits and orders. However, for more extreme droughts, 1 in 500 year return period, More Before Level 4 measures are required to ensure resilience. It should be noted that this resilience is at the significant detriment to the environment. The examples demonstrate all the effectiveness criteria listed above in section 8.1, including criteria 3, the ability to demonstrate adherence to Levels of Service. However, these scenarios highlight the reliance on drought permits or orders for extended periods of time, as well as the requirement for additional 'More Before Level 4' measures. This reliance on such long durations of drought permit installation would have a significant adverse impact on the environment and small businesses and so indicate that to meet the challenge of potentially very severe droughts in the future, greater resource development is required in order to protect the environment from potentially severe damage in droughts of this return period.

SWOX

The examples of more severe droughts tested for SWOX are presented below, using stochastically generated droughts.

For the stochastic approach a similar early introduction of drought measures would be implemented although these are not presented in detail for each case.

Impact of stochastically generated droughts

In the same way as for London, analysis of the impact of stochastically generated droughts has been undertaken for SWOX. The droughts are the same as those selected for London (i.e. these are 1 in 200 and 1 in 500 droughts for London, but not necessarily for SWOX). The results of the analysis for 1 in 500-year droughts are shown in Figure 21 , and results for the 1 in 200-year droughts are shown

in Figure 22. These graphs show that, assuming a demand of DYAA DI, plus an allowance for outage, plus an allowance for bulk supplies, neither 1 in 200-year not 1 in 500-year droughts would require the imposition of emergency drought orders in SWOX. Whilst this demonstrates significant resilience for the SWOX WRZ there is uncertainty as to whether this is also a 1:500 year drought for SWOX as for London due to the selection methodology (the drought being selected on the basis of severity in London), and currently we do not have fully stochastic results available for Farmoor in order to select 'SWOX libraries'. Therefore, further assessment of resilience to severe drought in SWOX has been undertaken. In order to demonstrate resilience to more severe droughts in SWOX and to display the efficacy of drought permits in the SWOX WRZ (drought permits provide a much larger proportional benefit in SWOX than in London), the 1 in 500-year library was re-run through WARMS2 with a higher level of demand (SWOX's deployable output). Graphs showing Farmoor storage with and without drought permits can be seen in Figure 23 and Figure 24.

In this example, drought permits have been assumed to be triggered by the Farmoor control diagram; this control diagram is not used as our trigger for implementation of drought permits, but has been used as a modelling simplification (permits would be triggered by a combination of reservoir storage, river flows, and groundwater levels). The drawdown on figure 24 can be seen to follow a 'saw-tooth' pattern, which is following the control curve; in the model, drought permits are turned on and off as storage goes above and below this control curve, and so permits are being modelled as turning on and off.

These charts confirm the evidence from the historic record, which shows that, whilst there is spatial coherence of droughts across the Thames basin, the time series patterns of droughts that affect Farmoor are very different to those that affect London. The size of storage deficit that occurs in Farmoor is related to the highly flashy nature of the catchment to Days Weir and the nature of the Hands-off Flow control rules. These effectively combine so that the amount of deficit is entirely related to the duration that flows spend below a very low percentile (>Q99). In comparison, the drought stresses on the London reservoirs tend to depend on the duration of flows below approximately Q80, so some rainfall can occur without significantly alleviating the drought. This means that Farmoor's key vulnerability is to events such as 1975-1976, which was very intense but relatively short, rather than events such as 1921-22 or 1933-34. A comparison of the available abstraction during the 1921 and 1976 events at Farmoor (taken from the WARMS2 model) is provided in Figure 21 and Figure 22 below. This shows that the duration of very low flows during 1921 was significantly shorter than 1976, and that even the relatively modest autumn rainfall in that year was sufficient to provide additional abstraction availability as a result of the flashy catchment and the ability to abstract under relatively low flows.

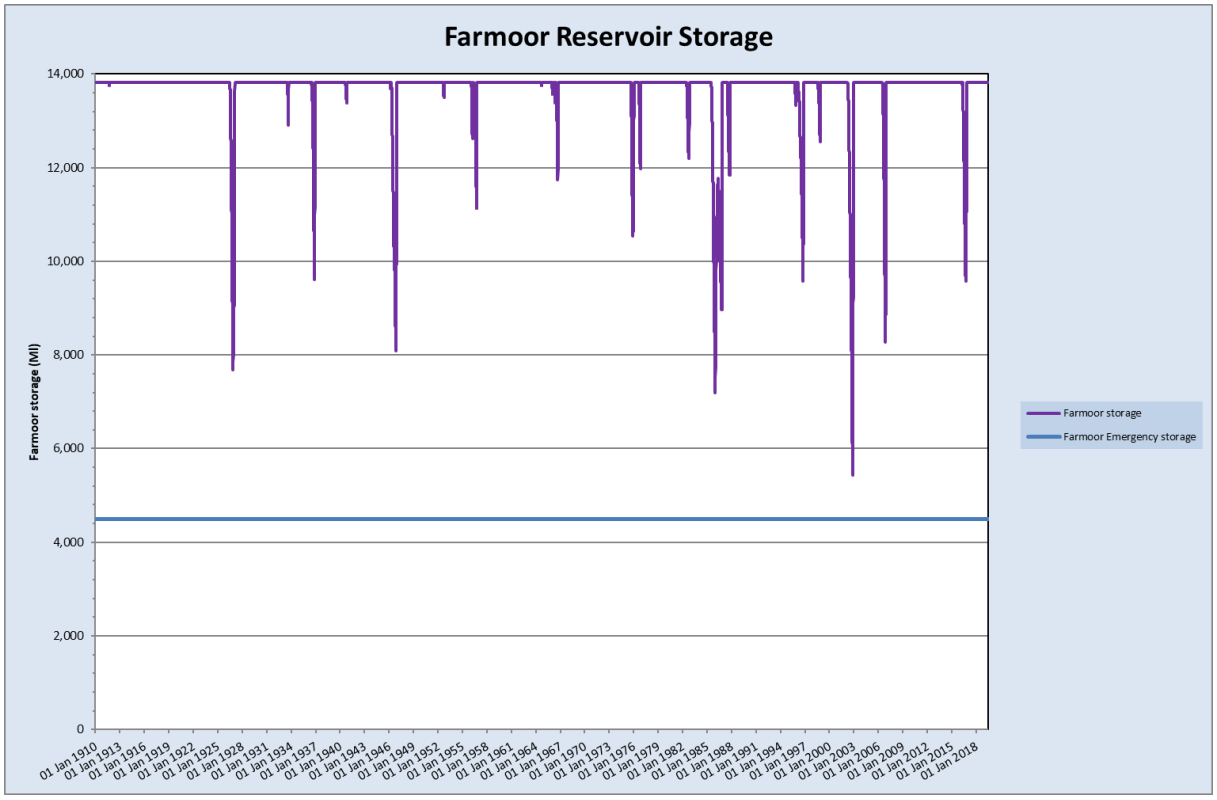

Figure 21 Impact on Farmoor Reservoir Storage of the Extreme Events generated for London, 1 in 500 return period

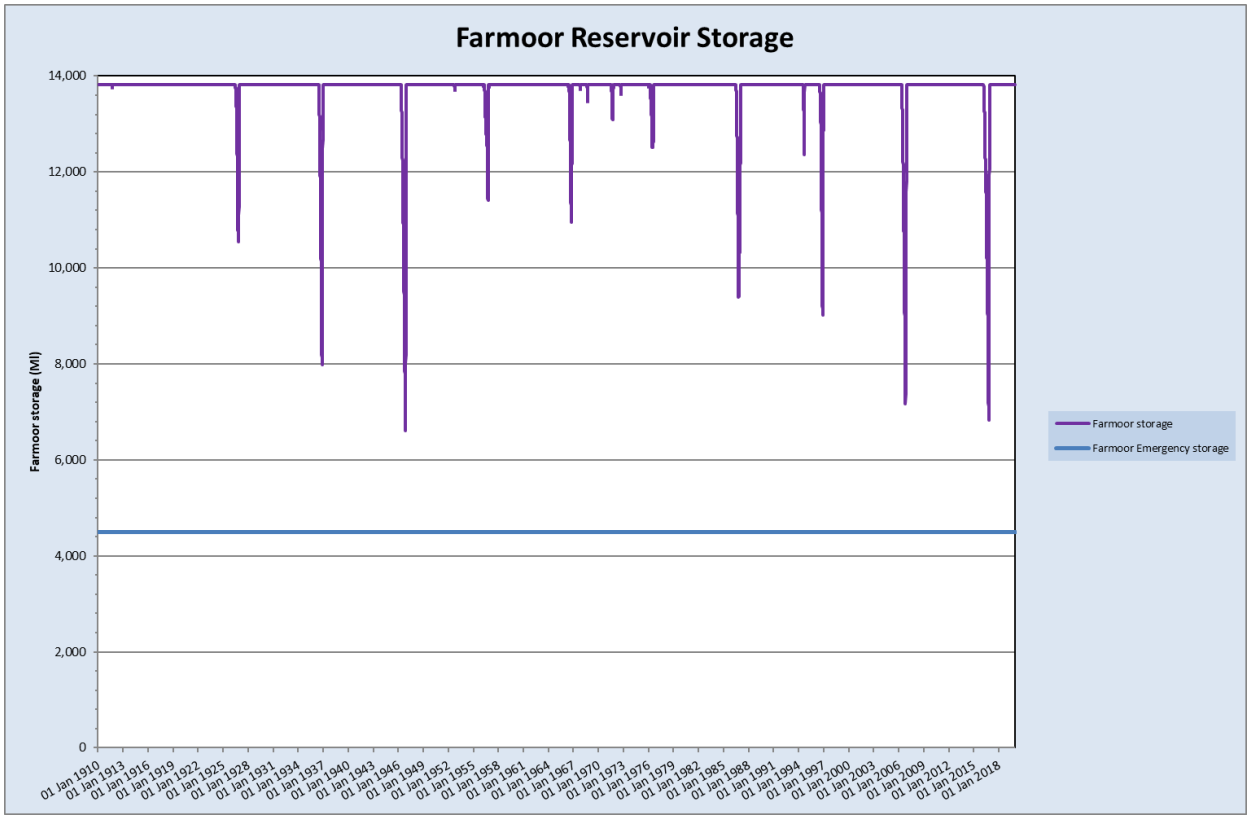

Figure 22 Impact on Farmoor Reservoir Storage of the Severe Events generated for London, 1 in 200 return period

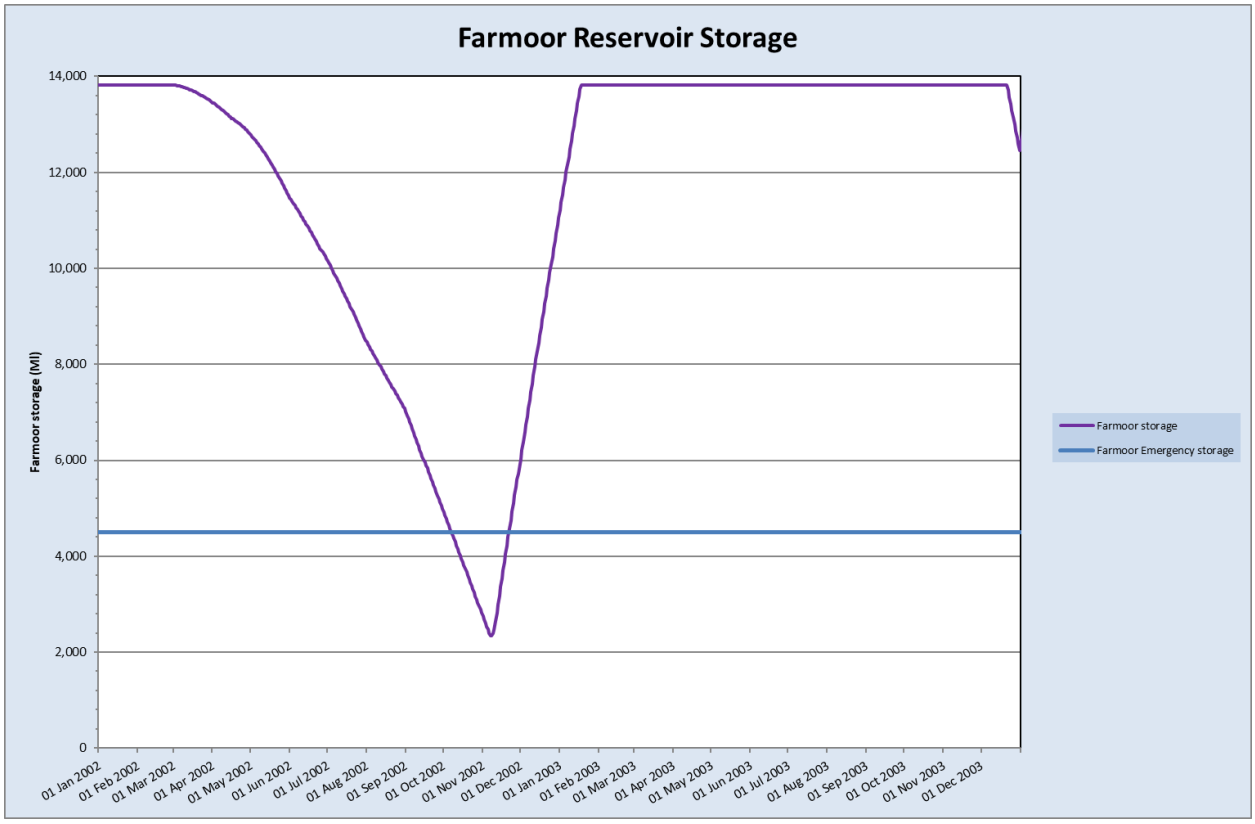

Figure 23 Impact on Farmoor Reservoir Storage of the most extreme events Generated for London, 1 in 500 return period, assuming a higher level of demand, without drought permits

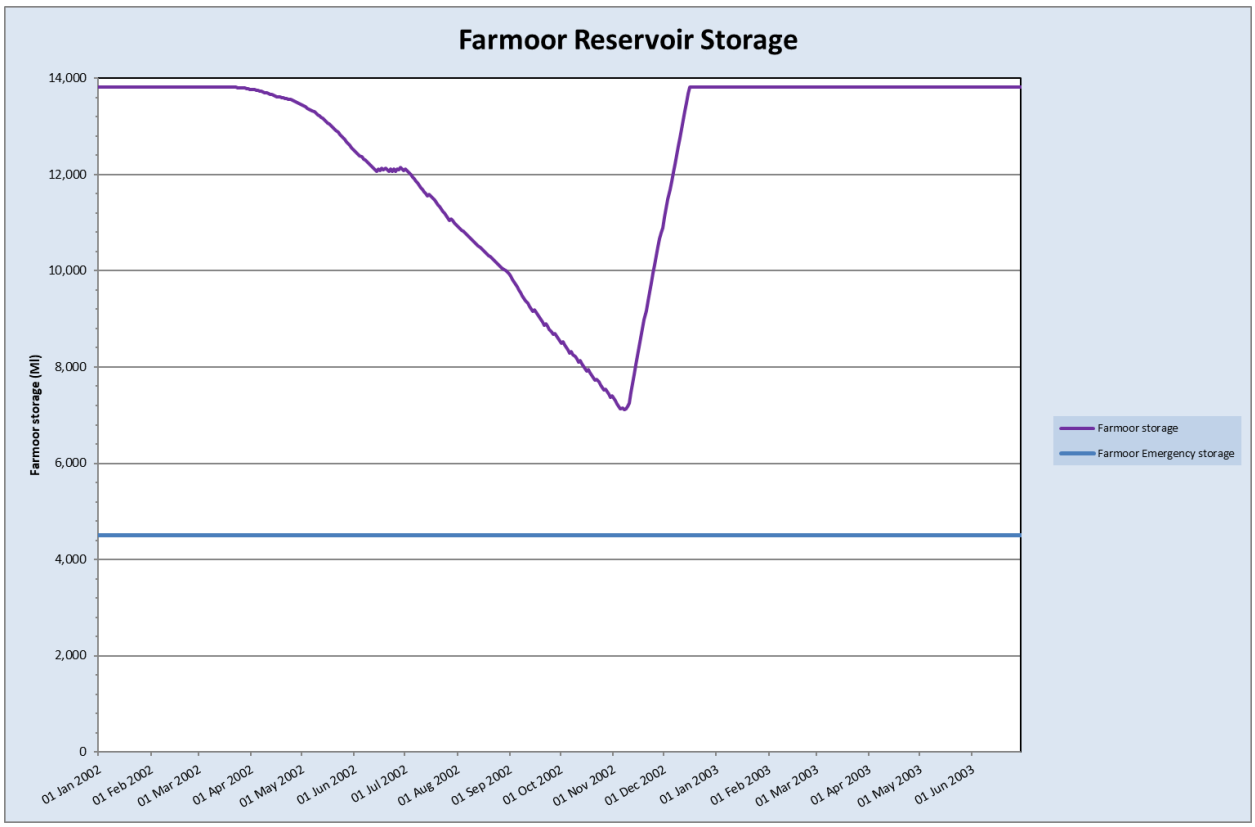

Figure 24 Impact on Farmoor Reservoir Storage of the most extreme events generated for London, 1 in 500 return period, assuming a higher level of demand, with drought permits

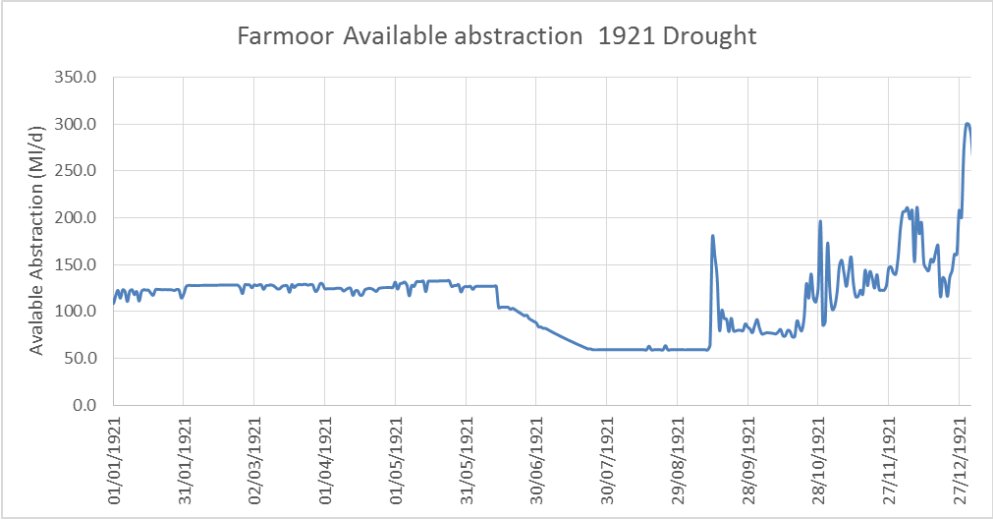

Figure 25 Farmoor available abstraction during the 1921 Drought

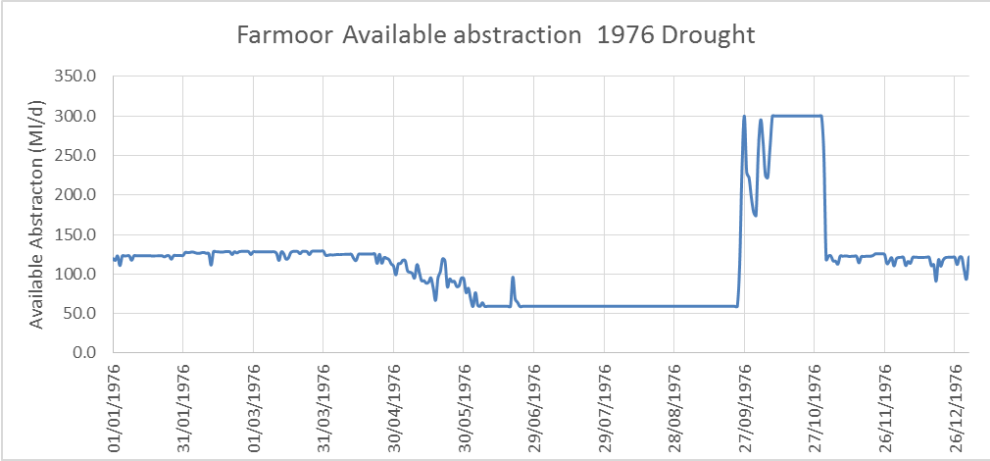

Figure 26 Farmoor available abstraction during the 1976 Drought

Extended 1976 drought

For SWOX an assessment has also been undertaken for an extended 1976 drought.

Impact of worst-case scenario of extended 1976 drought

Figure 27 shows the storage trend resulting from applying demand saving and drought permit measures for a scenario in which the 1976 drought is extended for a further 2 months. It can be seen that by the beginning of December, storage has fallen to just above the Level 4 control curve, levelling off and increasing thereafter. At this point the revised protocol would have made ready the appropriate emergency measures. This would have involved submitting an Emergency Drought Order by mid-September, but as the Level 4 control curve was not crossed, the need to actually implement it would not have arisen.

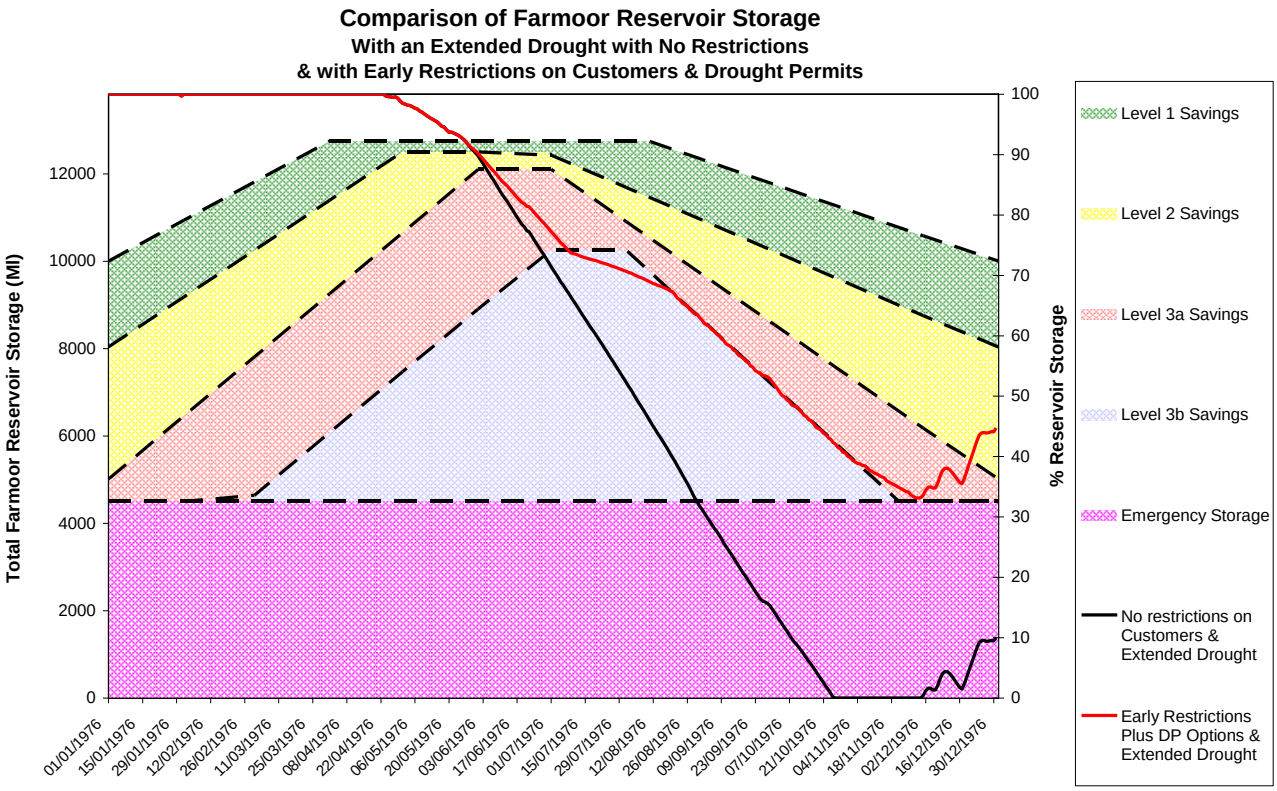

Figure 27 Farmoor reservoir storage for an extended 1976 test scenario.

This scenario demonstrates that the drought protocol for Farmoor, with the early imposition of restrictions, and River Thames triggers would enable Level 4 to be avoided even under this extreme worst-case scenario. In the predictive worst-case mode, the 200 Ml/d and 100 Ml/d triggers provide useful guides as to the minimum time available for preparation and application of drought permits, a key factor for SWOX resilience. These triggers also provide robust triggers to guide decisions on the implementation of drought permit applications and the introduction of drought permit options. This scenario shows that to ensure supplies are maintained through a drought of this severity there would be a significant detrimental impact on the environment.

On a probabilistic basis, the droughts that affect Farmoor are therefore much more focused on a lack of rainfall over a given, shorter timescale than the London reservoirs. Whilst the stochastic data set contains large numbers of such droughts (1975/76 is between 1 in 100 and 1 in 150 drought severity in this respect, so the stochastic data set contains over 100 droughts that are worse than 1976), a specific analysis of the response of Farmoor across the whole stochastic data set was not available in time for the 2022 Drought Plan. Therefore an 'extended 1976 drought', which was included in the 2017 Drought Plan has been assessed and shown to be a very severe event. Simple analysis of the sort of rainfall deficits in the autumn and early winter that would be required to generate such an event, as presented for the Kennet & Guildford surface water sources below, indicates that such an event is liable to have a return period in the order of 1 in 500 years or more.

Conclusions

The stochastics test scenarios illustrate the ability of SWOX's water resources system as operated within the SWOX protocol, even under an extreme scenario not yet seen in the historic record to maintain supply throughout a very severe drought. The examples demonstrate all the effectiveness criteria listed above, including criteria 3, the ability to demonstrate adherence to Levels of Service. However, as for London, these scenarios highlight the reliance on drought permits or orders for extended periods of time. This reliance on such long durations of drought permit installation would

have a significant adverse impact on the environment and so indicate that to meet the challenge of potentially very severe droughts in the future greater resource development is required in order to protect the environment from potentially severe damage in droughts of this return period.

8.3. Worked Examples - Kennet Valley and Guildford WRZs

In order to demonstrate the effectiveness of the drought protocol, it has been applied to the historic droughts for which data is available to test the protocol. The worked examples shown below demonstrate how the protocol for the Kennet Valley and Guildford WRZs ensures that the effectiveness criteria described above in section 8.1 are met. The protocol has been applied to the period of record to demonstrate how it ensures that all measures required in a severe drought would be implemented in a timely manner in order to ensure security of supply. In each case the implementation of demand management measures in severe drought episodes is driven by the protocol for London because of the need to implement demand management measures catchment wide.

We have also tested the drought plan for these WRZs against more severe droughts as required by the guidance. For the Kennet Valley and Guildford WRZs flows have been generated for the stochastic record produced for WRMP19 for the surface water sources in these zones. This has enabled a test of the resilience of these sources in relation to 1:200 and 1:500 year droughts in a similar way to that undertaken for London and SWOX.

Kennet Valley

The drought protocol for Kennet Valley is described in Section 4.5. The protocol has been designed to ensure that the Holy Brook control structure is operated to enable the licensed abstraction at Fobney AWTW to be achieved even under extreme low flow conditions. As the rating curve for Theale gauge versus Fobney flow shows, for licensed abstraction (72.7 Ml/d) to be maintained the flow at Theale must be at least 150 Ml/d. Note that because of the agreed minimum flow allocated to the Holy Brook when Gate 2 is closed, for these flows to be maintained at or above the critical levels the WBGWS needs to be in operation.

As shown in Section 4.5, the worst drought on record for the River Kennet at Theale was 1976. Examining the results from the 1 in 500 and 1 in 200-year stochastic drought libraries run through WARMS2, the lowest flow at Theale from WARMS2 in these severe drought libraries is not lower than the flow reached in 1976, and so no flow from these libraries would be sufficiently low to mean that abstraction of Fobney's full licence would not be possible.

In addition to the above, a Catchmod model for the Kennet at Theale has been run using the stochastic dataset generated for WRMP19. Assumptions regarding flows from WBGWS as triggered by London have been made, based on results from stochastic modelling of the London WRZ. Results from this analysis demonstrate that, were the WBGWS not available, the Fobney source would be very vulnerable to severe and extreme drought, with a yield declining to near zero, but that with the WBGWS available Fobney should be resilient in all but the most extreme droughts across the stochastic record (those more severe than 1 in 500-year).

As for London and SWOX, a robust test is the 1976 scenario. Thus using 1976 as the test year and implementing the protocol gives a flow sequence past Fobney works as shown in Figure 28. It can be seen that during the lowest flow period from July through to the end of August, the flow past Fobney AWTW is just sufficient to enable the licensed quantity to be abstracted, even when the WBGWS is set in operation on 15 July as triggered by the London protocol (London reservoir storage draws down to Level 2 control curve).

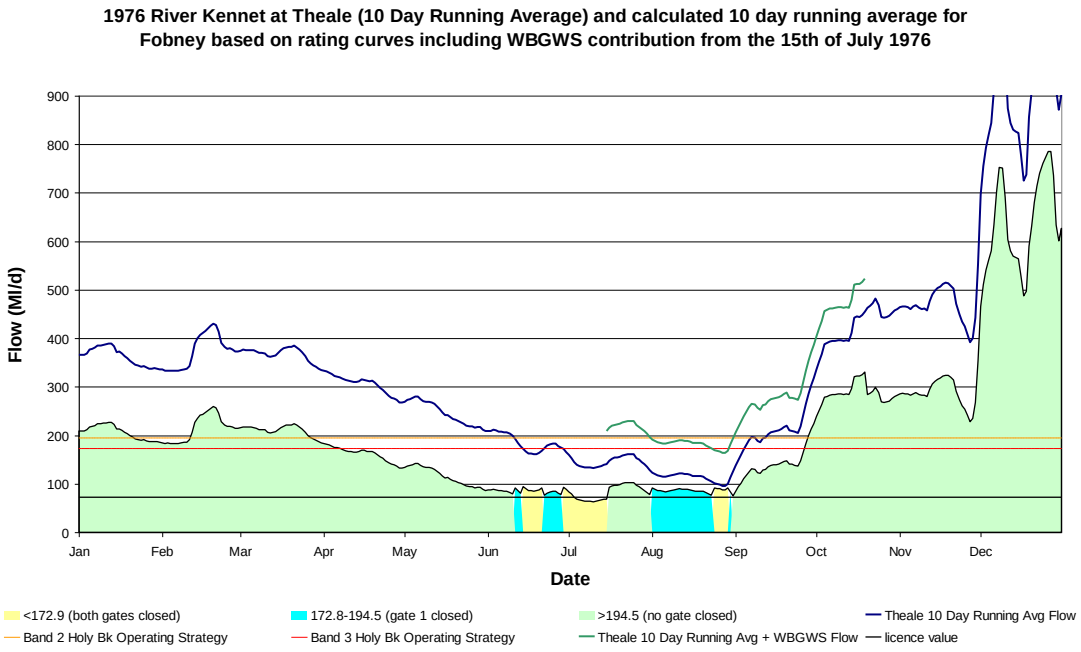

Figure 28 Flows at Theale and Fobney WTW for 1976 test scenario

Impact of worst-case scenario of extended 1976 drought

As in the London and SWOX examples, Figure 29 shows the impact of extending the 1976 drought at Theale and Fobney WTW. It can be seen that the flow past Fobney WTW gradually reduces to rates that are below the licensed abstraction quantity of 72.7 Ml/d. It is clear that under these very low flow conditions the deployable output of the source would not be achieved. Under these circumstances the drought permit options discussed in Section 6.4.4 would certainly be necessary in order to maintain security of supply. A shortfall of up to some 10 Ml/d is suggested by the analysis.

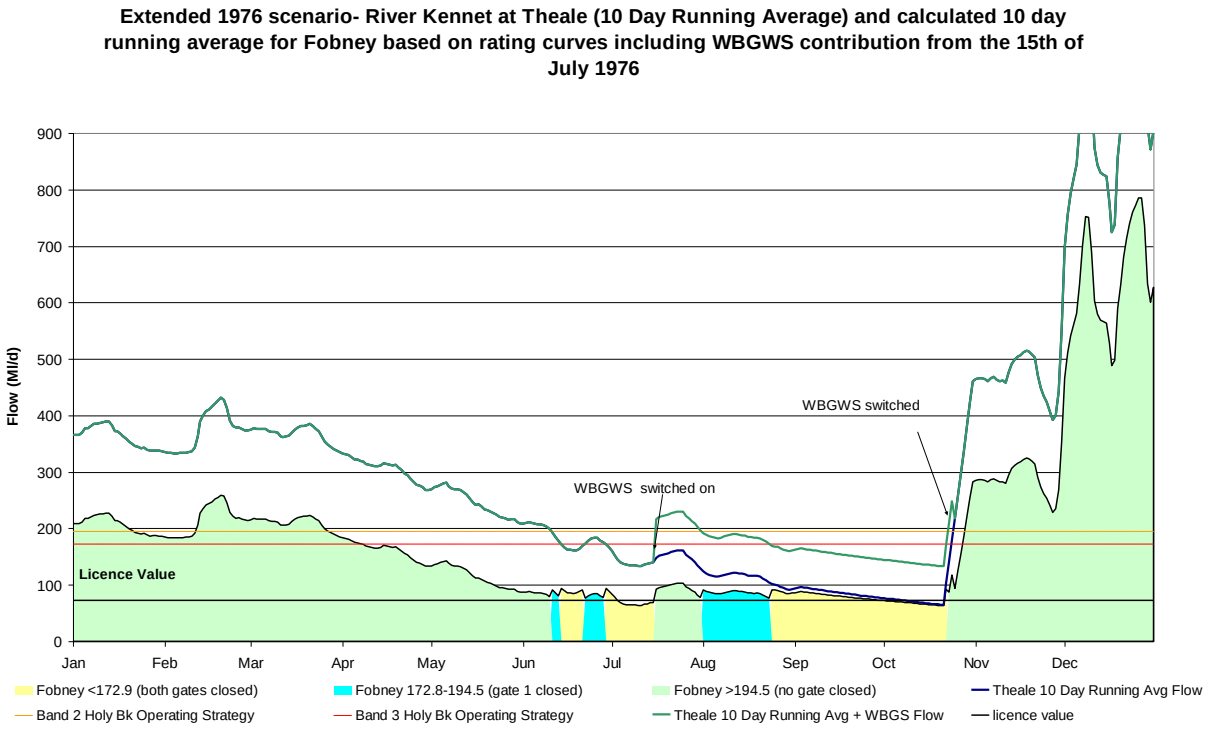

Figure 29 Flows at Theale and Fobney WTW for an extended 1976 test scenario

Drought Permits

Because of the inadequate flows past the Fobney AWTW during extremely low flow periods with WBGWS in operation, to ensure that Fobney AWTW and the Kennet Valley WRZ can meet demand, drought permit options would be made operationally available at the point of the closure of Gate 2. Also, the net contribution from the Pangbourne source drought permit into the Reading area is set at 7 Ml/d. The contribution from the Fobney Emergency boreholes is estimated to range between 12 and 28 Ml/d. Thus, the contribution from the groundwater sources range from 19 to 35 Ml/d. In this example it would be appropriate to have options ready by mid-June when Gate 2 is closed, see Figure 29. The trigger for submission of drought permit applications is 10 weeks prior to the prediction of the closure of Gate 2 (Section 4.5), which in this example would be early April.

For these options to be available the Kennet Valley protocol must ensure that the necessary demand management restrictions are in place at least at the time of submission of the drought permit application.

As discussed in Section 4, in a severe drought, such as that of 1976, demand-side drought management measures would be implemented catchment wide, as triggered by the protocol for London. As the corresponding London example for 1976 shows, demand management measures (media campaign and sprinkler and TUB) would have been implemented company-wide in early April (see also Appendix F).

Groundwater sources

The groundwater sources in the Kennet Valley zone are robust under drought conditions such that their deployable output would be maintained under conditions observed for the period of record. In the event of a serious drought of greater severity than has been experienced previously, requiring support to any of the groundwater sources the drought permit options at Fobney and Pangbourne would provide increased supply to the WRZ and could support the sources in the Reading area and also support the transfer up catchment to Newbury.

In addition to evaluating drought risk over the period of record, analysis has been carried out under conditions of greater drought severity than experienced in the historical record in order to demonstrate the resilience of the Drought Plan for those areas not supplied by the surface water abstraction. Previously, a statistical extrapolation of historical groundwater level data was used to assess groundwater source yields and Drought Permit benefits in more extreme droughts. The current approach is based on more robust hydrological modelling, using the stochastic dataset that has been generated to support the WRSE regional plan and WRMP24.

A reassessment of hydrogeological influences on source yield has been carried out, and there are two groundwater sources within the Kennet Valley WRZ that have a Source Deployable Output (SDO) that is potentially vulnerable to increased drought severity. The risk of severe droughts on these sources was evaluated using the standard UKWIR 'curve shifting' approach, as adopted by Thames Water for hindcasting groundwater SDO in its WRMP19. This relies on the anticipated change in groundwater levels at a catchment indicator borehole during the analysed drought, which is then translated into an impact on SDO through curve shifting. The drought vulnerable sources and associated catchment indicator boreholes examined in the Kennet Valley WRZ were:

- The Fognam Down source (Sparsholt OBH)
- The Pangbourne source (Bucklebury OBH)

The analysis of expected OBH groundwater levels for severe droughts was carried out using the stochastic weather sequences that support the WRSE regional plan and WRMP24. Droughts of severity of approximately 1 in 200 years and 1 in 500 years were identified within the stochastic record, and ten of each return period were selected to determine the impact of more severe droughts on groundwater source yields. The groundwater level assessment takes into account other strategic drought schemes that may be in operation at the time.

This analysis indicated the following potential drought Peak DO (PDO) reductions:

- 1 in 200 groundwater level (GWL) return period drought = 2.0 Ml/d lower than the 'baseline'
- 1 in 500 GWL return period drought = 2.5 Ml/d lower than the 'baseline'

In the event of a drought of these severities occurring the shortfall in PDO would need to be made up through a combination of demand reductions and the provision of additional supply from drought permits.

Conclusions

The London protocol initiates a company-wide set of demand management measures in April 1976. This is sufficiently early to meet the requirements for the Kennet Valley zone.

The London protocol triggers the introduction of the WBGWS in mid-July. This comes just in time to relieve the low flows at Fobney AWTW.

The measurement of River Kennet flows at Theale and the Gate 1 and 2 triggers on the Holy Brook control structure provide an effective protocol for initiating increases in flow for Fobney AWTW. Even so, the 1976 scenarios show that some contribution from drought permits is likely to be required in order to underpin any shortfall in output from Fobney AWTW. Note that the analysis assumes that all the flow in the canal can be taken and the fish pass at Labyrinth weir (Section 4.5) is closed for the duration of the extreme low flow critical period. However, the need for an adequate sweetening flow under these extreme conditions would need to be considered. An alternative option would be to abstract from the river Kennet adjacent to Fobney intake and transfer the water via a short temporary pipeline to the intake thereby allowing the Kennet flow to pass through the Labyrinth weir. This option could potentially be implemented through the mechanism of a Transfer Licence to avoid recourse to a drought permit.

Drought permit applications should be submitted 10 weeks prior to the predicted date for closure of Gate 2. It is therefore important that a predictive model capable of simulating River Kennet flows is available as one of the analytical tools for managing this zone to enable an early forecast of the impact of the drought (effectiveness criteria 1).

8.3.1. Guildford

The Shalford source has historically been robust through drought periods. Its yield could be maintained during the droughts experienced over the period of record for the two gauging stations on the rivers from which abstraction takes place (River Wey - October 1954-2006, River Tillingbourne – October 1967 – March 2007).

As for the Kennet, flows have been generated for the stochastic record produced for WRMP19 for the Wey and Tillingbourne, using Catchmod models for these rivers. Results for this modelling suggest that in all droughts contained in the stochastic record there should be significantly more than the 30 Ml/d licensed quantity available for abstraction at Shalford.

The operation of the protocol for the Guildford zone is illustrated by means of the 1976 drought; as with the other zones discussed above, 1976 was one of the worst years on record. Figure 30 shows the application of the protocol to the 1976 drought event and an indicative recession line with an extrapolated trend based on the observed recession on the River Wey. The extrapolated curve illustrates what would have happened had the drought persisted into the late summer and autumn of 1976 i.e. a worst-case scenario (i.e. a drought with a return period of approximately 1:500). The Guildford WRZ protocol for triggering measures is given for convenience in Table 28 below.

As can be seen in Figure 30 , the requirement for a TUB in the Guildford WRZ does not arise until late July 1976, whereas the protocol for London, see Section 8.2.2 above, would have already imposed a TUB company-wide in early April, some two months earlier. This demonstrates that the application of the combined protocols for London and Guildford WRZs takes adequate account of the need for both timely introduction of measures to maximise benefits and provide sufficient time for measures to be implemented (effectiveness criteria 2b).

In addition, if the drought had persisted there would not have been a potential requirement for drought permits until mid-October at the earliest which would have required a permit application in late August. However, this scenario is likely to be more extreme than that which would have occurred if the drought had persisted in 1976. The extrapolated recession line shows that even in this extreme scenario, the combined flows in the Wey and Tillingbourne would have remained significantly above the critical level of 50 Ml/d, thereby ensuring that the licensed abstraction at Shalford could have been maintained. Moreover, if additional supply were needed elsewhere in the zone, increased abstraction above the licence quantity under a drought permit could also have been sustained.

Table 28 Indicative Flow Triggers for Guildford WRZ

Measure	Flow rate
Temporary Use Ban	90 Ml/d (on average for 5 days)
NEUB DD11 order	75 Ml/d (on average for 5 days)
Drought permit	75 Ml/d (on average for 5 days)

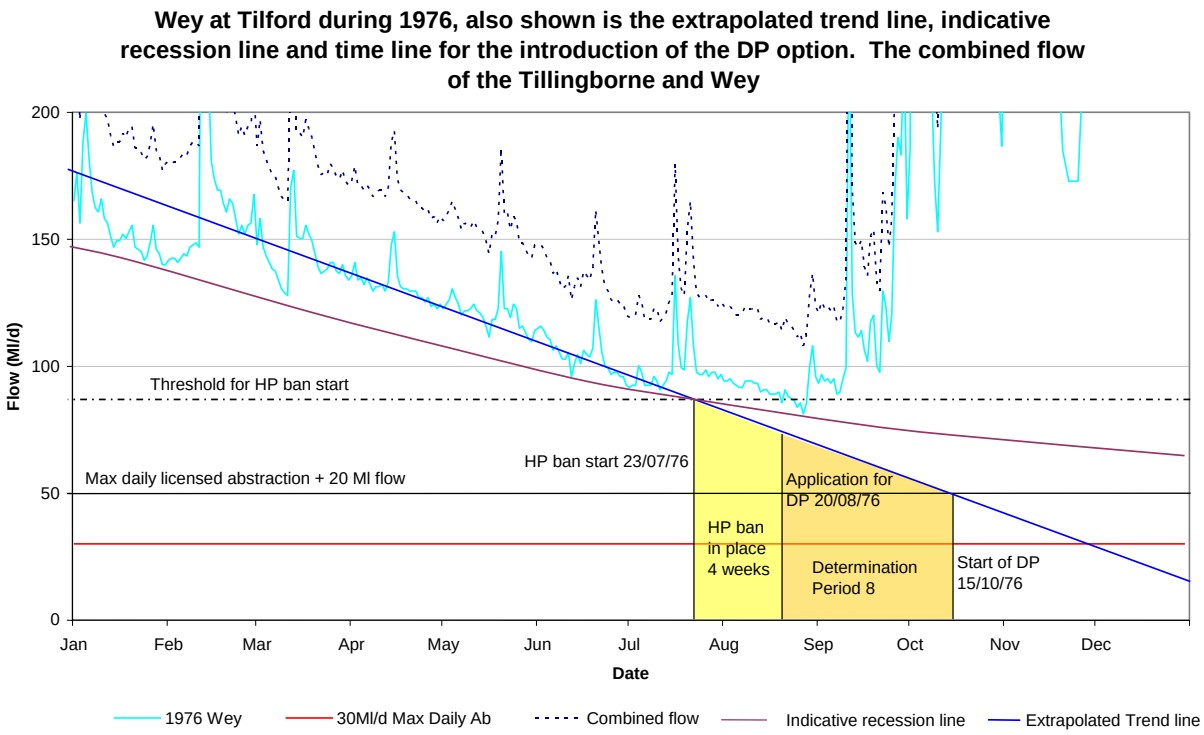

Figure 30 Wey at Tilford 1976 and drought permit options, also shown is the flow in the Wey combined with the flow in the Tillingbourne as a dashed line.

Groundwater sources

The groundwater sources in the Guildford zone are robust under drought conditions such that their deployable output would be maintained under conditions observed for the period of record. In the event of a serious drought of greater severity than has been experienced previously, requiring support to any of the groundwater sources the drought permit option at Shalford would provide increased supply to the WRZ and could support the sources in the Guildford area.

In addition to evaluating drought risk over the period of record, analysis has been carried out under conditions of greater drought severity than experienced in the historical record in order to demonstrate the resilience of the Drought Plan for those areas not supplied by the surface water abstraction. Previously, a statistical extrapolation of historical groundwater level data was used to assess groundwater source yields and Drought Permit benefits in more extreme droughts. The current approach is based on more robust hydrological modelling, using the stochastic dataset that has been generated to support the WRSE regional plan and WRMP24.

A reassessment of hydrogeological influences on source yield has been carried out, and there are no groundwater sources within the Guildford WRZ that have a Source Deployable Output (SDO) that are potentially vulnerable to increased drought severity.

In the event of a drought of 1 in 200 or 1 in 500 severity occurring, there is currently no evidence that there would be a shortfall in PDO. This demonstrates that the WRZ appears to be resilient to severe drought, however for some sources we do not have very long data sets and so we will undertake further work to verify these conclusions using the HRW hydrological model. If in the event that further measures were required in a very severe drought any shortfall would need to be made up through a combination of demand reductions and the provision of resource from drought permits.

Conclusions

The extreme 1976 test scenario has shown the protocol for Guildford zone to be effective in combination with London's revised protocol, introducing restrictions early on in the drought. Moreover, the Shalford source has been shown to be robust by virtue of the sustained flows in the Wey and Tillingbourne during very low flow periods. As with the Kennet Valley example, an important feature of the methodology is the ability to predict accurately the flows in the Wey and Tillingbourne at an early stage of a drought event i.e. the impact of the drought on water resources (effectiveness criteria 1).

8.4. SWA and Henley

To demonstrate the effectiveness of the drought management protocol for the SWA and Henley WRZs, the protocol has been applied to the historic drought of 1976 and an extended 1976 drought. The 1976 drought has been selected as groundwater levels in the Chalk aquifer of the Chiltern Hills reached the lowest levels on record during this drought event. Using this drought, the protocol has been applied to demonstrate how it ensures that all measures required in a severe drought would be implemented in a timely manner in order to ensure security of supply. However, for each of these severe drought scenarios, the implementation of drought management measures is driven by the drought protocol for London because of the need to implement catchment-wide demand management measures.

Worked example for 1976 drought

The drought protocol for SWA and Henley is described in Section 4.7. The protocol is based on a series of control curves defined using the historic Stonor Park groundwater hydrograph, assuming that source deployable outputs can be sustained down to the minimum historic groundwater levels in the Chilterns Chalk aquifer. As illustrated in Section 4.7, the worst historic drought in terms of lowest groundwater levels in the Chilterns occurred in 1976, therefore, as for the London, SWOX, Kennet Valley and Guildford WRZs, a robust test of the SWA and Henley drought protocol is the 1976 scenario.

Using 1976 historic groundwater conditions, the SWA and Henley protocol would have triggered various drought management measures as set out in Table 29. This shows that a drought permit application would have been triggered, if considered necessary, towards the end of July 1976. This would have enabled implementation of drought permits by the end of September 1976, but in practice, groundwater levels did not decline beyond the historic minimum. Consequently, the implementation of drought permit options would have been unlikely, given the proven robustness of groundwater sources in the SWA and Henley zones at 1976 minimum groundwater levels. Furthermore, the London WRZ protocol would have triggered drought management earlier, across the whole water supply area, as summarised in Table 29 taking precedence over decisions made using the SWA and Henley protocol.

Table 29 Triggering of 1976 drought measures in SWA & Henley WRZs

Measures	Timing	
	SWA & Henley	London
Enhanced abstraction performance & demand monitoring	Early Feb 1976	Not defined
Temporary Use Ban	23 May 1976	30 April 1976
Drought permit application	25 July 1976	23 May 1976
Drought permit implementation	Not required	1 August 1976 (if deemed necessary)

Impact of worst-case scenario of extended 1976 drought

If the 1976 drought had persisted in the SWA and Henley zones, with groundwater levels in the Chilterns continuing to decline below the historic minima, the protocol makes the assumption that the groundwater sources outputs would have decreased below their respective deployable outputs. The Stonor Park groundwater hydrograph for this scenario is shown in Figure 31. In this instance, with a drought permit application having been made by the end of July 1976, the timing of the permit implementation would have been in early December 1976 as groundwater levels declined below the historic minimum. The decision to implement the drought permit would have considered prevailing demand at that time, but analysis of the scenario presented suggests that source deployable output could have reduced by around 5 Ml/d at the time the February 1977 minimum is reached. By implementing, for example, the operation of the Pann Mill increased groundwater abstraction under a drought permit, an additional deployable output of around 7 Ml/d would be available, thus balancing the deployable output reduction at other sources.

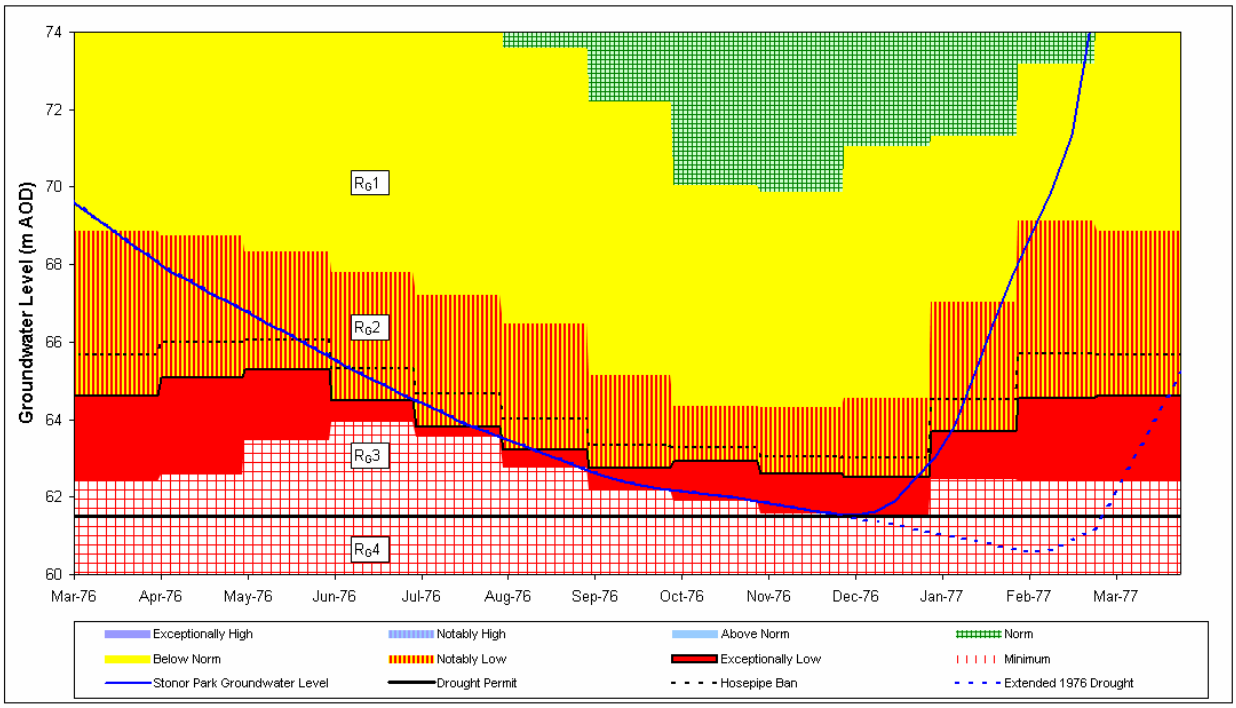

Figure 31 Groundwater Control Curves for Stonor Park OBH for extended 1976 drought

In addition to evaluating drought risk over the period of record, analysis has been carried out under conditions of greater drought severity than experienced in the historic record in order to demonstrate the resilience of the Drought Plan for those areas not supplied by the surface water abstraction. Previously, a statistical extrapolation of historical groundwater level data was used to assess groundwater source yields and Drought Permit benefit in more extreme droughts. The current approach is based on more robust hydrological modelling, using the stochastic dataset that has been generated to support the WRSE regional plan and WRMP24.

A reassessment of hydrogeological influences on source yield has been carried out, and there are three groundwater sources within the SWA WRZ that have a Source Deployable Output (SDO) that is potentially vulnerable to drought severity. The risk of severe droughts on these sources was evaluated using the standard UKWIR 'curve shifting' approach, as adopted by Thames Water for hindcasting groundwater SDO in its WRMP19. This relies on the anticipated change in groundwater levels at a catchment indicator borehole during the analysed drought, which is then translated into an impact on SDO through curve shifting. The drought vulnerable sources and associated catchment indicator boreholes that were examined in this analysis for the SWA WRZ were:

- Dancers End (Champneys, Tring OBH)
- Hawridge (Champneys, Tring OBH)
- Radnage (Champneys, Tring OBH)

The analysis of expected OBH groundwater levels for severe droughts was carried out using the stochastic weather sequences that support the WRSE regional plan and WRMP24. Droughts of severity of approximately 1 in 200 years and 1 in 500 years were identified within the stochastic record, and ten of each return period were selected to determine the impact of more severe droughts on groundwater source yields.

This analysis indicated the following potential drought Peak DO (PDO) reductions:

- 1 in 200 groundwater level (GWL) return period drought = 0.8 Ml/d lower than the 'baseline'

- 1 in 500 GWL return period drought = 1.3 Ml/d lower than the 'baseline'

In the event of a drought of this severity occurring the shortfall in PDO would need to be made up through a combination of demand reductions and the provision of additional supply from drought permits.

Conclusions

During the 1976 drought, demand management actions would have been implemented by the London WRZ protocol driving measures throughout the water supply area, thus taking precedence over the SWA and Henley WRZ protocol. A similar situation would have occurred in the extended 1976 drought scenario. Implementation of the SWA and Henley protocol during the extended 1976 drought scenario would have enabled sufficiently early application for a drought permit to allow implementation at the time groundwater levels declined below the historic minimum.

For the purpose of planning ahead from the onset of a drought event and thereby anticipating the likely measures required under worst case scenarios, predictive modelling of the Stonor Park hydrograph trend is an important part of the protocol's methodology.

The results of the stochastic analysis for the SWA and Henley WRZs indicates that the SWA and Henley WRZs appear to be very resilient to drought risk under the current climate with resilience maintained in 1:200 and 1:500 year drought events. Those sources where the PDO is vulnerable under severe drought would be supported through a combination of demand reductions and the provision of resource from drought permits.

8.5. Summary and conclusions

We have tested the effectiveness of our drought plan by simulating water resources conditions that are worse than any in the historical record, the stochastic droughts. The assessment demonstrates that all six zones adhere to the effectiveness criteria. In all cases, the demand and supply options, as triggered by the protocols, introduced the appropriate measures sufficiently early to maximise their benefit and provide adequate lead times for subsequent more stringent measures, thereby averting Level 4 emergency measures in the historical record.

The London WRZ was shown to be hydrologically robust under the stochastics test scenarios provided that drought permit measures and orders were implemented promptly, but with significant detrimental impact on the environment and also potentially requiring 'More Before Level 4' measures to be implemented. This illustrates the flexibility and robustness of London's water resources system as operated within the London protocol, even under an extreme scenario not yet seen in the historic record. However, these scenarios highlight the reliance on drought permits or orders for extended periods of time and the requirement of 'More Before Level 4' measures. This reliance on such long durations of drought permit installation would have a significant adverse impact on the environment and so indicate that to meet the challenge of potentially very severe droughts in the future, greater resource development is required in order to protect the environment from potentially severe damage in droughts of this return period.

The key to SWOX's robustness is the timely introduction of drought permit options for which early restrictions and an adequate lead time are essential; the protocol has been designed to provide both requirements but with resultant significant detrimental impact on the environment. For the London and SWOX WRZs the drought risk is dominated by surface water vulnerability, so for these WRZs the assessment concentrates exclusively on the two major surface water systems; the London reservoirs and the SWOX Farmoor reservoir. Unlike the other WRZs, no analysis of groundwater drought

vulnerability was carried out. The stochastic analysis demonstrated that the 20th century record incorporates two events that are just worse than a 1 in 100 year event in terms of yield (1921 and 1933/34). Therefore, for the Drought Plan analysis of the London reservoir system, two even increments of drought severity beyond this historic baseline were tested; 'severe' droughts with a return period of approximately 1 in 200 years, and 'extreme' droughts with a return period of approximately 1 in 500 years.

In the same way as for London, analysis of the impact of stochastically generated droughts has been undertaken for SWOX. The droughts selected for analysis in the London WRZ were also run through the SWOX component of WARMS. The analysis shows that Farmoor's key vulnerability is to events such as 1975-1976, which was very intense but relatively short, rather than events such as 1921-22 or 1933-34. The stochastics test scenarios illustrate the ability of SWOX's water resources system as operated within the SWOX protocol, even under an extreme scenario not yet seen in the historic record to maintain supply throughout a very severe drought. However, as for London, these scenarios highlight the reliance on drought permits or orders for extended periods of time. This reliance on such long durations of drought permit implementation would have a significant adverse impact on the environment and so indicate that to meet the challenge of potentially very severe droughts in the future greater resource development is required in order to protect the environment from potentially severe damage in droughts of this return period.

For Kennet Valley, the WBGWS is a key element in ensuring its robustness. Again, this scheme is triggered through London's protocol. We have also tested the drought plan for the Kennet Valley, Guildford, SWA and Henley WRZs against more severe droughts of 1:200 and 1:500 year severity as required by the guidance. The results of the analysis for the Kennet Valley, Guildford, SWA and Henley catchment indicate that the surface water and groundwater sources appear to be resilient to drought risk under the current climate within these WRZs.

Section 9. Conclusions

This document, the draft Drought Plan, is an update of the Drought Plan 2017. This draft Drought Plan includes amendments to comply with the requirements of the Water Company Drought Plan Guideline 2020. The principal update to the plan is the amendment of the contribution of our desalination scheme at Beckton (TGWTW) from 150 Ml/d to 100 Ml/d and an update of the assessment of how we would deal with droughts of greater severity than experienced in the hydrological record. We have also worked closely with other water companies in the south east of England through the WRSE group and have developed a joint approach where possible to the implementation of TUBs, NEUBs and media comms during a drought.

The draft Drought Plan retains the methodologies and protocols given in Drought Plan 2017. The Plan includes measures to comply with Defra's request to ensure it takes account of the powers arising from the Flood and Water Management Act 2010 (FWMA 2010) and further prescribed by the Water Use (Temporary Bans) Order 2010 and Drought Direction 2011.

Incorporating the powers into the Plan involved:

- Defra/EA guidance.
- UKWIR Code of Practice generally and in particular adherence to the 2nd principle of proportionality.
- Findings from customer research survey.
- Clarity of message - consistent with our experience with recent droughts, Defra and the EA, Ofwat and CCWater have emphasised the need for clear and straightforward customer communication to facilitate an effective response to the new measures.
- The requirement for a consistent approach by water companies in the South East of England, see Appendix L
- The experience gained from implementing a TUB in 2012

We have retained the proposal to introduce all eleven categories of use of the Temporary Use Ban legislation in a single phase, however in line with the revised Drought Plan guidelines 2020 we have included this as part of Level 2 of the Company's Levels of Service.

We have undertaken a Strategic Environmental Assessment (SEA) for this Drought Plan. The SEA has been undertaken in order to provide a formal review of the environmental impact of the options for drought management included within this plan, particularly drought permit options. This ensures that all the drought management options have been assessed for environmental impact in a comprehensive and consistent manner and the results of the assessment reported systematically. We have also undertaken a Habitats Regulations Assessment (HRA) of this Drought Plan to ensure that the plan does not adversely affect the integrity of European designated sites. Information from the SEA Environmental Report and the HRA Screening Report was incorporated into the Drought Plan Appendix C tables and used, together with operational considerations, to prioritise the options for implementation in a drought.

For our drought plan to be considered effective, or fit for purpose, we consider that it must meet the following criteria:

- Forecasting the impact of drought - the methodology must be capable of predicting the risk to security of supply.
- Planning ahead - protocols should facilitate:
    - the full sequencing of measures to be taken to avoid or minimise the need for Emergency Drought Orders (EDOs);

- timely introduction of measures to maximise benefits and allow for their implementation;
- proactive communication to customers on their participation.
- a reliable assessment to show that the measures being either considered or actually implemented are consistent with the Company's Levels of Service.

The protocols for each of the six WRZs have been tested for flexibility and robustness using stochastic analysis. All six zones were shown to demonstrate their adherence to the effectiveness criteria. In all cases, the protocols triggered the appropriate demand and supply measures sufficiently early to maximise their benefit and provide adequate lead times for subsequent more stringent measures, thereby averting Level 4 emergency measures. The early implementation of demand-side measures is the primary difference between the historic and current protocols, the latter triggering measures some two to four months earlier than the former.

The London WRZ proved to be robust to a 1:500 year drought event with the implementation of drought permits and 'More Before Level 4' measures. The London protocol initiates a company-wide set of demand management measures at an early stage. This is sufficiently early to meet the requirements for all the other zones. In this respect, the London protocol is seen as integrating the rest of the supply area's drought management plan.

The SWOX protocol is seen to provide a robust trigger for initiating the application of a NEUB and drought permits.

Under extreme low flow conditions, the SWOX and Kennet Valley zones were dependent upon drought permit options in order to maintain a supply capability that did not need the back-up of Level 4 emergency measures. Additionally, for Kennet Valley, the WBGWS is shown to be a key element in ensuring its robustness and the protocol for London facilitates the scheme's timely introduction for both zones.

The Guildford WRZ was shown to be essentially robust under the most extreme low flow conditions and, consequently, it is unlikely that drought permit options will be required for the zone. However, in the unlikely event that permits would be needed, the integrated London and Guildford protocols provide an adequate lead time for drought permit preparation and implementation.

In regard to understanding and quantifying the impact of an impending drought event and the risk to security of supply (effectiveness criteria 1), the stochastic analysis highlighted the importance of having the appropriate tools to predict the likely worst case trends of the key hydrologic parameters: groundwater levels, river flows and associated reservoir storage.

Further to the testing described above and following guidance from the Environment Agency, we have tested the plan against a range of droughts of greater severity than those in the historic record. This has been done using different approaches for different WRZs taking into account the balance of surface to groundwater resources and the water resource resilience of the WRZs to drought. This approach enables the testing of the plan against more severe droughts to be undertaken using a risk-based approach with more in-depth analysis used for the more complex water resources systems that serve London and SWOX whilst a more simple approach can be taken for the less complex water resources systems for the remaining WRZs.

The approach for the London system has been to use a stochastic approach to develop a longer time series of river flows based on analysis and breakdown of the weather systems that drive the water resources with generation of a very long time-series of data built up from a combination of the underlying weather systems together with the random element that provides the uncertainty in the

weather. The use of this approach enables a simulated time series to be produced which is of much greater length than the historic record.

For the London and SWOX WRZs the drought risk is dominated by surface water vulnerability, The stochastic analysis demonstrated that the 20th century record incorporates two events that are just worse than a 1 in 100 year event in terms of yield (1921 and 1932/33). Therefore, for the Drought Plan analysis of the London reservoir system, two even increments of drought severity beyond this historic baseline were tested; 'severe' droughts with a return period of approximately 1 in 200 years, and 'extreme' droughts with a return period of approximately 1 in 500 years.

The stochastics test scenarios illustrate the flexibility and robustness of London's water resources system as operated within the London protocol, even under an extreme scenario not yet seen in the historic record. However, these scenarios highlight the reliance on drought permits or orders for extended periods of time and the potential need for 'more before Level 4' measures. This reliance on such long durations of drought permit implementation would have a significant adverse impact on the environment and so indicate that to meet the challenge of potentially very severe droughts in the future greater resource development is required in order to protect the environment from potentially severe damage in droughts of this return period.

In the same way as for London, analysis of the impact of stochastically generated droughts has been undertaken for SWOX. The three droughts selected for analysis in the London WRZ were also run through the SWOX component of WARMS. The analysis shows that Farmoor's key vulnerability is to events such as 1975-1976, which was very intense but relatively short, rather than events such as 1921-22 or 1932-34. The stochastics test scenarios illustrate the ability of SWOX's water resources system as operated within the SWOX protocol, even under an extreme scenario not yet seen in the historic record to maintain supply throughout a very severe drought. However, as for London, these scenarios highlight the reliance on drought permits or orders for extended periods of time. This reliance on such long durations of drought permit installation would have a significant adverse impact on the environment and so indicate that to meet the challenge of potentially very severe droughts in the future greater resource development is required in order to protect the environment from potentially severe damage in droughts of this return period.

We have also tested the drought plan for the Kennet Valley, Guildford, SWA and Henley WRZs against more severe droughts as required by the guidance. In contrast to our last plan rainfall-runoff models are now available for the two key main surface water resources in the Kennet Valley and Guildford WRZs (the River Kennet at Theale and the River Wey at Tilford), so a fully stochastically based analysis has been carried out, as undertaken for the London reservoirs. Therefore, it was possible to analyse the robustness of these WRZs to very severe droughts. The results of the stochastic assessment for the Kennet Valley, Guildford, SWA and Henley catchment indicate that the surface water and groundwater sources generally appear to be very resilient to drought risk with a small number of minor exceptions and that if needed drought permits would ensure resilience to severe drought in these WRZs.

Section 10. Glossary of Key Terms and Abbreviations

Abstraction Licence – The authorisation granted by the EA to allow the removal of water from a source.

Aquifer – A geological formation, group of formations, or part of a formation, that can store and transmit water in significant volumes.

Artificial Recharge – General term used to describe the addition of surface water to a groundwater reservoir by human activity, such as injecting treated river water down boreholes into a confined aquifer.

Demand Management – The implementation of policies or measures which serve to manage control or influence the consumption or waste of water

Deployable Output – the output of a commissioned source or group of sources or of a bulk supply for a given level of service as constrained by:

- Environment
- Abstraction licence, if applicable
- Pumping plant and/or well/aquifer properties
- Raw water mains and/or aquifers
- Transfer and/or output main
- Treatment
- Water quality

NEUB - Non Essential Use Ban - The Drought Direction 2011

Drought Order – An authorisation granted by the Secretary of State under drought conditions which imposes restrictions on the use of water and /or allows for abstraction/impoundment outside the schedule of existing licences on a temporary basis.

Drought Permit – An authorisation granted by the EA under drought conditions which allows for abstraction/impoundment outside the schedule of existing licences on a temporary basis.

Groundwater – Water in the zone of an aquifer where the voids in a rock or soil are filled with water at a pressure greater than atmospheric pressure.

LTCD – Lower Thames Control Diagram – A guideline, contained within the LTOA (see below) in the form of a diagram setting out how much water must be allowed to flow over Teddington weir and at what time demand management measures should be implemented in relation to the storage in the Thames Reservoirs.

LTOA – Lower Thames Operating Agreement – An Operating Agreement between the EA and Thames Water under Section 20 of the Water Resources Act which sets out controls over the abstraction of water from the Lower Thames under the existing abstraction licence.

Methodology – used herein to describe the tools and techniques for evaluating risk to security of supply from hydrologic data, primarily based on groundwater levels across the Thames catchment,

river flows, primarily lower and upper Thames and reservoir storage (combined reservoir levels in London and Farmoor).

Protocol – term generally used herein to describe the framework that converts the results from the hydrologic assessment methodologies into a decision-making procedure for making decisions on appropriate drought management measures to be considered and/or implemented.

SAC – Special Area of Conservation – Designated under the European Habitats Directive (1991)

Stochastics – stochastic means having a random variable. A stochastic model is a tool for estimating probability distributions or potential outcomes by allowing for random variation in one or more inputs over time. The random variation is based on fluctuations observed in the historic data for a selected period using standard time series techniques. Distributions of potential outcomes are derived from a large number of simulations which reflect the random variation in the inputs.

Supply/demand balance – The difference between water available for use and demand at any given point in time.

Trigger – The term used to describe a decision mechanism for providing definitive guidance on the introduction of drought management measures.

WARMS (Water Resources Management System) – WARMS is a modelling system made up of a series of mathematical simulation models and is used to simulate future reservoir storage levels within the LTCD through 'what if' behavioural analysis of the Thames Water system. It is also used to calculate the deployable output for London and SWOX through operation in a time series mode using historic hydrometric records.

WRZ – Water Resources Zone - The largest possible zone in which all resources, including external transfers, can be shared and hence the zone in which all customers experience the same risk of supply failure from a resource shortfall.

Yield – A term generally used to describe the quantity of water pumped from a borehole usually expressed as a continuous rate of flow eg megalitres per day.